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DIVISION OF RURAL HOME RESEARCH  
AND  
DIVISION OF HORTICULTURE

## LENGTHENING THE STORAGE PERIOD OF CUCUMBERS



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Cucumbers wrapped in a moisture-proof (M. T.) grade of Cellophane took about four times as long to lose 15 per cent in weight as did unwrapped fruits, in common storage. Considering only loss of weight the period of common storage was increased from 1 to 7 weeks. When other factors such as palatability are taken into account, M. T. Cellophane wrapped cucumbers remained in good condition only about 10 days compared with 7 days for those unwrapped. Under refrigeration unwrapped fruits remained in good condition about 10 days and those wrapped in M. T. Cellophane about 14 days. For home refrigerator storage, a ventilated pan was found to be as effective as moisture-proof Cellophane. Lining crates or other containers with moisture-proof Cellophane was found to be as satisfactory as wrapping the individual fruits. Wrappers that retain moisture and thus reduce loss from evaporation tend to favor loss from mold, which disinfecting the cucumbers before wrapping did not control. Results of a number of other treatments are presented.

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## LENGTHENING THE STORAGE PERIOD OF CUCUMBERS

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There are in Texas some 7,000 acres planted annually to cucumbers. It is a localized industry; four counties—Brooks, Jim Wells, San Patricio, and Nueces—produce about 85% of the entire spring crop. In the seven years, 1931-37 inclusive, a total of 2,683,000 bushels were harvested in the state, with a farm value of approximately \$2,560,940. Tendency of the industry to grow in value was well defined; the 1937 crop alone was worth nearly half a million dollars.\*

Practical problems with which both growers and distributors must contend are the marked perishability of fresh cucumbers and the highly seasonal character of the crop. In 1938, shipments of the Texas crop began April 29 and ended June 15. But in eight consecutive days, May 2 to 9, approximately half the shipments were made and one-third of the total was moved in the following eight days. Hence, measures that will preserve the freshness of cucumbers for a period of eight days to two weeks may be of considerable economic value. They may aid greatly in keeping the cucumbers in good condition during transit, especially in the case of long hauls or re-routing to market. They may extend the period during which cucumbers may be offered for sale in the retail market, thus enabling stores to handle them more effectively, and so increase the distribution through smaller stores.

### TESTS MADE

This project, begun in 1933 at Substation No. 19 at Winter Haven in the Winter Garden region of Texas, at first gave attention primarily to marketability; for this reason emphasis was placed on maintenance of fresh weight, turgidity, color, and odor. With extension of the work to College Station in 1935, factors of eating quality—good texture, flavor, and palatability—were given more emphasis. The last data, those of the fifth consecutive season, were collected in the summer of 1937.

Among the treatments giving protection to individual fruits, were wrappers of four grades of Cellophane† (P. T., plain transparent, S. S. T. and S. A. T. intermediate grades; M. T. moisture-proof transparent), waxed paper such as is used for bread; disinfecting with a solution of chlorinated

\*Information on locality, acreage, yield, and farm values was secured through the courtesy of Mr. J. C. Mackey, Division of Crop and Live Stock Estimates, State Department of Agriculture, Austin, Texas; that upon shipments, from Mr. W. D. Googe, U. S. Bureau of Agricultural Economics, Brownsville, Texas.

†Cellophane is the registered trade name of the cellulose film made by E. I. du Pont de Nemours and Company, Inc., who furnished the Cellophane used in these tests.

lime before wrapping in M. T. Cellophane, the stem having been removed from some fruits during harvest but not others; spraying with paraffin. In bulk storage of unwrapped fruits protection was afforded by the container,—a refrigerator humidifier (covered and slightly ventilated enamel pan, standard equipment with a mechanical household refrigerator), or a shipping container (bushel size wood crate, half-bushel splint basket, or corrugated paper carton) lined with moisture-proof Cellophane. Places of storage were an open shelf in the laboratory (room temperature), a ventilated pantry (somewhat lower than room temperature), and electric refrigerators regulated as for household use (35° to 40°F.). In each place where individually wrapped fruits were stored, unwrapped ones were used as controls.

