Processing Characteristics of Pigeonpeas of the Kaki and Saragateado Selections

F. Sánchez-Nieva[1]

INTRODUCTION

Two selections of pigeonpeas, the Kaki and the Saragateado, are generally grown in Puerto Rico for canning purposes. The Kaki selection is an early type harvested usually from late December to about the middle of January. A second crop of this selection is harvested late in January and up to the middle of February. The Saragateado selection is of the late type and is harvested from the middle of February to early March. The use of these two selections offers the advantage that the pigeonpeas for processing are available for a longer period than would be possible if only one type, either early or late, were grown.

Since both selections are canned indistinctively, it was convenient to study their processing characteristics and to determine the effect of selection characteristics on product quality. Although this work was carried out with the main objective of comparing the two selections with respect to those characteristics which may affect the canning operations, the data obtained will also be of interest to the plant breeder as a guide in the development of new selections and varieties of pigeonpeas suitable for canning.

MATERIAL AND METHODS

PIGEONPEA SELECTIONS

The pigeonpeas used throughout this study were Kaki and Saragateado selections and were grown on the experimental farms at Isabela and Fortuna, near Ponce. Harvesting was by hand following established commercial procedures. The pigeonpeas were harvested when fully developed, but still in the green stage, at an alcohol-insoluble-solids content of approximately 25.0 percent. The pigeonpeas were packed at the farm in ⅘-bushel crates and delivered to the laboratory the same day harvested. The crates were stored at 45° F. until the peas could be processed.

PROCESSING

The pigeonpeas were processed as described by Sánchez *et al.* (*1*)[2]. The pods were heated with steam to inactivate the enzyme system of the peas and

[1] Technical Director, Food Technology Laboratory of the Agricultural Experiment Station of the University of Puerto Rico, Río Piedras, P.R. The author wishes to express his gratitude to the many members of the staff of the Laboratory and of the Isabela, Gurabo, and Fortuna Substations for their assistance in this work.

[2] Italic numbers in parentheses refer to Literature Cited, p. 33.

shelled while hot. The peas from the huller were flumed to a rotary washer with rod spacings of $\frac{5}{16}$ of an inch. Two classes of peas were obtained from the washer, the large peas which were discharged from the drum, and the small which went through the rod spacings together with the debris. The former will be designated as "primary" peas and the latter "secondary" in this paper. Only primary peas were used for processing, but the secondary peas were collected and weighed to determine shelled-out percentages. The pods were shelled twice to determine the total shelled-out percentage; they were collected, weighed, and shelled a second time after the first shelling.

The primary peas discharged from the washer were collected in trays for processing and transferred to a picking-belt for removal of defective units. After picking, the peas were washed in a rotary washer, blanched in water at 185° F. for 5 minutes, and cooled in a rotary washer with water sprays. The cooled peas were transferred to a second picking-belt for a final picking and packed in plain tin cans with C-enamel ends at a filling-weight of 11.5 ounces. Boiling water and a 70-grain salt tablet were added to the cans. The cans were processed for 35 minutes at 240° F. and cooled to 100° F. with water. They were stored at room temperature (85° F.) for 15 days before being opened for analyses and inspection.

ANALYTICAL METHODS

Alcohol-insoluble solids were determined by the AOAC procedure (*2*) modified as follows: The samples for analyses are prepared by dispersing in a Waring blendor a known weight of pigeonpeas with an equal weight of water. About 15 gm. of this mixture are transferred to a 600-ml. beaker and extracted for 30 minutes with 80-percent alcohol. After the extraction is completed the sample is filtered, the solids are washed with alcohol until the filtrate is free of coloring matter, and the washed solids are transferred to an aluminum dish and dried at 100° C. for 2 hours.

COLOR OF BRINE

To measure the color of the brine 30 ml. of brine are taken from a can immediately after opening and placed in a Hellige No. 8010–50 cup, 50-mm. viewing depth. The color of the brine was measured by transmittance in a Hunter color and color-difference meter calibrated for T 99, a — 0, b — 0. Color values were calculated from the equation: Color = $\sqrt{T^2 + a^2 + b^2}$ where T, a, and b are the values read directly from the meter scales.

