Determination of Maturity of Frozen Lima Beans

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ABSTRACT

FOUR methods for the determination of the maturity of frozen lima beans were tested and found to be of value. Samples of Henderson's Bush grown in Virginia and of Henderson's Bush and Clark's Bush, an all-green type, produced in New York were used in the studies.

The first method, based on specific gravity, is a modification of that devised for the determination of the maturity of frozen peas. The second method is based on alcohol-insoluble solids. This determination was run directly on the thawed product after suitable sampling without further treatment. The third method is based on total solids.

The first two methods seem to have particular value for this work. It seems likely also that total solids may be used as an index of maturity of frozen lima beans.

Data are also presented regarding the use of the texturemeter for evaluating the maturity of blanched lima beans. It seems possible that this method might lend itself for use within the processing plant for purposes of quality control.

A table of coefficients of correlation is given.

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DETERMINATION OF MATURITY OF FROZEN LIMA BEANS

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INTRODUCTION

THE determination of the maturity and quality of frozen products by means of objective methods continues to grow in importance. It has been recognized (2)[1] for some time that organoleptic methods by a group of tasters are not so reliable as objective tests based on physical or chemical measurements. Furthermore, the selection and training of people to serve on a taste panel is a considerable task (1, 3). In vegetables of the type of lima beans, maturity is one of the dominant characteristics that determines quality.

Early work on this subject carried on in this laboratory included maturity tests for frozen peas (5) and frozen whole kernel corn (8, 9), both based on specific gravity, as well as an objective method for the determination of the toughness of asparagus (6) based on alcohol-insoluble solids. Work on the quality of fresh vegetables intended for preservation by freezing also completed in this laboratory included studies on asparagus and lima beans (4, 7). The tenderometer was used for asparagus and a special tenderometer was used for the lima beans.

An objective test for the maturity of frozen lima beans is in use at the present time.[2] Since it is based on color, it is applicable to beans which turn white as maturity progresses. With the all-green types, the cotyledons of which remain green in all stages of maturity up to and including the seed stage, such a method would encounter difficulties.

PLAN OF THE WORK

Samples of Henderson's Bush lima beans were taken at Exmore, Va., under commercial conditions at the plant of John B. Dulany & Sons in 1940. In 1941, samples were again collected under commercial

[1] Figures in parenthesis refer to Literature Cited, page 12.

[2] Tentative United States standards for grades of frozen lima beans. War Food Admin., Office of Marketing Services. Effective March 15, 1945.

conditions at the plant of Olney and Carpenter, Inc., at Wolcott, N. Y. Again, Henderson's bush was the variety available. In 1942, samples of Clark's Bush, an all-green type, were collected at Wolcott, N. Y.

These samples were blanched in water at 210° to 212° F for 2½ minutes. The beans collected in 1941 and 1942 were put through a brine separator, but the beans collected in 1940 were not so treated.

Several methods that seemed to be of use in the determination of the maturity of this vegetable were studied. Previous work (5, 8) demonstrated that these methods possessed considerable merit in the determination of the maturity of peas and corn, both starchy vegetables. These methods are based on (a) specific gravity, (b) alcohol-insoluble solids, and (c) total solids.

When processors used the Henderson's Bush for the preparation of the frozen product, many of them determined the grade by the percentage of the green beans present in a sample after steaming for about 2 minutes. This method would be of little help if the packer was using the all-green varieties. Some packers have determined the percentage of wrinkled seeds, based on numerical count, following steam treatment; however, this has not been satisfactory.

METHODS STUDIED

Organoleptic tests.—The organoleptic tests were run by groups of qualified, disinterested judges who were uninformed as to the status of the samples until the tests were complete. The samples were rated for maturity on the basis of 1 to 5. Number 1 rating was extra fancy and number 5 was the poorest. One set, in which other values were used, was converted into these figures for uniformity.

