Hydration and Cooking Properties of Dry Beans[1]

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ABSTRACT

The hydration times of 22 dry bean (*Phaseolus vulgaris*) selections of red kidney, white, and striped varieties were determined. The Lajas red kidney selection duplicates its weight in 7 h, whereas the striped Calima and Rosita Lajas selections duplicate their weights in 10 h. All other selections duplicate their weights in about 12 to 18 h. All bean selections were accepted when they were sensory evaluated for appearance, flavor, and overall acceptability. The red kidney selections Lajas and 1973 (28), the white selections White 117 and White 142, and the striped selections Dominicana #5, Naranjito, Pompadour Dominicana and Galana scored poorly regarding texture (mouth feel) because they were somewhat hard. Texture was the sensory attribute that contributed most to the overall acceptability (r = .92).

INTRODUCTION

Dry beans are consumed in considerable amounts by all sectors of the Puerto Rican population, but the island production is low. In 1973–74 the per capita consumption of beans of all kinds was 16.31 lb, only 0.33 lb of which was locally produced, and 15.98 lb imported (2). In 1980 Puerto Rico imported 53,276,695 lb of beans from the United States only, with a cash value of $18,213,257. Of these, $45,643,279 lb were dry beans with a cash value of $15,639,536 (1). Puerto Rico has an ideal climate to produce several crops per year. Guadalupe-Luna (7) found that it is possible to harvest good marketable beans three times per year if the beans are planted in spring, summer and winter.

Beans must be rehydrated prior to processing or cooking. Burr et al. (4) found that in canned beans this practice insures product tenderness and a uniform expansion of beans thus increasing product yield. Usually dry beans are commercially hydrated to a 50% level in a hydration time of 10 to 18 h (5, 13). Nordstrom and Sistrunk (12) working with 8 types of beans, found that a low original moisture level before soaking resulted in higher hydration ratios in all bean types, except two. Snyder (15) had previously determined that the passage of water through the general surface of the bean is limited by the permeability of the seed coat. High moisture beans which had been held in storage absorbed water somewhat faster than similar beans of low moisture content (4). Some authors studied the effect of hot water and of additives in the soaking water to increase hydration rate (6, 8, 14).

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Cooking tenderizes the seed coat and cotyledons, developing acceptable flavor and texture, and rendering the bean protein nutritionally available. Rockland et al. (14) stated that the middle lamella softens during cooking, thus permitting the separation of adjacent whole cells. On the other hand, cultivar and location have been reported to affect the cooking quality, primarily color and texture, of pinto beans (11, 13).

This study was undertaken with the purpose of evaluating the hydration and cooking properties of 22 bean selections which at present are being tested for commercial culture in Puerto Rico.

MATERIALS AND METHODS

The bean selections used in this study were grown at the Isabela Substation of the Agricultural Experiment Station. Beans were planted in winter and left to dry in the field. They were brought to the laboratory and stored under controlled conditions (75°F and 60% RH) until used.

Moisture, color and hydration ratios of the dry beans were determined prior to sensory evaluations. Moisture was determined by the vacuum oven method (3). Color measurements were performed with a Hunter Color Difference Meter[3] with a white tile as a standard ($L = 92.8$, $a = -.5$ and $b = +2.5$). The Hunter container was filled to the middle and covered with a Kodak neutral test card with the white side of 90% reflectance down. Hydration ratio experiments were performed by weighing 25-g samples of dry beans and by soaking them in 75 ml tap water. Samples were weighed every hour. Before weighing, excess surface water was eliminated with absorbent paper. After beans were weighed they were put back in 75 ml tap water.

Sensory evaluations were conducted with a 6-point hedonic scale ranging from "like very much" (6 points) to "dislike" (1 point). Samples were evaluated for appearance, flavor, texture (mouth feel), and overall acceptability.

Stewed bean samples were prepared by weighing 227 g of dry beans, soaking them to three times their weight in tap water for the specified time for each selection to double its weight as found in the hydration experiment described above. Beans were cooked Puerto Rican style, which briefly consists in boiling the beans until soft, adding a condiment prepared from onion, sweet peppers, garlic, coriander, tomato sauce, cooking ham, salt pork, and salt. Fifty grams of pumpkin cut into small pieces was also added as a thickening agent. The stew was cooked until thickened. Samples were presented in small dishes to the taste panel in groups of not more than 4 samples per serving.