The specific treatments are shown in the following list:

Wrapping	Disinfecting	Container	Place of Storage
(1) None	None	None	Laboratory shelf
(2) None	None	None	Pantry shelf
(3) None	None	None	Refrigerator
(4) None	None	Humidifier	Refrigerator
(5) None	None	Bushel basket	Laboratory floor
(6) None	None	Shipping containers lined with M. T. Cellophane	Refrigerator
(7) P. T. Cellophane	None	None	Laboratory shelf
(8) S. S. T. Cellophane	None	None	Laboratory shelf
(9) S. A. T. Cellophane	None	None	Laboratory shelf
(10) M. T. Cellophane	None	None	Laboratory shelf
(11) M. T. Cellophane	None	None	Pantry shelf
(12) M. T. Cellophane	None	None	Refrigerator
(13) Waxed paper	None	None	Laboratory shelf
(14) Waxed paper	None	None	Refrigerator
(15) Paraffin spray	None	None	Laboratory shelf
(16) M. T. Cellophane	Chlorinated lime	None	Laboratory shelf
(17) M. T. Cellophane	Chlorinated lime, stem removed	None	Refrigerator
(18) M. T. Cellophane	None	Bushel basket	Laboratory floor

Fig. 1 illustrates the method of wrapping and the appearance of wrapped and unwrapped fruits after one day in storage. Twisting the wrapper tightly at each end of a fruit served to hold it in place during subsequent handling. The fruits were not sealed in the wrappers; usually there was an air passage where the edges of wrappers overlapped. In Fig. 2 are shown the containers of suitable size for shipping lined with moisture-proof Cellophane held in place by strips of Scotch drafting tape.

The cucumbers stored at Winter Haven were grown in that locality either on the Substation farm or by a commercial producer. All of the wrapped cucumbers stored at College Station and most of the unwrapped, were shipped from the Substation; the remainder were grown on the Main Station farm at College Station. The same field in the Winter Garden region supplied the fruits for storage at both Winter Haven and College Station in any one of the three seasons when storage was done at both places.

Fruits from a varietal trial of cucumbers at the Substation were used the first season, but each variety was equally distributed through all treatments. Only two varieties, Early Fortune and Kirby Stays Green, equally distributed, were employed the second season. Thereafter but one variety, either Kirby Stays Green or Early Fortune was used any season, with the possible exception of some mixing in the commercial seed used.

In all cases the fruits were weighed, labeled, and placed in storage as promptly as possible; locally grown fruits were stored within a few hours after harvesting. Fruits prepared at Winter Haven for storage at College Station were shipped by express on the day of harvesting and were received at College Station some 48 hours later. They were promptly reweighed individually and placed in storage.

In each storage period, the cucumbers handled individually were weighed at frequent intervals—at Winter Haven daily as they neared 90%, and again as they neared 85% of original weight; at College Station fruits were weighed every other day for the first two weeks, and thereafter twice weekly until they were considered unsalable and for this reason discarded. In 1937, the fruits stored in shipping containers at College Station were weighed by the same schedule as was used there for the individual fruits.

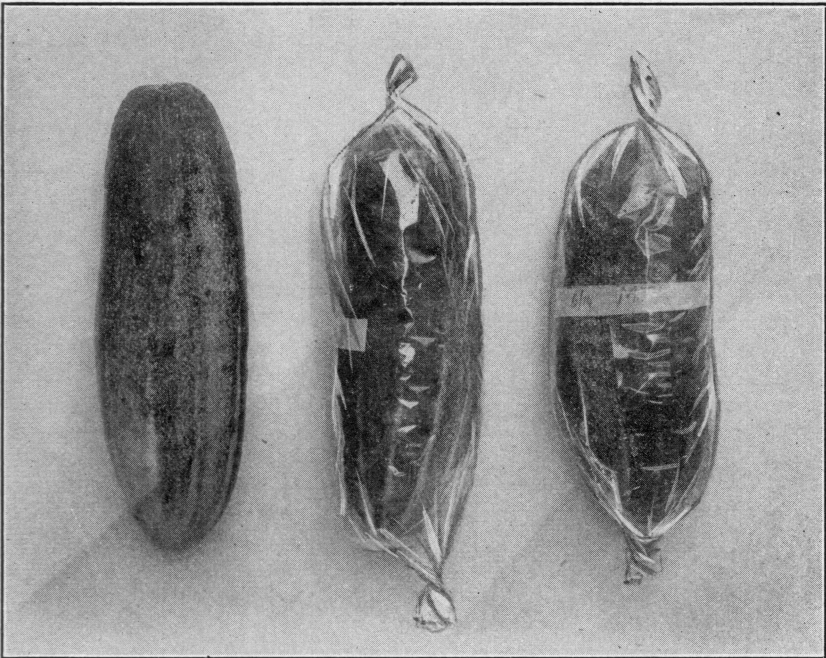


Fig. 1. Appearance of wrapped and unwrapped cucumbers one day after placing in storage on laboratory shelf. Left, unwrapped; middle, wrapped in plain transparent cellophane; right, wrapped in moisture-proof cellophane. Note condensation of water on the inner side of the moisture-proof cellophane wrapping, but not within the plain transparent cellophane.