Specific gravity.—The samples were thawed overnight at room temperature, or previous to analysis, by setting the packages in front of an electric fan. The frozen beans could also have been removed from the packages, placed in pliofilm bags, and thawed by immersion in water heated to 150° F, as was done in the work on corn (8).

The thawed samples were then plunged into sufficient boiling water to cover them and, when the water returned to boiling, were allowed to boil for 3 minutes. They were then cooled in cold water. Care was taken to make sure that the beans did not come in contact with the air until they were cooled to room temperature. This step is a modification of the method proposed by the author for peas (5). It was found that lima beans under some conditions can hold some of the air

under the seed coat throughout the blanching process. This is especially true of the older beans. This boiling step eliminates all but an insignificant quantity of this air, which, in turn, eliminates a possible source of error. After cooking and cooling, the beans were drained on a screen for 2 minutes, and the specific gravities determined.

The equipment used is a modification of that employed by Nichols and Reed (10), so as to be convenient for the smaller samples of thawed vegetables. However, larger baskets and samples could have been used. A triple beam balance weighing to 0.1 gram can be used. It was set on a stand or shelf and the basket attached to the hook under the pan. The basket used was made from 16-mesh brass screen, 3¼ inches high by 2¼ inches in diameter. The specific gravity of the water was determined by means of a hydrometer or a Westphal balance. The specific gravity of the water can be brought to 1.000 by the addition of a little salt if necessary.

The specific gravity was determined as follows: the basket was weighed in air and in water. One hundred grams of the boiled, cooled, and drained lima beans were used. The beans were then weighed in air. Their weight in the water was then determined by subtracting the weight of the basket in water from that of the basket and the beans in this same liquid. The sample after immersion should be shaken or stirred to remove any air bubbles clinging to the beans before weighing. Care should be taken to have the beans the same temperature as the water in which they are weighed. The following formula is used for calculating the results:

$$\text{Specific Gravity} = \frac{\text{Weight in air}}{\text{Loss of weight in water}}.$$

The data obtained are recorded in Tables 1, 2, and 3.

The coefficient of correlation between specific gravity and organoleptic tests are given in Table 5.

Alcohol-insoluble solids.—This method was originally used for the determination of the maturity of canned peas. Since it has survived as a method to evaluate the maturity of processed peas, it seemed reasonable that it should possess some merit for lima beans, which, like peas, show an increase in substances insoluble in alcohol as they mature. Preliminary tests showed that the canning step is apparently unnecessary for lima beans to obtain good results by this method. The alcohol-insoluble solids was run directly on the thawed products.

The lima beans were thawed and drained as described under specific

gravity. The cooking step, however, is unnecessary. The beans were then ground to a paste in a Wedgewood mortar, so as to secure a uniform sample. In the case of the oldest and hardest beans, it was necessary to resort to the use of a food chopper before grinding in the mortar to obtain well-mixed samples.

Twenty gram samples of the paste were weighed and transferred to 500-ml Pyrex erlenmeyer flasks with 250 ml of 80 per cent ethyl alcohol. The samples were simmered on a steam bath under reflux air condensers for 30 minutes. After this they were filtered on weighed filter papers with the aid of suction, washed with hot 80 per cent ethyl alcohol until white or nearly so, and dried overnight in tared aluminum dishes in an air oven at 95° C. The alcohol-insoluble solids are the total weight, less that of the dish and the filter paper. This figure is multiplied by five to give the percentage of alcohol-insoluble solids. The data obtained are recorded in Tables 1, 2, and 3. The results showed this test to be a good index of maturity, as indicated by the coefficients of correlation given in Table 5.

Total solids.—Total solids were determined by drying 10 grams of sample, ground as described under alcohol-insoluble solids, in the vacuum oven at 70° C for 48 hours.

The determination of total solids gave results that correlated very well with the organoleptic tests on each of three years. It seems possible, therefore, that total solids can be used as an index of maturity of frozen lima beans. The correlation of total solids with other indices is given in Table 5.