COLOR OF PEAS

The color of the fresh peas was measured on a sample placed in a Hellige No. 8010–50 cup; actual color was determined by reflectance in a Hunter color and color-difference meter calibrated with a standard color plate

whereon $R_d = 25.0$, $a - 28.0$, $b + 6.9$. The canned peas were drained to measure their color, just as was done for the determination of drained weight; actual color was determined with the Hunter meter as already explained for raw peas, but calibrated with a standard color plate whereon $R_d - 9.7$, $a - 0.1$, $b + 19.6$. Instead of calculating the color difference ΔE between sample and standard, a color index was obtained from the formula color $= \sqrt{R_d^2 + a^2 + b^2}$, where R_d, a, and b are the values read directly from the meter scales.

SIZE OF PEAS

To determine the size of the pigeonpeas a weighed sample was placed in a multiple sizer with the sizes of screen as follows: $^{9}/_{32}$, $^{10}/_{32}$, $^{11}/_{32}$, $^{12}/_{32}$, $^{13}/_{32}$ inches. The sizer was shaken until complete separation by size occurred. The pieces on each screen were weighed and the percentage of each size was calculated.

RESULTS AND DISCUSSION

The first point to consider in comparing the canning characteristics of different selections or varieties of pigeonpeas should be the efficiency of the shelling operation. Several factors affect the determination of its efficiency. In the first place it is necessary to consider the shelled-out percentage that can be obtained when the pigeonpeas are shelled only once, and the pods are discarded. Second, it is necessary to consider also what occurs when the pods from the first shelling are shelled a second time to increase yields. A comparison of the yields obtained from both shellings indicates the resistance to shelling of the variety or selection under study. The third factor to be considered is the number of mashed units resulting from the shelling operation. If the huller is operated at the same rate of feed, at constant speed, and the angle of the beaters is similarly adjusted when shelling the two varieties, the percentage of mashed units in the shelled peas is a characteristic of the variety, and serves also to measure the ease with which the pods can be opened.

In table 1 the percentage of primary and secondary peas, total shelled-out percentage for the first shelling operation, total shelled-out percentage for the second shelling operation, and the percentage of mashed units obtained are given for the Kaki and Saragateado selections. A comparison of the data shows that the percentage of primary and secondary peas from the first shelling was similar for both selections. The yield of peas obtained from the second shelling was about 1 percent higher for the Saragateado selection. The percentage of mashed units was about 4 higher for the Saragateado selection. Total shelled-out percentage was higher for the Saragateado selection.

To determine whether there was any difference in the shelling charac-

TABLE 1.—*Efficiency of the shelling operation for the Kaki and Saragateado selections of pigeonpeas*

Item	Average values for runs											Range	Mean
Kaki selection													
Percentage of primary peas from first shelling	37.7	40.7	40.1	41.5	43.1	35.1	36.0	—	—	—	—	35.1–41.5	39.2
Percentage of secondary peas from first shelling	.4	2.0	1.5	2.4	1.6	2.1	1.8	—	—	—	—	.4– 2.0	1.7
Percentage of peas from second shelling	5.3	6.4	8.5	6.5	6.7	7.6	9.2	—	—	—	—	5.3– 9.2	7.2
Total shelled-out percentage	43.4	49.1	50.1	50.4	51.4	44.8	47.0	—	—	—	—	43.4–50.4	48.1
Ratio of green to yellow peas	38.0	15.2	8.7	18.3	12.0	17.0	5.4	—	—	—	—	5.4–38.0	16.3
Percentage of mashed units	5.6	5.0	4.5	10.1	1.7	7.6	9.8	—	—	—	—	1.7–10.1	6.32
Saragateado selection													
Percentage of primary peas from first shelling	37.2	40.5	40.7	38.5	39.0	42.6	40.6	36.5	41.9	40.6	37.4	36.5–42.6	39.6
Percentage of secondary peas from first shelling	.7	1.3	1.1	.8	1.0	1.1	1.7	1.5	1.1	1.7	.8	.7– 1.7	1.2
Percentage of peas from second shelling	7.3	6.1	6.9	7.6	8.6	9.3	7.1	8.7	8.0	7.1	11.9	6.1–11.9	8.1
Total shelled-out percentage	45.2	47.9	48.7	46.9	48.6	53.0	49.4	46.7	51.0	49.4	50.1	45.2– 5.10	48.9
Ratio of green to yellow peas	7.5	19.0	13.30	2.7	2.3	4.5	4.9	5.7	2.1	4.9	3.1	2.1–13.3	6.3
Percentage of mashed units	7.1	12.2	18.1	5.7	7.7	8.0	15.8	10.3	5.1	15.8	10.3	5.1–18.1	10.6