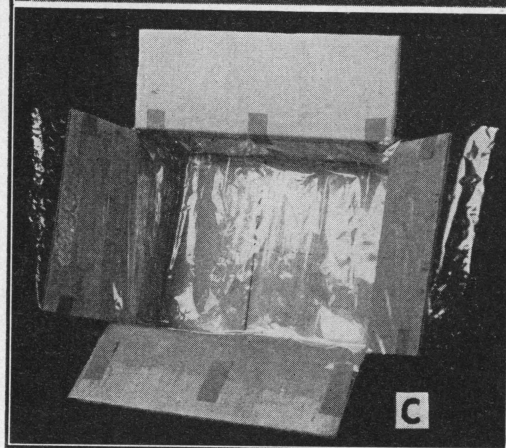
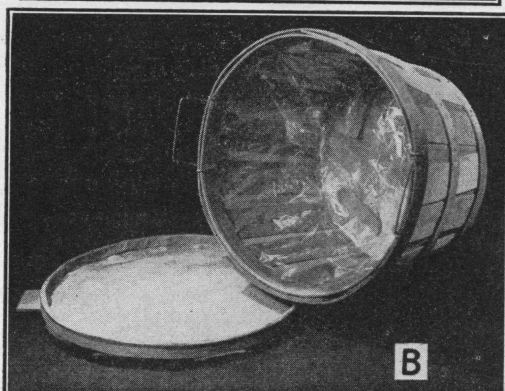
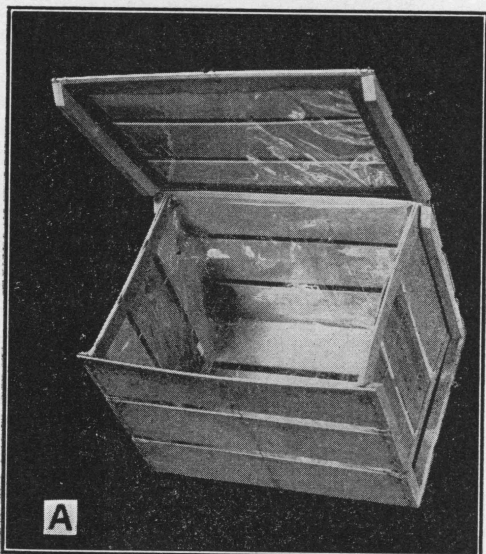


Fig. 2. Containers lined with moisture-proof cellophane, suitable for shipping fresh cucumbers.

A. Standard wood crate, bushel size.

B. Splint basket, half-bushel size.

C. Corrugated paper carton used originally for shipping glass fruit jars.



At Winter Haven in the same year all the fruits in a given treatment were weighed as one lot, in most instances every other day, but a few times after an interval of 3 to 5 days. Sample fruits from each treatment were taken from time to time for tasting and judging the several points of quality desired by producer, distributor, and consumer.

## RESULTS

### Loss in Weight

The first tests at Winter Haven showed that unwrapped fruits which had lost 15% of their original weight were usually unfit for use, and some had a decided lack of turgidity which made them unsalable. Therefore, a loss of 15% in weight was made the basis for discarding fruits at the Substation, and record was kept to determine when they had lost only 10% in weight. At College Station, fruits were discarded when they were considered in unsalable condition regardless of what the loss in weight might be, or how long they had been in storage.

### Time for Individual Cucumbers to Reach 90 Per Cent and 85 Per Cent of Original Weight

A report of the work in the first two seasons, when tests were made only at Winter Haven, has been published elsewhere (2). The relationship between loss in weight and the time which elapsed during that loss for each of four seasons at Winter Haven is shown in Table 1. In Table 2 are recorded the mean temperature and relative humidity during the months in which the cucumbers were in storage. From the figures in Table 1 it is apparent that the plain transparent (P. T.) Cellophane and the intermediate grades of this material (S. S. T. and S. A. T.) were but little if any better in maintaining weight than no wrapper at all. The average time for unwrapped fruits and for those in plain transparent and for either of the intermediate grades of Cellophane to reach 90% of original weight was 3 to 5½ days. But in moisture-proof transparent (M. T.) Cellophane approximately 5 to 12 times as long was required to effect a similar loss. The average time in three seasons for the M. T. wrapped fruits to reach 90% weight level was 50 days. The high efficiency of M. T. Cellophane wrappers for maintaining weight was thus demonstrated. Disinfecting alone, and after removal of the stem during harvest in M. T. Cellophane (M. T. D. and M. T. D.—stem) extended this period to 59.6 and 63.8 days respectively. Paraffin spray and also waxed paper, each tried two seasons, gave an average of only 19.2 and 22.2 days respectively for comparable results. These two treatments while much more effective for maintaining weight than were the plain and intermediate Cellophanes were much inferior to wrappers of M. T. Cellophane.