Texturemeter.—This instrument was tried on blanched samples only, and for one year only. In 1940, the texturemeter figures on the blanched samples showed a correlation with the corresponding organoleptic tests of 0.9266 ± 0.0243 (standard error). This part of the study was not carried on during the 1941 and 1942 seasons because a texturemeter was not available for use. While a year's work is hardly sufficient to express a final opinion, it does suggest that this instrument may have some value for determining the maturity of the blanched samples for purposes of factory control.

Starch.—Starch determinations were run on selected samples by the method of the Association of Official Agricultural Chemists.[3] It seemed desirable to have further information to compare the two varieties as to stage of maturity. When one goes over the data on

[3] Methods of Analysis. Washington, D. C.: Assoc. Off. Agr. Chemists. Ed. 5. 1940. (Page 359.)

alcohol-insoluble solids, total solids, and the rather limited data on starch, as compared with the organoleptic tests, given in Table 4, it seems reasonable to assume that these two varieties are in similar stages of maturity when the several constants are of approximately the same value. Taste comparisons tend to confirm this conclusion.

DISCUSSION

An inspection of Tables 1, 2, and 3 shows the following figures for the several grades, assuming that these are tentative and subject to revision if the stages of maturity to be packed as fancy are altered:

Grade	Henderson's Bush	Clark's Bush (an all-green type)
	Specific Gravity	
Fancy	Up to 1.104	Up to 1.120
Extra Standard	1.105–1.122	1.121–1.145
Reject	1.123 and higher	1.146 and higher
	Alcohol-Insoluble Solids	
Fancy	Up to 26.5%	Up to 30.0%
Extra Standard	26.6–30.0%	30.1%–35.0%
Reject	30.1% and higher	35.1% and higher
	Total Solids	
Fancy	Up to 30.0%	Up to 34.0%
Extra Standard	30.1%–34.0%	34.1%–39.0%
Reject	34.1% and higher	39.1% and higher

These results show that the packers can use slightly older beans in each grade if the all-green types are used. This is what one would expect because heretofore color has been used as the criterion for the determination of the grade of the product. However, it is known that many people prefer the mature flavor of the older beans, and, therefore, there is little reason that this tendency to pack a slightly older bean should not continue, so long as the bean is not tough or otherwise undesirable.

It seems, also, that the specific gravity is a little more reliable because the results of the work on the Henderson's Bush variety obtained for the 2 years, 1940 and 1941, were slightly more consistent. It is important, also, to bear in mind that these two series of Henderson's Bush beans came from two different states, namely, Virginia and New York. Such differences in growing conditions, perhaps, could have an effect on the final composition of the beans. The dif-

ferences in total solids and alcohol-insoluble solids as seen in these two groups tend to lend support to this idea. The specific gravity method has the advantage of being easy of operation and can be run in a relatively short time.

SUMMARY

1. A method is described, based on specific gravity, for the determination of maturity of frozen lima beans modified from that originally proposed for peas. It appears to be a good index of maturity of lima beans and can be used for the all-green varieties.

2. The alcohol-insoluble solids were determined directly from the thawed beans without further processing, and this method also appears to be a good index of maturity of lima beans and can be used for the all-green varieties.

3. Total solids as a method to be used for the determination of the maturity of lima beans is given consideration and seems to be satisfactory.

4. Data are presented regarding the use of the texturemeter for evaluating the maturity of blanched lima beans in the processing plant.

TABLE 1.—LIMA BEAN MATURITY TESTS, HENDERSON'S BUSH, 1940 SERIES, GROWN IN VIRGINIA.