[3] Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

The panel scores were submitted to analysis of variance and the Duncan's multiple range test (10). Correlation coefficients were calculated with a quick ranking procedure as explained by Kramer and Twigg (9).

RESULTS AND DISCUSSION

Table 1 shows the results of moisture and color determination. Tables 2, 3, and 4 show the hydration values.

Moisture content was about the same for all samples ranging from

TABLE 1.—*Moisture and Hunter color determinations of dry beans*

Class	Selection	Moisture	Hunter color values[1]		
			L	+*a*	+*b*
		%			
Red kidney	Violeta	13.04	29.72	6.71	5.62
	Lajas	13.60	20.00	9.44	3.45
	1973 (28)	14.02	25.96	13.20	8.08
	27 R	13.27	26.20	12.74	8.07
White	Bonita #4	13.03	64.30	0.17	12.43
	Bonita #7	12.14	65.13	0.26	12.29
	Bonita #8	12.50	65.38	0.17	12.53
	Abrams Africa	12.38	63.21	0.14	11.87
	Cuarentena	12.74	66.32	−0.17	12.18
	White #142	12.66	63.51	0.34	13.21
	White #117	13.24	64.63	0.15	13.03
Striped	Dominicana #5	13.25	29.89	6.81	4.12
	Naranjito	14.04	28.50	10.40	7.71
	Pompadour Dominicana	13.24	29.89	8.08	4.71
	Galana	12.63	37.40	4.47	10.11
	Pompadour	13.26	27.95	7.43	5.03
	Borinquen	13.02	27.30	9.80	6.35
	Colombia 91P	13.87	27.92	8.03	4.43
	Calima	13.52	25.50	6.18	2.95
	Rosita Lajas	14.11	27.54	6.68	6.44
	Oro Rico	13.64	40.43	7.13	11.68
	Guayamesa	13.73	28.34	9.95	6.90

[1] *L* = lightness, +*a* = redness, −*a* = greenness, and +*b* = yellowness.

14.11% in the Rosita Lajas Striped selection to 12.14% in the white selection Bonita #7. White selections had lower moisture content; red kidney had about the same moisture content as striped beans.

As expected, lightness of beans was higher and redness lower in White varieties, but yellowness was higher.

Lajas, a red kidney selection doubled its weight in only 7 h (table 2), while striped Calima and Rosita Lajas doubled their weights in 10 h (table 4). The other selections took from 12 to more than 18 h to double their weights.

TABLE 2.—*Hydration values of four selections of dry kidney beans*

Hydration time (h)	Increments in weight of beans (g)			
	Violeta	Lajas	1973 (28)	27R
0	25.00	25.00	25.00	25.00
1	25.68	35.66	29.65	30.35
2	29.60	42.59	35.83	36.82
3	35.00	45.64	39.61	40.89
4	39.83	47.89	42.58	42.89
5	43.69	49.02	44.13	44.12
6	44.98	49.88	45.32	45.03
7	46.25	50.31	46.06	45.64
8	47.02	50.67	46.59	45.98
9	48.74	51.09	47.34	47.27
10	49.89	—	47.78	48.53
11	50.20	—	48.14	48.84
12	50.64	—	48.60	49.30
13	50.74	—	48.77	49.43
14	—	—	48.97	49.70
15	—	—	49.36	49.84
16	—	—	49.58	49.95
17	—	—	49.77	50.05
18	—	—	49.90	50.07