teristics of the selections the percentage of peas obtained from the first shelling operation, including primary and secondary, was calculated expressed as percentage of the total weight of peas obtained, and statistically analyzed for significant difference between means. The results in table 2 show no significant differences in the yields obtained from the two selections. Both selections behaved exactly alike as to yield during shelling when the pods were steamed before shelling, but when the pods were not steamed, the Saragateado selection was more difficult to shell than the Kaki.

The main difference between the two selections during shelling was in the percentage of mashed units, the Saragateado having a higher percentage of mashed and broken peas than the Kaki. This seems to be a varietal characteristic, probably caused by toughness of the pods which may require a longer beating before they open up. The increase in mashed units in the Saragateado in the experiments listed in table 1 cannot be attributed to the stage of maturity. The pigeonpeas of the Saragateado selection were more

TABLE 2.—*Percentage yield by weight of pigeonpeas obtained from first shelling in terms of total weight of shelled-out Kaki and Saragateado peas*

Selection	Values from several runs											Mean value
Kaki	86.9	82.9	80.0	82.3	83.9	78.3	76.5					81.54
Saragateado	82.3	84.6	83.6	82.1	80.2	80.4	82.2	78.2	82.2	82.2	76.4	81.14

developed in general than the Kaki, as evidenced by the lower ratios of green to yellow peas in the former. Since tender peas are more prone to mash than overripe yellow peas it would be reasonable to expect that fewer mashed units would result when more yellow peas were processed.

During the many years that we have been working with pigeonpeas in this Laboratory we have processed those coming from many different sections of the Island. To determine whether the section in which the pigeonpeas are grown affects yield, as well as whether there is any difference in yield for both selections from season to season, the percentage yields obtained when shelling pigeonpeas from the Isabela farm on the North Coast were averaged for the 1956 and 1957 crops; so also were the percentage yields of those obtained from the Fortuna experimental farm near Ponce on the South Coast for the 1960 crop. The average figures for the percentage yields of primary and secondary peas, and the total shelled-out percentages are given in table 3.

Similar shelled-out percentages for primary, secondary, and total peas were obtained for selections of the 1956 crop. The Kaki selection outyielded the Saragateado in the 1957 crop at Isabela. The Saragateado also yielded

much less than the Kaki selection in the 1960 crop harvested at the Fortuna experimental farm on the South Coast. Since the Saragateado selection showed a definite trend after the 1956 crop to yield fewer shelled-out peas than the Kaki selection, it is reasonable to assume that the original selection used during the 1956 crop was much better than the one available for later plantings.

TABLE 3.—*Shell-out percentage for the Kaki and Saragateado selections grown at Isabela and Fortuna Substations*

Item	Kaki selection grown at—			Saragateado selection grown at—		
	Isabela 1956	Isabela 1957	Fortuna 1960	Isabela 1956	Isabela 1957	Fortuna 1960
Percentage of primary peas	39.2	40.76	44.07	39.6	39.74	36.72
Percentage of secondary peas	1.7	2.41	4.35	1.2	1.13	4.98
Shelled-out percentage	40.9	43.17	48.42	40.8	40.87	41.70

TABLE 4.—*Characteristics of shelled pigeonpeas of the Kaki and Saragateado selections grown at the Isabela Substation in 1956*

Characteristic	Kaki selection		Saragateado selection	
	Range of values	Mean	Range of values	Mean
Percentage alcohol-insoluble solids	23.5 - 28.2	25.68	22.8 - 28.2	26.08
Percentage starch	12.4 - 17.9	15.17	13.2 - 17.5	15.25
Specific gravity	1.089- 1.122	1.115	1.070- 1.130	1.105
Hunter *a*	−13.8 --19.0	−16.0	−9.3 --17.5	−15.05
Hunter *b*	18.7 - 22.4	20.81	18.5 - 22.9	20.82