SAMPLE NO.	SPECIFIC GRAVITY	ALCOHOL-INSOLUBLE SOLIDS, PER CENT	TOTAL SOLIDS, PER CENT	TEXTUREMETER	ORGANOLEPTIC RATING*	FACTORY GRADE
1822	1.051	16.0	18.95	55	1.0	Midgets
1813	1.058	15.5	19.84	—	1.0	Midgets
1853	1.060	17.1	20.28	52	1.0	Midgets
1865	1.062	16.4	19.63	51	2.0	Midgets
1839	1.064	16.5	20.25	52	2.0	Midgets
1833	1.078	16.9	20.28	55	1.3	Midgets
1816	1.086	23.5	27.52	—	2.2	Fancy
1851	1.091	25.3	29.24	82	2.5	Fancy
1862	1.092	23.9	28.57	76	2.0	Fancy
1858	1.092	23.2	28.24	75	2.5	Fancy
1825	1.092	23.4	27.27	74	2.5	Fancy
1857	1.092	23.2	27.30	80	2.5	Fancy
1834	1.094	21.6	26.07	76	2.8	Fancy
1806	1.095	23.6	28.92	—	2.0	Fancy
1849	1.095	23.5	27.23	77	2.5	Fancy
1807	1.097	23.0	27.32	—	1.0	Fancy
1829	1.098	21.8	27.68	74	2.0	Fancy
1830	1.098	23.8	26.60	79	2.0	Fancy
1836	1.098	22.3	28.03	75	2.5	Fancy
1820	1.099	23.0	26.78	72	1.0	Fancy
1809	1.100	23.0	27.08	—	1.0	Fancy
1863	1.100	24.1	27.69	73	2.5	Fancy
1852	1.101	26.1	31.10	105	3.6	Extra Standard
1818	1.102	25.5	28.22	—	3.5	Extra Standard
1814	1.105	24.5	28.65	—	2.5	Fancy
1811	1.105	25.1	31.02	—	3.0	Extra Standard
1826	1.108	23.9	30.24	108	2.8	Fancy
1812	1.108	30.1	33.42	—	4.0	White
1832	1.110	27.4	31.91	104	3.0	Extra Standard
1828	1.113	28.9	32.94	108	3.0	Extra Standard
1819	1.113	27.0	30.82	—	4.0	Extra Standard
1821	1.118	27.7	30.89	110	3.8	Extra Standard
1837	1.119	26.9	31.28	108	3.0	Extra Standard
1861	1.122	29.5	32.89	139	3.8	Extra Standard
1864	1.125	28.3	33.97	115	3.5	Extra Standard
1810	1.126	31.8	33.53	—	4.5	White
1859	1.128	33.3	38.60	143	4.0	White
1850	1.129	31.2	34.14	112	4.2	White
1817	1.130	32.3	36.84	—	4.0	White
1804	1.131	29.9	34.25	—	4.0	White
1815	1.132	33.4	34.43	118	4.0	White
1827	1.133	32.3	35.91	118	4.0	White
1838	1.134	30.1	35.72	118	4.0	White
1866	1.135	32.9	36.53	142	4.0	White
1831	1.136	32.5	35.78	119	4.0	White
1805	1.136	32.4	37.21	—	5.0	White
1835	1.138	33.4	36.31	130	4.0	White

*The samples were rated for maturity on the basis of 1 to 5; No. 1 rating was extra fancy and No. 5 was the poorest.

TABLE 2.—LIMA BEAN MATURITY TESTS, HENDERSON'S BUSH, 1941 SERIES, GROWN IN NEW YORK.