TABLE 3.—*Hydration values of seven selections of white dry beans*

Hydration time (h)	Increments in bean weight (g)						
	Bonita #4	Bonita #7	Bonita #8	Abrams Africa	Cuarentena	White 142	White 117
0	25.00	25.00	25.00	25.00	25.00	25.00	25.00
1	39.42	38.68	36.96	41.07	38.80	36.79	34.50
2	42.74	42.79	39.43	43.60	43.23	41.55	40.09
3	44.89	44.91	42.44	45.95	45.23	44.53	42.86
4	46.38	46.21	44.64	47.11	46.72	46.24	44.74
5	47.08	46.91	46.07	47.72	47.58	47.31	47.78
6	47.57	47.44	46.79	48.13	48.22	47.97	46.62
7	47.96	47.88	47.43	48.44	48.70	48.39	47.76
8	48.17	48.08	47.84	48.68	48.91	48.79	47.61
9	48.43	48.28	48.14	48.80	48.35	49.02	47.66
10	48.58	48.60	48.29	48.15	48.85	49.28	48.09
11	48.83	48.51	49.11	49.00	49.11	49.76	48.09
12	48.36	48.78	48.79	48.58	49.41	49.45	48.62
13	48.63	48.93	49.10	48.74	49.47	49.73	48.87
14	48.59	49.00	49.23	48.73	49.58	49.77	49.12
15	48.74	49.23	49.42	48.83	49.72	50.01	49.33
16	48.81	49.28	49.59	48.86	49.84	—	49.47
17	48.99	49.38	48.87	49.01	49.99	—	49.54
18	49.06	49.48	49.95	49.08	50.09	—	49.68

TABLE 4.—*Hydration values of eleven selections of dry striped beans*

Hydration time (h)	Increments in beans weight (g)										
	Dominicana #5	Naranjito	Pompadour Dominicana	Galana	Pompadour	Borinquen	Colombia 91P	Calima	Rosita Lajas	Oro Rico	Guayamesa
0	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
1	32.19	35.59	28.58	26.92	35.69	32.38	27.42	29.25	25.41	38.09	34.23
2	37.69	39.35	32.99	28.25	40.82	39.66	30.31	34.49	26.01	42.00	39.75
3	42.35	48.88	37.83	29.91	43.44	43.19	34.76	39.68	27.02	44.53	41.93
4	44.37	45.00	41.42	31.36	44.99	44.97	37.94	43.32	28.37	45.24	44.65
5	45.52	45.90	43.56	33.04	45.81	45.88	46.77	47.40	30.18	46.54	45.51
6	46.74	46.78	44.97	34.70	46.54	46.81	43.22	47.46	32.12	47.17	46.31
7	46.79	47.33	45.96	36.76	46.96	47.70	45.10	48.46	34.68	47.70	46.83
8	47.14	47.78	46.71	39.03	47.40	47.90	46.36	49.07	37.07	48.05	47.25
9	47.88	48.36	47.59	44.84	47.71	48.41	47.13	49.86	44.46	48.52	47.78
10	48.24	48.70	48.26	46.19	48.02	48.77	48.53	50.34	50.03	48.88	48.16
11	48.57	49.55	48.55	49.98	48.75	49.03	49.85	50.47	50.56	49.21	48.58
12	48.86	49.21	48.83	49.86	48.98	49.30	50.23	50.83	50.99	49.54	48.79
13	49.01	49.38	49.02	49.99	49.07	49.41	50.49	—	—	49.74	48.93
14	49.12	49.60	49.13	50.20	49.26	49.48	—	—	—	49.85	49.13
15	49.18	49.75	49.22	50.24	49.41	49.53	—	—	—	49.99	49.27
16	49.37	49.89	49.42	—	49.56	49.78	—	—	—	50.26	49.40
17	49.49	49.91	49.45	—	49.75	49.82	—	—	—	—	49.55
18	49.66	—	49.65	—	—	49.99	—	—	—	—	—