CHEMICAL AND PHYSICAL CHARACTERISTICS OF SHELLED PEAS

The chemical and physical characteristics of the shelled peas of the Kaki and Saragateado selections are given in table 4. The data show the average values for all samples analyzed from the 1956 crop grown at the Isabela Substation. Since, as shown by Sánchez *et al.* (*3*), there is a loss in the intensity of the green pigment and an increase in the alcohol-insoluble solids as the pigeonpeas mature, only samples with similar alcohol-insoluble solids content are listed in table 4 for comparative purposes. In this way it is possible to make the comparison between selections at the same maturity, thus eliminating the effect of maturity on the different characteristics measured. The data in table 4 show that pigeonpeas from both selections have similar starch contents at the same stage of development, as well as

similar specific gravity and the same intensity of the green pigment, as evidenced by the values of the Hunter *a* and Hunter *b* color indices.

SIZE DISTRIBUTION OF PIGEONPEAS OF BOTH SELECTIONS

Data from sieve-size measurements of samples of pigeonpeas of the Kaki and Saragateado selections obtained from the Fortuna Substation during the 1960 crop are given in table 5. Average values for the samples listed in the table for each sieve-size are shown graphically in bar-graph form on figure 1.

TABLE 5.—*Size distribution of pigeonpeas of the Kaki and Saragateado selections harvested at Fortuna Substation during the 1960 season*

Alcohol-insoluble solids	Peas of sieve size—					
	13/32	12/32	11/32	10/32	9/32	79/32
Kaki selection						
27.44	24.03	20.79	39.60	10.39	3.24	1.95
29.11	35.16	17.87	36.31	6.92	1.73	2.01
29.59	26.86	17.88	36.87	11.73	5.03	1.68
30.87	27.17	21.51	39.25	10.57	1.13	.37
23.42	13.94	7.27	43.64	23.03	9.09	3.03
Saragateado selection						
24.74	4.55	18.64	42.86	21.12	10.35	2.48
26.69	9.36	19.88	24.56	23.98	13.45	3.77
27.09	10.80	21.59	34.66	21.02	7.95	3.98
24.65	3.35	9.33	25.75	39.18	17.54	4.85
26.79	15.22	14.49	33.33	20.29	13.04	3.63

It should be noted from the data in table 5 that the alcohol-insoluble-solids content of the samples listed varied from around 23 to 28 percent, which means that the samples examined were not at the same stage of maturity. The samples listed in table 5 were chosen at random from the many samples examined during the 1960 crop, in order to include the usual range in alcohol-insoluble solids, and hence of stages of development usually encountered in pigeonpeas harvested throughout a crop. The data in table 5 and figure 1 show the wide variation in the size of the peas in the samples examined.

This wide variation in sieve-size makes it impossible to can a product of uniform size, since it would be economically infeasible to grade the pigeonpeas by size and can each grade separately. The data also show a different

pattern for the size distribution of pigeonpeas for each of the two selections. The samples of pigeonpeas of the Kaki variety had a greater percentage of large peas of sieve-size from $^{13}/_{32}$ to $^{11}/_{32}$ inch than the samples of the Saragateado variety. At the other extreme, the samples of pigeonpeas of the Saragateado selection had a greater precentage of sieve-sizes ranging from $^{10}/_{32}$ to less than $^{9}/_{32}$ inch, that is of smaller peas.