SAMPLE NO.	SPECIFIC GRAVITY	ALCOHOL-INSOLUBLE SOLIDS, PER CENT	TOTAL SOLIDS, PER CENT	ORGANOLEPTIC RATING*	FACTORY GRADE
2130	1.091	25.2	29.92	2.2	Fancy
2178	1.092	23.9	32.17	2.3	Fancy
2183	1.093	24.6	28.05	2.0	Fancy
2158	1.093	25.4	30.02	2.5	Fancy
2146	1.093	26.3	30.83	2.7	Fancy
2125	1.093	24.9	28.96	3.0	Fancy
2149	1.095	25.1	28.72	2.5	Fancy
2159	1.097	25.2	29.57	2.3	Fancy
2135	1.098	25.6	26.96	2.3	Fancy
2175	1.098	25.7	29.63	2.5	Fancy
2170	1.099	25.2	28.00	2.3	Fancy
2174	1.099	25.5	32.05	2.5	Fancy
2185	1.099	26.2	31.14	2.5	Fancy
2191	1.099	25.9	30.34	3.0	Fancy
2138	1.099	25.1	34.06	3.0	Fancy
2127	1.100	27.8	31.43	2.3	Fancy
2157	1.100	24.5	28.98	3.3	Fancy
2129	1.101	27.8	31.78	2.3	Fancy
2182	1.101	23.0	26.29	2.3	Fancy
2171	1.101	26.6	30.11	2.5	Fancy
2153	1.101	26.2	30.25	2.6	Fancy
2169	1.101	25.3	29.73	3.0	Fancy
2150	1.101	26.2	31.19	3.1	Fancy
2167	1.102	26.4	30.40	2.3	Fancy
2193	1.103	27.4	——	2.5	Fancy
2190	1.103	25.2	29.96	2.5	Fancy
2180	1.103	27.9	32.55	2.6	Fancy
2161	1.103	26.4	30.52	2.8	Fancy
2163	1.104	25.2	29.51	2.8	Fancy
2128	1.104	26.2	32.14	3.0	Fancy
2184	1.104	28.1	35.85	3.5	Extra Standard
2181	1.105	26.4	30.71	2.5	Fancy
2160	1.105	28.9	32.63	3.0	Extra Standard
2147	1.107	29.2	33.85	3.2	Extra Standard
2164	1.109	27.9	31.86	3.0	Extra Standard
2156	1.109	29.7	33.27	3.8	White
2165	1.112	30.4	34.05	2.8	Extra Standard
2151	1.113	31.0	35.22	3.0	Extra Standard
2188	1.114	30.4	34.48	3.5	Extra Standard
2155	1.115	28.7	34.93	2.8	Extra Standard
2172	1.115	29.2	33.51	3.0	Extra Standard
2176	1.115	30.6	34.73	3.5	Extra Standard
2148	1.115	31.6	35.38	3.5	White
2173	1.118	31.6	36.44	3.5	Extra Standard
2192	1.119	30.2	35.21	3.5	Extra Standard
2166	1.123	31.8	38.39	4.3	White
2162	1.125	34.2	36.46	3.3	White
2189	1.125	33.1	36.48	4.0	White
2187	1.128	28.5	33.23	3.5	Extra Standard
2179	1.137	——	——	3.8	White
2154	1.138	35.3	39.61	3.3	White
2131	1.139	36.6	42.64	3.5	White
2177	1.144	44.5	51.35	4.8	White
2168	1.151	45.1	53.04	4.8	White
2186	1.154	45.8	53.76	4.8	White
2136	1.158	49.1	57.00	4.8	White
2139	1.161	44.1	51.28	4.5	White

*The samples were rated for maturity on the basis of 1 to 5; No. 1 rating was extra fancy and No. 5 was the poorest.

TABLE 3.—LIMA BEAN MATURITY TESTS, CLARK'S BUSH, AN ALL-GREEN VARIETY, 1942 SERIES, GROWN IN NEW YORK.