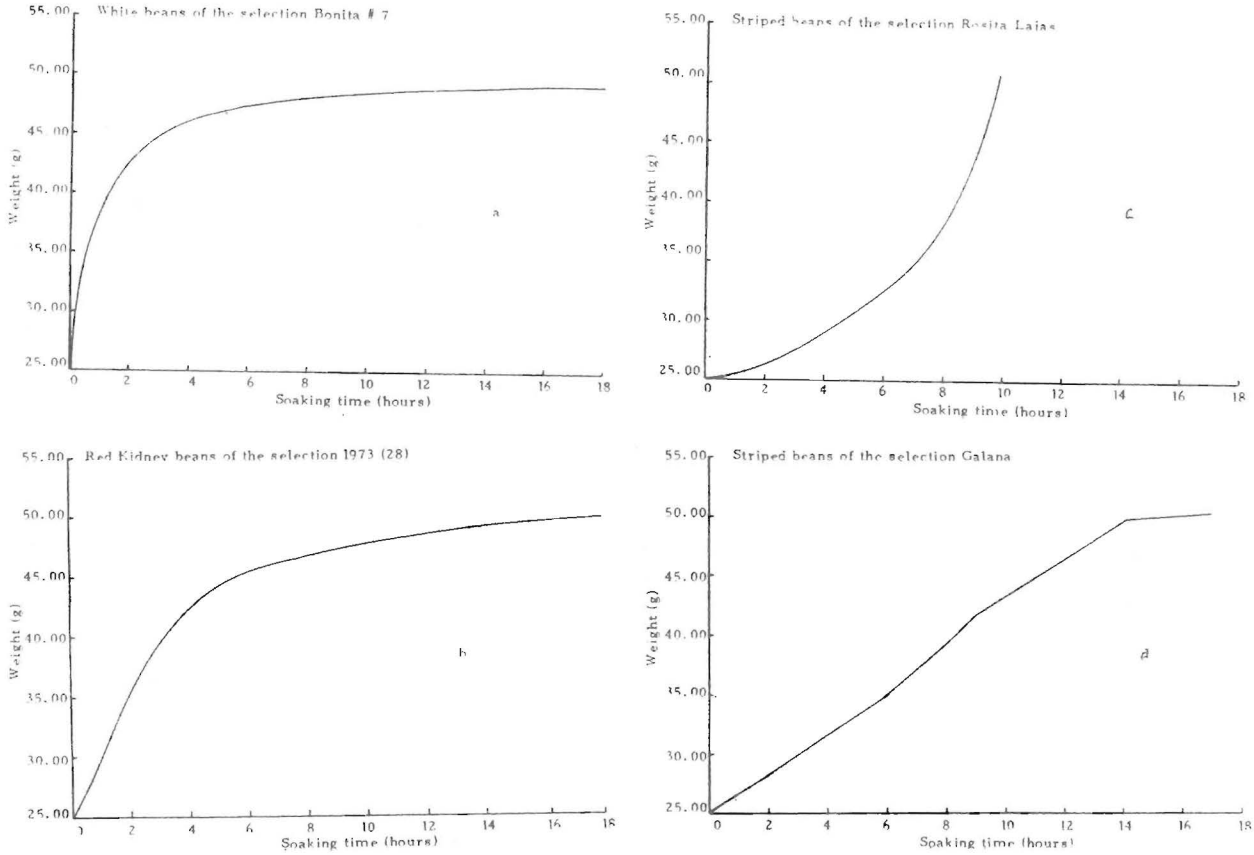

FIG. 1.—Typical hydration patterns of dry bean selections.

Except in Rosita Lajas and Galana selections, hydration was faster at the beginning of the hydration time; then there was a drop to a plateau at the end of this time. In figure 1, *a* and *b* are typical hydration curves for beans of all the varieties studied; *c* and *d* correspond to the hydration patterns of the Rosita Lajas and Galana selections, both of which are Striped beans.

Table 5 shows the results of the sensory evaluations. All samples were found acceptable regarding appearance. Borinquen and Guayamesa,