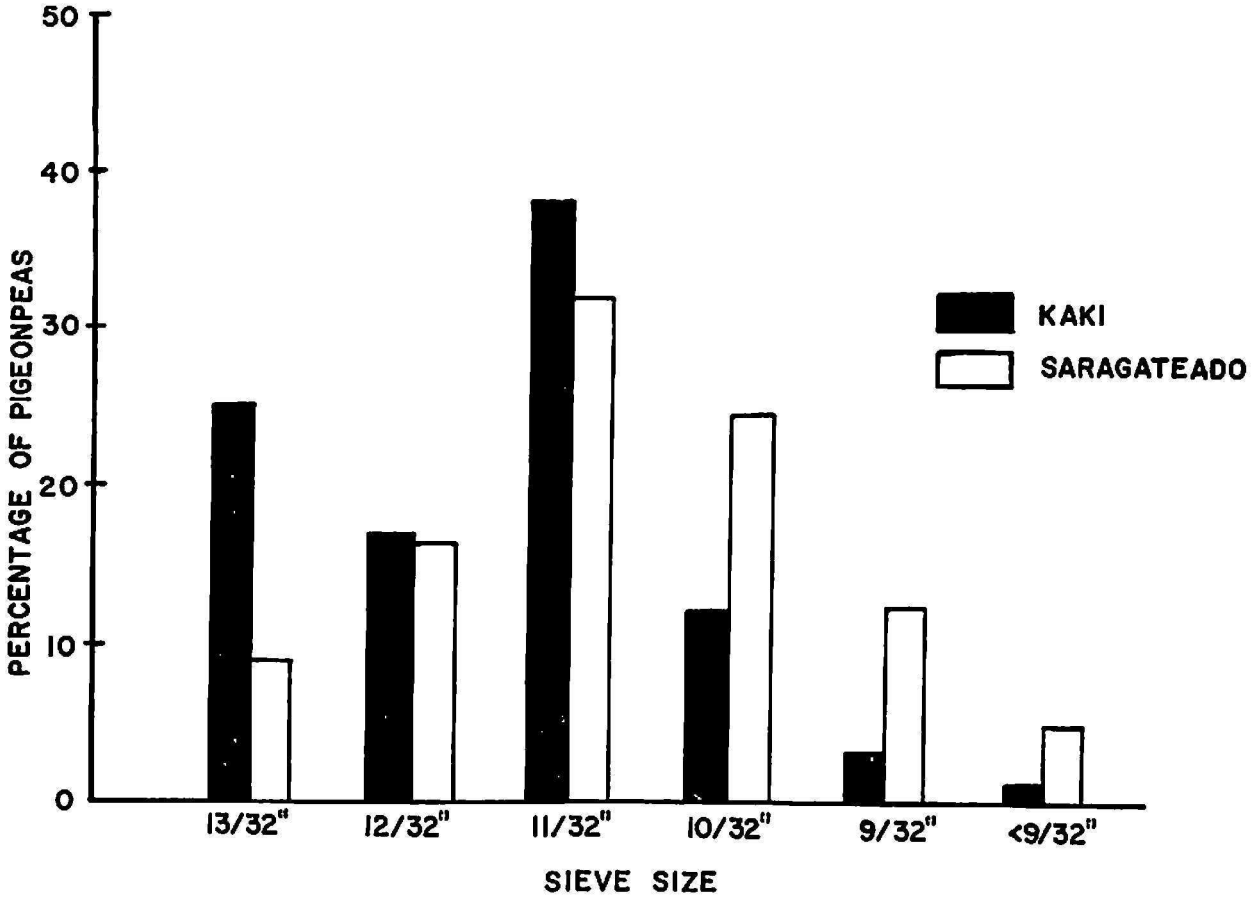

FIG. 1.—Size distribution of pigeonpeas of the Kaki and Saragateado selections.

CHARACTERISTICS OF THE CANNED PIGEONPEAS

The color and turbidity of the brine of canned pigeonpeas of the Kaki and Saragateado selections are given in table 6. The data in the table include average values for a large number of samples analyzed during the 1957 crop, and show that the brine of canned pigeonpeas of the Kaki selection was more turbid and darker than the brine of those of the Saragateado selection. This was also observed to happen whenever pigeonpeas of both selections were processed either by the steaming method described by Sánchez *et al.* (*1*), or as processed commercially. Pigeonpeas of the Saragateado selection always had a better appearance in the open can than those of the Kaki selection. This difference in behavior during canning seems to

be a definite varietal characteristic, as changes in the blanching treatment or other processing variable had no effect in lowering the turbidity and preventing darkening of the brine of canned pigeonpeas of the Kaki selection.

The color of the drained canned peas as measured by the Hunter meter is given in table 7. Although there are small differences in the *R*, *a*, and *b* values for the samples listed, these are within the experimental error obtained when measuring color by the method described. Therefore, no significant differences in the color of the drained canned peas was found between the two selections.