SAMPLE NO.	SPECIFIC GRAVITY	ALCOHOL-INSOLUBLE SOLIDS, PER CENT	TOTAL SOLIDS, PER CENT	ORGANOLEPTIC RATING*	FACTORY GRADE
2484	1.104	25.7	30.37	2.3	Fancy
2494	1.105	26.4	31.78	1.5	Fancy
2512	1.108	24.8	30.07	1.9	Fancy
2511	1.110	25.1	30.16	2.0	Fancy
2507	1.113	25.8	31.38	2.0	Fancy
2497	1.113	26.9	32.16	2.6	Fancy
2321	1.113	27.7	30.01	2.0	Fancy
2317	1.113	—	30.42	2.3	Fancy
2479	1.114	27.3	32.60	1.7	Fancy
2482	1.118	28.4	32.33	1.8	Fancy
2510	1.118	29.7	33.59	2.5	Fancy
2481	1.131	29.9	35.02	3.0	Mixed (unseparated)
2492	1.134	33.1	36.67	3.1	Mixed
2480	1.141	32.1	38.27	3.7	Mixed
2493	1.142	33.5	38.75	4.6	Mixed
2318	1.147	38.0	38.75	4.3	Reject
2478	1.148	47.1	55.40	5.0	Reject
2495	1.149	46.6	54.03	5.0	Reject
2152	1.149	48.1	57.30	5.0	Recjet
2508	1.152	47.8	56.25	5.0	Reject
2485	1.157	51.4	60.75	5.0	Reject
2483	1.158	48.7	57.35	5.0	Reject

*The samples were rated for maturity on the basis of 1 to 5; No. 1 rating was extra fancy and No. 5 was the poorest.

TABLE 4.—COMPARISON OF TOTAL STARCH IN LIMA BEANS WITH CERTAIN OTHER FACTORS.

CLARK'S BUSH (ALL-GREEN)					HENDERSON'S BUSH					
Sample No.	Organoleptic rating*	Specific gravity	Alcohol-insoluble solids, per cent	Total solids, per cent	Starch, per cent	Sample No.	Organoleptic rating*	Specific gravity	Alcohol-insoluble solids, per cent	Total solids, per cent	Total starch, per cent
2484	2.3	1.104	25.7	30.37	11.78	2135	2.3	1.098	25.6	26.96	11.89
2494	1.5	1.105	26.4	31.78	13.83	2169	3.0	1.101	25.3	29.73	12.29
2321	2.0	1.113	27.7	30.01	14.02	2128	3.0	1.104	26.2	32.14	13.01
2479	1.7	1.114	27.3	32.60	14.59	2188	3.5	1.114	30.4	34.48	13.70
2315	2.3	1.120	31.8	37.19	14.69	2155	2.8	1.115	28.7	34.93	13.99
2481	3.0	1.131	29.9	35.02	14.92	2173	3.5	1.118	31.6	36.44	15.53
2318	4.3	1.147	38.0	38.75	19.77	2162	3.3	1.125	34.2	36.46	15.67
2495	5.0	1.149	46.6	54.03	24.39	2131	3.5	1.139	36.6	42.64	16.35
2485	5.0	1.157	51.4	60.75	24.66	2136	4.8	1.158	49.1	57.00	22.60

*The samples were rated for maturity on the basis of 1 to 5; No. 1 rating was extra fancy and No. 5 was the poorest.

TABLE 5.—COEFFICIENTS OF CORRELATION.

CORRELATION BETWEEN	COEFFICIENT AND STANDARD ERROR
Season of 1940	
Specific gravity and organoleptic rating	0.8247±0.0461
Alcohol-insoluble solids and organoleptic rating	0.8702±0.0350
Total solids and organoleptic rating	0.8580±0.0381
Alcohol-insoluble solids and specific gravity	0.9458±0.0152
Total solids and specific gravity	0.9507±0.0139
Texturemeter and organoleptic rating	0.9203±0.0266
Season of 1941	
Specific gravity and organoleptic rating	0.8694±0.0323
Alcohol-insoluble solids and organoleptic rating	0.8565±0.0353
Total solids and organoleptic rating	0.8703±0.0330
Alcohol-insoluble solids and specific gravity	0.9496±0.0131
Total solids and specific gravity	0.9261±0.0196
Season of 1942	
Specific gravity and organoleptic rating	0.9627±0.0156
Alcohol-insoluble solids and organoleptic rating	0.9260±0.0304
Total solids and organoleptic rating	0.9120±0.0359
Alcohol-insoluble solids and specific gravity	0.9181±0.0335
Total solids and specific gravity	0.8986±0.0411

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