TABLE 5.—*Sensory evaluation of dry beans*

Class	Selection	Scores[1]			
		Appearance	Flavor	Texture	Overall acceptability
Red kidney	Violeta	4.45 a[2]	4.81	3.64 a b	4.45 a b
	Lajas	3.73 b	4.27	3.00 b	3.73 b
	1973 (28)	5.09 a	4.69	3.45 b	4.36 a b
	27R	5.09 a	4.99	4.45 a	4.82 a
White	Bonita #4	5.13 a	5.24 a	4.56 a b	4.77 a b
	Bonita #7	5.13 a	5.02 a	4.56 a b	4.77 a b
	Bonita #8	4.48 a	5.18 a	3.88 b c	4.09 a b
	Abrams Africa	4.48 a	4.58 a b	3.88 b c	4.09 b
	Cuarentena	4.98 a	5.18 a	5.08 a	5.09 a
	White 142	4.68 a	4.08 b	3.48 b c	3.89 b
	White 117	4.78 a	4.38 a b	3.28 c	3.79 b
	Dominicana #5	4.90 a b	3.90 c	3.19 d	3.57 b c
	Naranjito	5.00 a b	3.90 c	2.86 d	3.46 c
	Pompadour Dominicana	4.64 a b c	4.15 b c	3.40 c d	3.64 b c
	Galana	3.89 d	4.40 b c	3.15 d	3.39 c
Striped	Pompadour	4.51 b c d	4.90 a b	4.02 a b c d	4.39 a b c
	Borinquen	5.26 a	5.02 a b	5.02 a	4.77 a
	Colombia 91 P	4.99 a b	4.53 a b c	4.50 a b c	4.53 a b
	Calima	5.13 a b	5.10 a b	5.07 a	5.10 a
	Rosita Lajas	3.99 c d	4.39 a b c	3.64 b c d	3.53 b c
	Oro Rico	5.01 a b	5.02 a b	4.77 a b	4.89 a
	Guayamesa	5.26 a	5.40 a	5.15 a	5.27 a

[1] 6-point hedonic scale, 6 = like very much, 1 = dislike.

[2] Means followed by one or more letters in common do not differ significantly at P = .05.

Striped varieties, obtained the higher scores, while Lajas, a red kidney variety obtained the lowest score. No significant differences in appearance were observed among white selections.

All selections were also found acceptable regarding flavor (table 5), ranging from between "like" and "like very much" in selections Guayamesa, Bonita #4, #7, and #8. Cuarentena, Borinquen, Calima and Oro Rico scored "neither like nor dislike;" Dominicana #5 and Naranjito scored "like moderately." No significant differences in flavor were observed among samples of red kidney varieties.

The Naranjito selection was slightly rejected on account of texture. Selections White 117 and 142, Lajas, 1973 (28), Dominicana #5, Pompadour Dominicana, and Galana also obtained low scores. Guayamesa, Calima, and Cuarentena selections obtained the highest texture scores (table 5).

All samples were accepted when evaluated for overall acceptability. Texture or mouth feel was one of the most important attributes that contributed to the acceptability of cooked beans. Thus, correlation coefficient (r) between overall acceptability and texture when all beans selections were taken into account was equal to 0.92; thus, 84.64% of the overall acceptability may be explained in terms of texture. The correlation coefficent between overall acceptability and flavor was 0.83, still a significant correlation, but the correlation coefficient between overall acceptability and appearance was nonsignificant ($r = .70$).

When correlation coefficients were calculated for individual varieties the same relationships were observed; that is, texture was the most important attribute contributing to overall acceptability, followed by flavor and finally appearance.

RESUMEN

Se determinó el tiempo que le toma en duplicar su peso a las habichuelas (*Phaseolus vulgaris*) secas de 22 selecciones de las variedades marcadiablo, (colorada) blanca y moteada (localmente denominada galana). La selección Lajas, una variedad marcadiablo, duplicó su peso en 7 h, mientras que las selecciones Calima y Rosita Lajas de la clase moteada duplicaron su peso en 10 h. Las otras selecciones tardaron entre 12 y 18 h.

Todas las selecciones de habichuelas fueron aceptables en apariencia, sabor y aceptabilidad general cuando se guisaron al estilo puertorriqueño y apreciadas sensorialmente usando una escala hedónica de 6 puntos. Las selecciones Lajas y 1973 (28) de la clase marcadiablo, las White 117 y 142 de la blanca y las Dominacana #5, Naranjito, Pompadour Dominicana y Galana de la moteada obtuvieron una evaluación baja en textura, ya que eran un poco duras. Las demás fueron aceptables en ese atributo.

La propiedad que más contribuyó a la aceptación de las habichuelas guisadas fue la textura, con un coeficiente de correlación de 0.92.

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