Most fruits in losing weight from the 90% to the 85% level required more than half as much time as for the loss to 90% of original weight. Obviously, the rate of moisture loss decreased somewhat as the storage period lengthened.

**Table 1. Summary of time for individual cucumbers in the various treatments to reach 90 per cent, then 85 per cent of their original weight without decaying (Stored on laboratory shelf at Winter Haven)**

Treatment*	1933		1934		1935		1936		Average 1933-1936	
	Days to reach 90 per cent									
	Range	Av.	Range	Av.	Range	Av.	Range	Av.	Range	Av.
Unwrapped			2-7	4.2	2-23	6.2	3-9	5.9	2.3-13.0	5.4
P. T.			2-6	3.2						
S. S. T.			3-8	4.9						
S. A. T.			3-8	5.2						
Paraffin Spray					7-65	30.2	4-12	8.2	5.5-38.5	19.2
Waxed Paper			9-36	18.4	15-33	26.0			12.0-34.5	22.2
M. T.			18-38	26.3	65-88	72.7	35-71	51.0	39.3-65.6	50.0
M. T. D.					45-83	67.1	38-66	52.2	41.5-74.5	59.6
M. T. D.—Stem					56-83	72.3	44-70	55.3	50.0-76.5	63.8
Days to reach 85 per cent										
Unwrapped	2-10	5.0	3-14	8.2	3-49	13.6			2.7-24.3	8.9
P. T.	3-11	5.1	3-10	5.0					3.0-10.5	5.0
S. S. T.	5-14	7.8	5-13	7.5					5.0-13.5	7.7
S. A. T.			6-11	7.8						
Paraffin Spray					18-96	42.1				
Waxed Paper			14-54	32.8	26-65	40.0			20.0-59.5	36.4
M. T.	18-42	26.4	26-50	34.6	74-103	88.5			39.3-65.0	49.8
M. T. D.					61-91	76.0				
M. T. D.—Stem					74-103	88.5				

\*P. T. means plain transparent Cellophane.  
S. S. T. and S. A. T. are intermediate Cellophanes,  
Waxed paper, such as is used for wrapping bread,  
M. T., moisture-proof transparent Cellophane,  
M. T. D., disinfected before wrapping in moisture-proof Cellophane,  
M. T. D.—Stem, moisture-proof Cellophane wrapper after removal of stem and disinfecting.

**Table 2. Mean outside temperature\* and relative humidity at Winter Haven during months in storage periods**

Month	1933		1934		1935		1936	
	Temp.	R. H.	Temp.	R. H.	Temp.	R. H.	Temp.	R. H.
May			79.0	60.4	78.5	67.5	76.6	75.2
June	83.4	55.7	86.9	54.1	81.7	76.8	85.4	65.4
July	88.2	60.1	87.2	59.2	85.2	66.7	85.5	64.4
August					86.4	61.5		

\*Observations on several occasions indicated that the temperature in the laboratory was 5° to 6° F. lower than outside. Doors and windows of the laboratory were open during all daylight hours permitting free circulation of air.

The small differences in mean relative humidity and mean temperature during the months in which the storage periods fell in the different years (Table 2) do not appear to be related to the differences in length of time required to make the stated losses. Laboratory doors and windows were left open during all daylight hours permitting a free circulation of air. Observations on several occasions indicated that indoor temperatures were usually 5 to 6 degrees lower than outside.

### Loss of Weight by Individual Cucumbers During Storage of Two Weeks and Three Weeks

All losses of weight in cucumbers stored at College Station were calculated as percentage of the net weight at the time of placing in storage. For cucumbers grown at College Station, fresh weight at harvest and net weight at storage were the same. But for fruits shipped from Winter Haven, the net weight at storage was less than the weight at harvest by the amount of the loss of weight in transit. This loss in transit was exceedingly small for all treatments using M. T. Cellophane (seven lots), the average losses ranging from 0.19% to 0.42% of the individual weight. Fruits wrapped in waxed paper (one lot) showed an average loss of 0.94% during transportation. Such losses are regarded as negligible. Unwrapped fruits (nine lots) while in transit lost on the average in the three seasons from 2.15% to 3.98% of weight.

