

Evaluation of
Lima Bean Varieties
for Dehydration .

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EVALUATION OF LIMA BEAN VARIETIES FOR DEHYDRATION ¹

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Present day dehydrated lima beans are not considered to be a satisfactory product. This, coupled with the demand on the part of the Armed Forces for a limited quantity of lima beans which when reconstituted would resemble the fresh product, prompted the Ohio Agricultural Experiment Station to start a project designed to evaluate lima bean varieties and dehydration techniques.

Twelve varieties of lima beans were planted in a Latin square arrangement on June 12, 1951 in the Ohio State University Gardens at Columbus, Ohio. During the growing season the plants were sprayed so that insects and diseases were effectively controlled. Water was applied from the overhead irrigation lines as needed so that the crop did not suffer at any time for lack of moisture.

Harvesting started on August 27 when the earliest variety had reached the optimum stage of maturity for freezing preservation as it was assumed that beans of this maturity would be best for dehydration purposes. Harvesting continued through September 4.

As soon as the beans were harvested they were shelled in a Sinclair-Scott pea and bean sheller. The shelled beans were washed, weighed, blanched in live steam for 5 minutes and dehydrated in a cabinet tray type of dehydrator.

Objective measures of quality were made of the fresh and reconstituted lima beans. These measures included alcohol insoluble solids content (AIS), moisture, number of beans per 100 grams and Texture Meter readings.

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²Taken in part from a thesis by Gordon Peters submitted as partial fulfillment for the M. S. degree.

The methods employed in dehydration included the following:

Method 1.

The fresh, shelled and washed lima beans were blanched in live steam for a period of five minutes. Immediately following the blanching the lima beans were placed in the cabinet dehydrator. The temperature of the dehydrator was held at 220° F. for a period of 1 hour and 20 minutes. The temperature was then cut back to 130° F. in order to finish the drying, which required 8 hours.

The dehydrated lima beans were canned in plain tin upon removal from the cabinet.

Method 2.

The fresh, shelled and washed lima beans were blanched in live steam for 5 minutes. Following the blanching, the lima beans were fast frozen on the dehydration trays at —20° F., then held for 24 hours at 0° F. At this time the trays were placed in the cabinet dehydrator and heated to 230° F. This temperature was maintained for 1 hour, at the end of which time the temperature was lowered to 135° F. for 8 hours in order to finish drying.

The dehydrated lima beans were canned in plain tin upon removal from the dehydrator.

Method 3.

The fresh, shelled and washed lima beans were blanched for 5 minutes in live steam. After the beans were placed in the dehydrator the cabinet was charged with steam to 70 percent relative humidity (wet bulb—184° F., dry bulb—204° F.). After a short pre-heating period the steam was turned off and a stream of dry air was allowed to pass over and through the lima beans for an additional two hours at 204° F. After the drying at the high temperature the temperature was cut back to 140° F. and the drying completed at this temperature which required seven hours.

The lima beans were canned in plain tin immediately after removal from the dehydrator.

Method 2 was slightly superior to method 3 but because the equipment employed in method 3 would more likely be accessible for commercial operations it was decided to employ this method of dehydration for the beans to be evaluated for varietal differences. During dehydration many of the cotyledons of all varieties separated and some cracked. However, upon dehydration the halves usually united.

The triangular evaluation technique was employed by the trained taste panel to evaluate the quality of dehydrated, frozen and canned samples of all 12 varieties.

Results—The yield records of the 5 replicates of all 12 varieties are arranged in Table 1 for statistical analyses.

From the table it is apparent that Fordhook 242, Early Thorogreen, Concentrated Fordhook, Allgreen, Oklahoma 13-1, Henderson and Clarks Bush are superior yielding varieties. The average yield of 11.05 pounds of Fordhook 242 from a 50 foot row would be equivalent to 3,157 pounds of shelled beans per acre. On the other hand the yield of the Emerald variety based on an average yield of 3.34 pounds per 50 foot row would be only 959 pounds per acre. Thus the yields per acre varied from 959 to 3,157 pounds per acre.