TABLE 6.—*Turbidity and color of the brine of canned pigeonpeas of the Kaki and Saragateado selections from the 1957 crop*

Item	Kaki selection		Saragateado selection	
	Range of values	Mean	Range of values	Mean
Turbidity of brine	222 -355	288.0	161.0–327	251.5
Color of brine				
To	5.0– 41.3	17.4	21.8– 50.6	35.04
a	−1.9–+2.6	.3	−1.2–+6.8	+2.1
b	3.7– 17.7	8.3	10.6– 18.8	13.9
$\sqrt{To^2 + a^2 + b^2}$	6.2– 45.0	19.4	24.2– 52.8	37.8

TABLE 7.—*Color of canned pigeonpeas of the Kaki and Saragateado selections*

Item	Kaki selection		Saragateado selection	
	Range of values	Mean	Range of values	Mean
Rd	10.1–13.1	12.03	12.0–16.6	13.0
a	2.2– 5.4	4.10	1.2– 4.3	3.4
b	9.1–14.3	12.24	9.2–12.0	10.0
Percentage of alcohol-insoluble solids	21.0–23.0	22.14	20.5–22.0	21.46

When samples of canned pigeonpeas of the Kaki and Saragateado selections were submitted to organoleptic appraisal they were found to be similar in all such characteristics including, color, flavor, texture, and appearance.

DESIRABLE CHARACTERISTICS OF PIGEONPEAS FOR PROCESSING

It seems pertinent to list those characteristics that pigeonpeas for processing should have. In the first place, they should be easy to shell so that a high shelled-out percentage is obtained in only one shelling, with the least

mashing possible. In this respect, the Kaki selection is superior to the Saragateado. Although, as already shown, similar shelled-out percentages were obtained when both varieties were steamed before shelling, it was repeatedly observed in commercial canning operations that the Kaki selection is more easily shelled than the Saragateado. It is a prevalent practice to wilt the pods of the Saragateado by exposure to the sun to make shelling easier. This practice, of course, results in deterioration of the peas and a lowering of the quality of the canned pigeonpeas.

The second desirable characteristic is uniformity in size. Neither the Kaki nor the Saragateado selection had the desirable uniformity in size to enable canners to can a uniform product. From the observations we have made in the course of our work with pigeonpeas it seems that two factors are responsible for the lack of uniformity in the size of the peas. One of these is a definite selection characteristic, as evidenced by the fact that pigeonpeas of different sizes very frequently have the same starch and alcohol-insoluble-solid content, indicating a similar stage of maturity. The other factor is the variation in size due to maturity, since pigeonpeas at different stages of development are present all throughout the crop.

The third desirable characteristic involves the level of chemical constituents which are responsible for the darkening of the brine. The Saragateado selection is far superior to the Kaki in this respect, as it was found that whenever the former was processed, canned pigeonpeas with a brine having a lower turbidity and lighter color were always obtained. Although it is true that, at present, the nature of these color-forming constituents is not known, it is simple to determine how any new selection or variety behaves during processing by just canning a sample by the methods already described, and measuring the color and turbidity of the brine.

SUMMARY

The canning characteristics of the Kaki and Saragateado pigeonpea selections have been studied. The selections were both found to yield nearly the same percentage of shelled-out peas. The Kaki selection was easier to shell than the Saragateado, although this difference was less pronounced when the pods were steamed before shelling. Shelled peas of both selections were found to have similar chemical and physical characteristics and to possess similar color at the same stage of development. The drained peas were similar in color when the two varieties were canned. The Saragateado selection was found to produce less turbid and lighter colored brines than the Kaki. Both selections were found to lack uniformity as to the size of peas.

RESUMEN

Se llevó a cabo un estudio comparativo de las selecciones de gandures Kaki y Saragateado para determinar el comportamiento de ambas durante el proceso de enlatado. Ambas selecciones al desgranarse las vainas bajo condiciones similares produjeron la misma cantidad de granos, pero fue más fácil desgranar la selección Kaki. El gandur de ambas selecciones, en su estado natural, tiene igual composición química e igual color. Cuando se enlata el gandur de ambas selecciones no se observa diferencia en el color del grano escurrido, pero se puede notar que las salmueras del gandur Saragateado enlatado son más claras en color y menos turbias que las del Kaki. El grano de ambas selecciones no es uniforme en tomaño, característica que resulta indeseable por cuanto hace imposible enlatar un producto uniforme. No se encontró diferencia en las características organolépticas entre estas dos selecciones.

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