The total lengths of storage periods at College Station in the three successive seasons were 39, 41, and 30 days for fruits handled individually. But for comparison of loss of weight in the different treatments, two shorter periods of time were chosen. Two weeks is about the upper limit of time that the fruits in the most successful treatments were rated good to excellent in eating quality; beyond three weeks eating quality ratings were considerably lowered and deterioration occurred rapidly in features of quality other than weight. Storage periods of 13 to 15 days, and of 20 to 22 days were chosen therefore, and calculations of losses were made for all fruits held through the longer period. Data collected at Winter Haven in 1933 and 1936 upon fruits in M. T. wrappers permitted making calculations similar to those for cucumbers stored at College Station. Table 3 summarizes results on loss of weight in a given time, for the two most effective treatments of individual fruits, as compared with their controls.

A very conspicuous feature of these results is the small losses (ranging from 1.5% to 6.9% during two weeks in storage) by all the wrapped fruits and by the unwrapped ones in the refrigerator pan (humidifier) in contrast to the much larger losses (range 6.9% to 15.0%) by all other unwrapped fruits. At three weeks, the comparison is 2.3% to 7.7% loss for ten of eleven lots of the wrapped fruits and the unwrapped in refrigerator pan, against 10.5% to 19.5% for unwrapped fruit on the laboratory shelf, in the pantry, and on the refrigerator shelf. For a given treatment tried more than once, the results are fairly consistent. The difference between the losses in 1936 of fruits grown at Winter Haven for storage at College Station and those grown at College Station while probably significant appears greater than it really was because weight at storage, two days subsequent to harvesting, was the base for Winter Haven fruits, while weight at harvest was the base for College Station cucumbers. Adding to the losses for Winter Haven fruits the loss in transit of these lots, (2.63% for those on the laboratory shelf, 3.98% for those in the pantry) would bring total losses much closer together. Loss of those from Winter

Haven stored on the laboratory shelf would still be a little less (12.73% vs. 15.01%), but of those stored in the pantry slightly more (13.96% vs. 12.87%) than of those grown at College Station and stored under comparable conditions.

Table 3. Effect of storage on weight of cucumbers  
(Fruits weighed individually)

Year	Conditions of storage	Place grown	Place stored	Number of fruits	Av. net wt. at storage	Av. loss in storage as % of net wt.		Av. Temp.
					Grams	14 or 15 days	21 or 22 days	
Unwrapped								
1936	Laboratory shelf	W H*	C S*	28	285.8	10.10	13.28	87.6
1936		C S	C S	14	253.3	15.01	19.53	87.6
1937		W H	C S	16	321.4	13.75	18.38	89.7
1936	Pantry	W H	C S	28	280.2	9.98	13.20	69.4
1936		C S	C S	17	217.2	12.87	16.29	69.4
1935	Refrigerator shelf	W H	C S	19	292.1	6.94	10.48	38.3
1936		W H	C S	21	271.4	10.61	15.17	41.6
1937		W H	C S	30	323.1	9.36	15.25	40.1
1935	Refrigerator pan (humidifier)	W H	C S	13	263.8	3.32	4.84	38.3
1936		W H	C S	7	309.8	3.18	3.99	41.6
1937		W H	C S	7	319.8	2.95	4.37	40.1
Wrapped in moisture-proof transparent (M. T.) Cellophane								
1933	Laboratory shelf	W H	W H	21	214.5	6.94	10.82	88.1 <sup>†</sup>
1936		W H	W H	25	341.9	...	3.63 <sup>†</sup>	84.7 <sup>‡</sup>
1936		W H	C S	35	309.1	4.90	7.49	87.6
1937		W H	C S	8	328.2	5.08	7.67	89.7
1936	Pantry	W H	C S	25	269.9	3.12	4.60	69.4
1935	Refrigerator shelf	W H	C S	39	273.2	3.75	5.88	38.3
1936		W H	C S	32	288.6	1.53	2.30	41.6
1937		W H	C S	21	344.2	3.60	5.88	40.1

\*W H=Winter Haven; C S=College Station.

<sup>†</sup>Stored 20 days.

<sup>‡</sup>These are outside temperatures.

Fruits wrapped in M. T. Cellophane lost roughly one and one-half times as much one season and three times as much another season when stored on the laboratory shelf as when held in the refrigerator the same length of time. But the effect of refrigeration was less consistent with respect to the unwrapped fruits. One season, the loss of those on the laboratory shelf and of those in the refrigerator was the same after two weeks in storage, the next season, less for those in the refrigerator. At the end of three weeks' storage, losses by the unwrapped fruits in the refrigerator were in one season more, in the next less, than with unwrapped ones on the laboratory shelf. These inconsistencies in the loss of weight of the unwrapped cucumbers stored elsewhere than in the humidifier are in contrast to the more consistent losses of those in the humidifier and in the M. T. Cellophane wrappers.