TABLE 1.—Statistical Analyses of Total Net Weights of Shelled Lima Beans, Pounds per Plot. Average of 4 Lots. Columbus, Ohio—1951

Varieties	Replicates					Mean
	1	2	3	4	5	
Early Thorogreen	9.25	6.6	11.37	11.35	9.40	9.59
Clarks Bush	7.15	7.81	7.88	8.71	7.31	7.77
Evergreen	3.68	3.97	5.76	6.75	6.43	5.32
Emerald	4.15	3.78	2.68	3.50	2.59	3.34
Greencoat	4.50	6.63	8.25	7.96	6.31	6.73
Allgreen	8.43	9.21	10.21	8.25	7.75	8.77
Oklahoma 8-2	3.46	5.90	7.50	8.84	4.93	6.13
Concentrated Fordhook	8.46	10.08	10.25	10.75	4.81	8.87
Oklahoma 13-1	7.89	10.49	7.84	8.56	7.21	8.39
Fordhook 242	10.75	11.57	10.96	11.46	10.50	11.05
Henderson	7.85	8.16	9.28	6.56	5.87	7.54
Peerless	2.31	3.34	3.62	6.87	6.68	4.58
Mean	6.49	7.29	7.97	8.30	6.65	Gr. Mn. 7.34

Source of Variance	Sums of Squares	Degrees of Freedom	Mean Square	F Value	F.05	F.01
Columns	30.20	4	7.55	4.03	2.58	3.78
Rows	271.10	11	24.65	13.18	2.01	2.68
Error	82.29	44	1.87			
Total	383.59	59				

L.S.D. for rows at 1% level	.466
L.S.D. for columns at 1% level	.34

**TABLE 2.—Percent Sieve Size of Fresh Lima Beans
Columbus, Ohio—1951**

Variety	Picking	Percent of Sieve Size in Inches				
		20/64	24/64	28/64	32/64	40/64
Early Thorogreen	1st	3	68	29	—	—
	2nd	15	70	15	—	—
Clarks Bush	1st	—	—	—	—	—
	2nd	21	68	11	—	—
Evergreen	1st	—	—	—	—	—
	2nd	19	77	4	—	—
Emerald	1st	—	—	—	—	—
	2nd	26	65	9	—	—
Greencoat	1st	—	—	—	—	—
	2nd	31	67	2	—	—
Allgreen	1st	5	69	26	—	—
	2nd	11	59	30	—	—
Oklahoma 8-2	1st	14	79	7	—	—
	2nd	26	63	11	—	—
Concentrated Fordhook	1st	2	3	12	76	7
	2nd	7	8	12	48	25
Oklahoma 13-1	1st	11	84	5	—	—
	2nd	10	81	9	—	—
Fordhook 242	1st	0	1	8	91	—
	2nd	5	5	11	72	7
Henderson	1st	—	—	—	—	—
	2nd	32	68	0	0	0
Peerless	1st	3	6	11	78	2
	2nd	0	20	31	49	—

1st picking of beans was on August 27, 1951.

2nd picking of beans was on September 5, 1951.

The sieve sizes in inches at the green shell stage of maturity for the twelve varieties are shown in Table 2. The largest beans were produced by the Fordhook 242 and Concentrated Fordhook varieties. The smallest beans were of the Henderson variety. The Fordhook 242 variety was more uniform in size than the Concentrated Fordhook.

Table 3 summarizes the objective measures of quality for fresh lime beans. The Texture Meter values are averages of duplicate readings made on the Wiliam F. Christel Texture Meter. The percent A.I.S. values are averages of duplicate determinations made in accordance with the Food and Drug Administration procedure as published in the Food, Drug and Cosmetic bulletin No. 2, Revision No. 1, June 1951

**TABLE 3.—Objective Measurements of Quality for Fresh Lima Beans
Columbus, Ohio—1951**

Variety	Picking	Seeds per 100 grams	Texture meter	Percent A. I. S.	Percent moisture
Early Thorogreen	1st	138	255	31.43	64.28
	2nd	136	300	37.55	54.87
Clarks Bush	1st	—	—	—	—
	2nd	166	300	40.75	52.32
Evergreen	1st	—	—	—	—
	2nd	175	230	32.55	61.87
Emerald	1st	—	—	—	—
	2nd	216	250	33.05	65.32
Greencoat	1st	—	—	—	—
	2nd	160	300	41.30	55.20
Allgreen	1st	136	235	31.30	64.80
	2nd	161	290	36.00	57.02
Oklahoma 8-2	1st	185	190	20.50	65.46
	2nd	172	190	23.30	68.07
Concentrated Fordhook	1st	57	210	25.45	70.80
	2nd	54	210	23.30	69.95
Oklahoma 13-1	1st	160	195	28.85	70.60
	2nd	135	260	35.25	57.22
Fordhook 242	1st	58	190	23.10	72.82
	2nd	57	230	26.45	68.74
Henderson	1st	—	—	—	—
	2nd	176	300	49.35	54.85
Peerless	1st	74	150	22.80	72.02
	2nd	62	200	22.05	71.85

paragraph 51.1. The moisture determinations were made on 100 gram samples using the Steinlite wet cell in accordance with the manufacturers instructions.

From a study of the seed size data (Tables 2 and 3) it is evident that the Concentrated Fordhook, Fordhook 242 and Peerless varieties have very large seed, that Allgreen, Early Thorogreen, and Oklahoma 13-1 varieties have relatively small seed but that the seed of the remaining varieties is still smaller.

A study of the percent moisture, Texture Meter values and percent A.I.S. indicate that Peerless, Fordhook 242, Concentrated Fordhook and the Oklahoma strains are superior insofar as these measures of quality are concerned. The correlations between the three objective measures of quality are shown in Table 4.

TABLE 4.—Correlation Coefficients of Objective Measures of Quality for 12 Varieties of Fresh Lima Beans

Characteristics Correlated	Correlations ("r" values)
1. Alcohol Insoluble Solids vs. Moisture Content (Composite samples of all sieve sizes)	— .875*
2. Texture Meter Reading vs. Moisture (Composite samples of all sieve sizes)	— .886*
3. Texture Meter Readings vs. Alcohol Insoluble Solids (Composite samples of all sieve sizes)	.992*

*Significant at the 1 % level.

The drying ratios and drying yields computed as outlined in U.S.D.A. Misc. Pub. No. 540, of the 12 varieties of lima beans are shown in Table 5. Each lot was dehydrated according to method 3 described earlier.

Beans which had a low moisture content in the green state had a high drying yield and a low drying ratio. Those with a high moisture content in the green stage had a **high drying** ratio and low drying yield.

After approximately six months of storage a panel of seven judges evaluated through triangle tests the frozen, dehydrated, and canned samples of each variety. The data are given in Table 6.

It is interesting to note that in one instance the dehydrated product was deemed superior to the frozen product. In most instances, however, the frozen product was graded above either the canned or dehydrated samples.

TABLE 5.—Drying Ratios and Yields of 12 Varieties of Lima Beans Columbus, Ohio—1952

Variety	Moisture content fresh beans	Moisture content dried beans	Drying ratio	Drying yield
Early Thorogreen	64.28	6.32	2.62	38.17
Clarks Bush	52.32	5.44	1.98	50.05
Evergreen	61.87	6.91	2.44	40.98
Emerald	65.32	6.09	2.71	36.90
Greencoat	55.20	6.36	2.09	47.84
Allgreen	64.80	5.90	2.67	37.45
Oklahoma 8-2	65.46	5.84	2.73	36.63
Concentrated Fordhook	70.80	7.67	3.16	31.64
Oklahoma 13-1	70.60	5.99	3.19	31.35
Fordhook 242	72.82	7.04	3.42	29.24
Henderson	54.85	6.79	2.06	48.54
Peerless	72.02	7.60	3.02	33.11