The very similar results obtained with cucumbers in M. T. wrappers on the refrigerator shelf, and unwrapped fruits in the refrigerator pan is noteworthy. Unwrapped fruits in the refrigerator pan lost slightly less weight in two out of three seasons than did fruits in M. T. wrappers on a shelf of the same refrigerator. The humidifier may be especially recommended to the housewife and individual wrappers of moisture-proof Cellophane along with refrigeration may serve either in commercial use or in the home, to prolong the freshness of cucumbers.

With treatments tested at College Station other than the three included in Table 3 and discussed in the foregoing paragraphs, results were secured in line with those in comparable tests at Winter Haven, although difference between treatments in the refrigerator (College Station tests) were smaller than those at room temperature (Winter Haven tests). M. T. Cellophane proved a somewhat more efficient wrapper than waxed paper for fruits stored in the refrigerator, loss of weight in waxed paper (one season) after two weeks storage being 4.6% and after three weeks 6.8% in contrast with a range (three seasons) of 1.5% to 3.8% in two weeks and 2.3% to 5.9% in three weeks for the fruits in M. T. Cellophane. Disinfecting had no effect on loss of weight in the tests at College Station, losses being 1.9% at two weeks, 2.8% at three weeks storage compared with losses of 1.5% and 2.3% by fruits not disinfected.

#### Cucumbers Weighed in Bulk

Only in 1937 were stored cucumbers weighed in bulk. At Winter Haven two treatments were used—unwrapped, and M. T. wrappers on individual fruits. Both were stored in bushel baskets in the laboratory. The unwrapped fruits after being held for 19 days lost 28.6% of their original weight, whereas those in the M. T. Cellophane at the end of 31 days had lost only 17.6% of their original weight.

The primary object of the bulk weighing tests at College Station was to determine the practicability of M. T. Cellophane-lined containers for shipping cucumbers under refrigeration. This test was suggested by the success with the refrigerator pan for storing unwrapped fruits. All packed shipping containers, (Fig. 2) and the refrigerator humidifier as a control, were held at an average temperature of about 40°F. Results with the several containers were essentially the same. The weight losses are illustrated by those observed for the lined crate and the refrigerator pan. After storage for 22 days, the fruits in the pan had lost only 2.5% of their original weight. After 9 to 15 days storage (time variation due to the necessity of piecemeal packing) those in the crate had lost 1.2%, and after 19 to 25 days, the loss was but 1.8%. Preservation of weight of unwrapped cucumbers in containers lined with M. T. Cellophane was as good as of the fruits wrapped individually.

## Other Changes Affecting Salability

### Decay and Mold

In contrast to the excellent maintenance of weight by moisture-proof wrappers, was the greater readiness with which the fruits in them decayed. This was noted each season and for fruits under all conditions of storage. After a period of three weeks, decay was especially marked with M. T. Cellophane whether or not the fruits were disinfected before wrapping. Of the 25 fruits in M. T. Cellophane wrappers stored yearly at Winter Haven, the number decaying before weight was reduced to 90% of original, was for five consecutive seasons 3, 2, 21, 11, and 9. This variation is probably due to differences in rainfall around the time of harvest. The precipitation was light the first two seasons, heavy the last three. The number of the disinfected fruits, both with and without the stem, decaying was 18 out of 25 the third season (the first time of trial for these treatments), and 13 out of 25 the next year. The humid condition inside the wrappers no doubt encourages decay. Water of condensation within the M. T. Cellophane wrappers (Fig. 1) was usually visible for some 20 days. No decay in unwrapped fruit ever occurred at Winter Haven during the period of the experiment and in but very few of them stored at College Station on the laboratory shelf and in the ventilated pantry. Unwrapped fruits in the refrigerator pan and in the containers lined with M. T. Cellophane withstood decay for about 20 days. Mold usually appeared also at the time signs of bacterial attack were noted.

Although moisture-proof Cellophane and the humidifier did afford conditions favorable to the growth of bacteria and mold, deterioration caused by these organisms did not occur before other changes which made the fruits unacceptable had taken place. Hence the observations regarding decay and mold in no way change the recommendation of the use of M. T. Cellophane and the humidifier for preserving the freshness of cucumbers.

### Yellowing

One of the most consistently occurring changes in stored cucumbers was yellowing of the outside in certain of the treatments. In the tests at College Station, at the time of discarding the fruits, either tiny yellow spots or larger yellow areas were noted on most of them both wrapped and unwrapped and not stored in the refrigerator. But in the refrigerator there were only a few fruits that did not retain good color for from three to four weeks. Considerable difference in respect to yellowing was noted at Winter Haven between wrapped and unwrapped fruits. In the 1937 season, for example, only 12½% of the wrapped fruits, but 52% of the unwrapped, yellowed within 14 days. At College Station the same year, a few of the M. T. wrapped fruits on the laboratory shelf showed the first indication of yellow at 14 days, but only one of the M. T. wrapped fruits in the refrigerator yellowed even up to the time of discarding at

28 days. Delay of yellowing is an important advantage of refrigerating fruit.