TABLE 6.—Results of Triangular Taste Evaluation Tests Made on the Products Processed by Canning, Dehydration and Freezing
I—Frozen Green Lima Beans Compared to Dehydrated Green Lima Beans

Variety	Factor	Preference		No difference
		Canned	Dehydrated	
Early Thorogreen	Color	7*	0	0
	Flavor	7*	0	0
	Texture	7*	0	0
Clarks Bush	Color	3	4	0
	Flavor	5‡	0	2
	Texture	5‡	0	2
Evergreen	Color	6*	0	0
	Flavor	6*	0	0
	Texture	6*	0	0
Emerald	Color	8*	0	0
	Flavor	7†	1	0
	Texture	8*	0	0
Greencoat	Color	8*	0	0
	Flavor	7†	1	0
	Texture	7†	1	0
Allgreen	Color	6‡	0	2
	Flavor	6‡	0	2
	Texture	6‡	0	2
Oklahoma 8-2	Color	7*	0	0
	Flavor	7*	0	0
	Texture	7*	0	0
Concentrated Fordhook	Color	7*	0	0
	Flavor	7*	0	0
	Texture	7*	0	0
Oklahoma 13-1	Color	8*	0	0
	Flavor	8*	0	0
	Texture	8*	0	0
Fordhook 242	Color	7*	0	0
	Flavor	7*	0	0
	Texture	7*	0	0
Henderson	Color	4	3	0
	Flavor	5‡	2	0
	Texture	2	5‡	0
Peerless	Color	7*	0	0
	Flavor	7*	0	0
	Texture	7*	0	0

*Significant at the 0.1% level.
†Significant at the 1.0% level.
‡Significant at the 5.0% level

TABLE 6.—Results of the Triangular Taste Evaluation Tests Made on the Products Processed by Canning, Dehydration and Freezing—Continued

II—Frozen Green Lima Beans Compared to Canned Green Lima Beans

Variety	Factor	Preference		No difference
		Canned	Dehydrated	
Early Thorogreen	Color	7*	0	0
	Flavor	7*	0	0
	Texture	2	5‡	0
Clarks Bush	Color	5‡	1	1
	Flavor	5‡	1	1
	Texture	5‡	1	1
Evergreen	Color	6*	0	0
	Flavor	5†	1	0
	Texture	3	3	0
Emerald	Color	8*	0	0
	Flavor	6‡	2	0
	Texture	4	4	0
Greencoat	Color	8*	0	0
	Flavor	5	3	0
	Texture	3	5	0
Allgreen	Color	7†	0	1
	Flavor	6‡	2	0
	Texture	6‡	1	1
Oklahoma 8-2	Color	6†	1	0
	Flavor	6†	1	0
	Texture	6†	1	0
Concentrated Fordhook	Color	7*	0	0
	Flavor	7*	0	0
	Texture	7*	0	0
Oklahoma 13-1	Color	7†	0	1
	Flavor	6‡	1	1
	Texture	4	3	1
Fordhook 242	Color	7*	0	0
	Flavor	7*	0	0
	Texture	7*	0	0
Henderson	Color	2	5‡	0
	Flavor	2	5‡	0
	Texture	3	4	0
Peerless	Color	7*	0	0
	Flavor	7*	0	0
	Texture	7*	0	0

*Significant at the 0.1 % level.

†Significant at the 1.0 % level.