### Effect of Storage on Eating Quality

#### Method of Judging

Sample fruits of every treatment both at Winter Haven and College Station were tasted at intervals. Observations at Winter Haven were in the nature of an over-all judgment of palatability while those at College Station dealt with the several qualities individually. Four aspects of quality—turgidity (firmness), texture (crispness and tenderness), flavor, and palatability (flavor, texture, turgidity, odor, considered together) were rated independently by each of six judges using a score card especially devised for the purpose. Color, salability, and edibility were not given a score but each judge recorded his observations on these items. The predominating color inside and outside was noted and any departure from the judge's idea of normal color was mentioned. Salability was considered to be no departure from normal shape, color, odor, and firmness that would prevent the cucumber being bought in the market. Edibility was thought of as being fit to be eaten, whether or not the fruit was more or less pleasing to the palate. Results are illustrated by data obtained in 1937.

#### Time During Which Different Treatments Held Cucumbers in Good Condition

Of the 37 fruits from Winter Haven judged, from 5 to 9 were in each treatment. These fruits had been in storage for periods ranging as follows: in M. T. Cellophane wrappers,—on the laboratory shelf 3 to 25 days, on the refrigerator shelf 1 to 29 days; unwrapped,—in the refrigerator pan 3 to 16 days, on the refrigerator shelf 1 to 29 days, on the laboratory shelf 3 to 25 days. Only 9 of the entire number were in storage more than 14 days. Hence, three-fourths of those stored were judged within the period in which, according to previous findings, more fruits in acceptable condition were to be expected.

The summary of results pertaining to preservation of quality in these fruits is given in part in Table 4. The data were inspected to determine the greatest number of days any fruit in each treatment remained in good condition. The criterion of "good condition" on the qualities scored was an average of better than two-thirds of the perfect score; that on qualities not scored, unanimous agreement of the judges or not more than one of them dissenting. With very few exceptions, *all* the fruits in each treatment were in good condition up to the number of days shown in Table 4. In general, the fruits judged at the next longer storage period showed a distinct drop in acceptability. The data in Table 4 readily show that the most consistently effective treatment was storage of unwrapped fruits in the refrigerator pan, all qualities having remained in "good condition" for 16 days. A treatment nearly as effective was individual

wrappers of M. T. Cellophane and storage in the refrigerator, with turgidity good for 18 days and other qualities for 14 days.

The longest preservation of turgidity and salability, 25 days, was in the fruits in M. T. Cellophane on the laboratory shelf. But this treatment had the poorest record for preserving palatability. Not one of the six fruits judged had a rating of "good." This treatment showed the greatest irregularities of any in the length of period of good condition in the different qualities.

Table 4. Number of days stored cucumbers remained in good condition\*  
(Grown at Winter Haven, stored at College Station, 1937)

Qualities judged	Wrapped in M. T. Cellophane		Unwrapped		
	Laboratory shelf	Refrig. shelf	Refrig. pan	Refrig. shelf	Laboratory shelf
	(days)	(days)	(days)	(days)	(days)
Turgidity.....	25	18	16	10	14
Texture:					
Solid portion.....	10	14	16	10	7
Seed portion.....	5	14	16	29	7
Total texture.....	10	14	16	16	7
Flavor.....	10	14	16	10	10
Palatability.....	.. †	14	16	10	3
Color.....	18	14	16	16	12
Salability.....	25	14	16	10	12
Edibility.....	18	14	16	18	10
Total "good-condition-days"....	121	130	144	129	82

Range of loss in weight, per cent

	0.8 to 3.3	0.7 to 2.7	1.9 to 3.3	0.9 to 7.8	2.2 to 9.9
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\*Good condition for turgidity, texture, flavor, and palatability means that the average score was better than two-thirds of the possible (perfect) score; and that in the unscored qualities—color, salability, and edibility—fruits were considered normal by all judges or not more than one dissenting.

†Highest score 12.4 at 5 days storage.

The unwrapped cucumbers on the refrigerator shelf held up in all qualities for at least 10 days. Unsalability was due chiefly to marked wrinkling which was characteristic of this treatment. Except for turgidity, color, and salability, unwrapped fruits on the refrigerator shelf were preserved in corresponding qualities as well as, or better than, fruits in M. T. Cellophane on the laboratory shelf.

Aside from turgidity, refrigeration extended the period of "good condition" in scored qualities by 4 to 14 days with the fruits in M. T. Cellophane and by 3 to 19 days in unwrapped fruits with the one exception of equally long (10-day) preservation of flavor in two fruits, one on the laboratory shelf, the other on the refrigerator shelf.