‡Significant at the 5.0 % level

TABLE 6.—Results of the Triangular Taste Evaluation Tests Made on the Products Processed by Canning, Dehydration and Freezing—Concluded

III—Canned Green Lima Beans Compared to Dehydrated Green Lima Beans

Variety	Factor	Preference		No difference
		Canned	Dehydrated	
Early Thorogreen	Color	1	6†	0
	Flavor	4	3	0
	Texture	6†	1	0
Clarks Bush	Color	3	3	1
	Flavor	1	5‡	1
	Texture	1	5‡	1
Evergreen	Color	0	6*	0
	Flavor	4‡	2	0
	Texture	6*	0	0
Emerald	Color	7†	1	0
	Flavor	4	4	0
	Texture	4	4	0
Greencoat	Color	5	2	1
	Flavor	5	2	1
	Texture	7†	0	1
Allgreen	Color	2	6‡	0
	Flavor	4	4	0
	Texture	7†	1	0
Oklahoma 8-2	Color	2	5‡	0
	Flavor	3	4	0
	Texture	4	3	0
Concentrated Fordhook	Color	3	3	1
	Flavor	3	3	1
	Texture	4	2	1
Oklahoma 13-1	Color	1	7†	0
	Flavor	4	4	0
	Texture	6†	2	0
Fordhook 242	Color	5‡	2	0
	Flavor	5‡	2	0
	Texture	6†	1	0
Henderson	Color	2	5‡	0
	Flavor	4	3	0
	Texture	4	3	0
Peerless	Color	4	2	1
	Flavor	3	3	1
	Texture	3	3	1

*Significant at the 0.1 % level.

†Significant at the 1.0 % level.

‡Significant at the 5.0 % level.

SUMMARY AND CONCLUSIONS

The important conclusions that may be drawn from the 1951-52 data on the lima bean dehydration project are as follows:

1. Of the 12 varieties tested the following are superior yielders: Fordhook 242, Early Thorogreen, Concentrated Fordhook, Allgreen, Oklahoma 13-1 and Clarks Bush. The calculated yields per acre varied from 3,200 pounds of shelled beans per acre for Fordhook 242, and 2,792 pounds for early Thorogreen to 973 pounds for the variety Emerald.

2. At the green shell stage of maturity the Fordhook 242 beans were the largest and most uniform with 91 percent of the first picking averaging 32/64" in size. Concentrated Fordhook and Peerless were also of relatively large size. Early Thorogreen was an attractive all green shelled bean with 68% of the first picking in the 24/64" size class.

3. The quality of the raw product, i. e., green shelled beans was measured by means of a Christel Texture Meter, by percent Alcohol Insoluble Solids, and Steinlite moisture content. A Texture Meter reading of over 300 was obtained for at least one harvest of Greencoat and Henderson varieties, thus indicating an undesirable advanced stage of maturity.

A correlation coefficients of .922 was found between Texture Meter readings and AIS values, and .875 between Steinlite moisture content and AIS, thus indicating that these more rapid objective measurements are good indices of raw product quality.

4. Of the several methods of dehydration employed the one which proved most satisfactory for the Early Thorogreen and other varieties was that of blanching and followed by freezing prior to dehydration. It was apparent that the first dehydration could be accomplished with an air temperature of from 180 to 230° F. As soon as the moisture content of the beans had been reduced to a point where cooling by evaporation was no longer an important factor, usually after one hour, the temperature of the air had to be reduced to 140° F. to prevent undue darkening of the product.

No technique was discovered which prevented the separation of the cotyledons and subsequent cracking. However, upon rehydration the halves usually united so that this was not as serious a defect as might appear from an examination of the dried beans.

5. Rehydrated Fordhook 242, Concentrated Fordhook, Peerless and Early Thorogreen were all given a satisfactory evaluation by the taste panel. Early Thorogreen and Evergreen had the best color of dehydrated beans, even better than the canned product from the same lot of beans; however the texture of the dehydrated Early Thorogreen variety was given a very low evaluation. It is not known if this could have been improved by an earlier harvest of less mature beans. It is gratifying to note that the reconstituted dehydrated beans were in several instances rated as good as or even better than the canned samples which came from the same lots of beans in all of the quality factors measured, i. e. flavor, color and texture.