The total number of "good-condition-days" for each treatment (Table



4) emphasizes the advantage to be gained by wrapping fruits in M. T. Cellophane or placing them in the humidifier under refrigeration.

#### Changes in Factors Affecting Quality During Regularly Lengthened Periods of Storage

As shown by scores. The 84 cucumbers grown at College Station were left unwrapped and were divided equally for storage between the covered pan and the shelf in the refrigerator. Twenty of the fruits were tasted fresh, after having been in the refrigerator only about 4 hours, just long enough to be well cooled. The remainder were held for storage of 2 days or successive multiples thereof up to 14 days inclusive. Table 5 presents the comparative results of the two treatments in these systematically graduated storage periods.

The highest possible score for turgidity was 9, for texture, flavor, and palatability each 18. Bitterness was very prevalent in these cucumbers and accounts for the low flavor and palatability scores of the fresh cucumbers as well as for the same scores on the two treatments at 10 days storage. Table 5 shows the better preserved condition of the fruits in the refrigerator pan with respect to all considerations for storage of 4 days and more. Loss of weight of those in the pan ranged from 1.2% of original at 4 days to 2.2% at 12 days, and so turgidity remained practically perfect throughout storage; whereas for those on the refrigerator shelf for from 2 to 12 days there was a gradual loss of weight from 4.7 to 18.8% and consequently a reduction of turgidity rating from 8.3 to 2.8 points. In texture, fruits in the pan were practically as good as fresh up to 10 days, and exclusive of the influence of bitterness, nearly as good in flavor and palatability. There was a much greater decrease in eating quality of the fruits stored 12 and 14 days on the shelf than in those in the pan.

The changes in weight and in eating quality of the cucumbers in four treatments at College Station in 1937 are illustrated graphically in Fig. 3 and Fig. 4. In Fig. 3 the data from the 37 fruits grown at Winter Haven and stored at College Station were used. Each point located represents a single fruit with two exceptions—the data were averaged for the two fruits in M. T. Cellophane judged after being in the refrigerator 8 days and for the two unwrapped fruits on the laboratory shelf 7 days. In Fig. 4 the 84 fruits grown and stored at College Station are represented. The results were averaged for the 20 fresh fruits, and also for the number (2, 4, or 6) in each storage period. The trend of the lines in these graphs indicates the efficiency of both the humidifier for unwrapped cucumbers and moisture-proof Cellophane wrappers for individual fruits, along with refrigeration, to prolong the freshness of cucumbers for about two weeks.

The appearance of fresh cucumbers compared with some stored 4 days, others 15 days, in the refrigerator pan and on the refrigerator shelf respectively, may be noted in Fig. 5. Excellent turgidity was characteristic of those in the pan. Wrinkling of those on the shelf was noticeable at 2 days and by 12 days was sufficient to make the fruit hard to peel.

Table 5. Effect of storage on quality of cucumbers (Grown and stored at College Station, 1937)

	Total number fruits	Av. loss in wt. % of net	Number salable	Number edible	Average Scores†											
					Turgidity	Texture	Flavor	Palatability								
Fresh fruits																
	20	0.00	19	13	8.95	16.9	13.2	12.2								
Fruits stored in refrigerator																
No. days stored	Pan	Shelf	Pan	Shelf	Pan	Shelf	Pan	Shelf	Pan	Shelf	Pan	Shelf	Pan	Shelf	Pan	Shelf
2	4	4	1.26	4.74	4	4	2	1	8.8	8.3	14.7	14.6	8.2	8.7	6.8	7.2
4	4	4	1.15	6.89	4	3	4	2	8.95	6.5	16.2	15.8	14.1	11.3	12.6	9.8
6	6	6	1.26	11.23	6	3	3	1	8.8	5.3	13.5	13.3	9.0	7.8	7.8	6.2
8	6	6	1.62	13.32	6	4	4	5	8.6	5.1	15.1	13.9	11.5	10.9	10.2	8.7
10	4	4	1.82	13.95	4	2	2	2	8.7	4.9	15.1	13.2	7.9	7.8	6.0*	6.0*
12	6	6	2.22	18.84	6	0	2	1	8.4	2.8	12.8	9.4	7.9	4.6	5.3	2.8
14	2	2	2.02	17.70	2	0	1	0	8.6	3.4	11.4	9.6	8.9	4.9	6.3	2.8
	32	32														

†Of 6 judges. Perfect score: for turgidity = 9, texture, flavor, palatability, each = 18.

\*Bitterness was the chief cause of objection to 3 in the pan and 1 on the shelf having low scores.

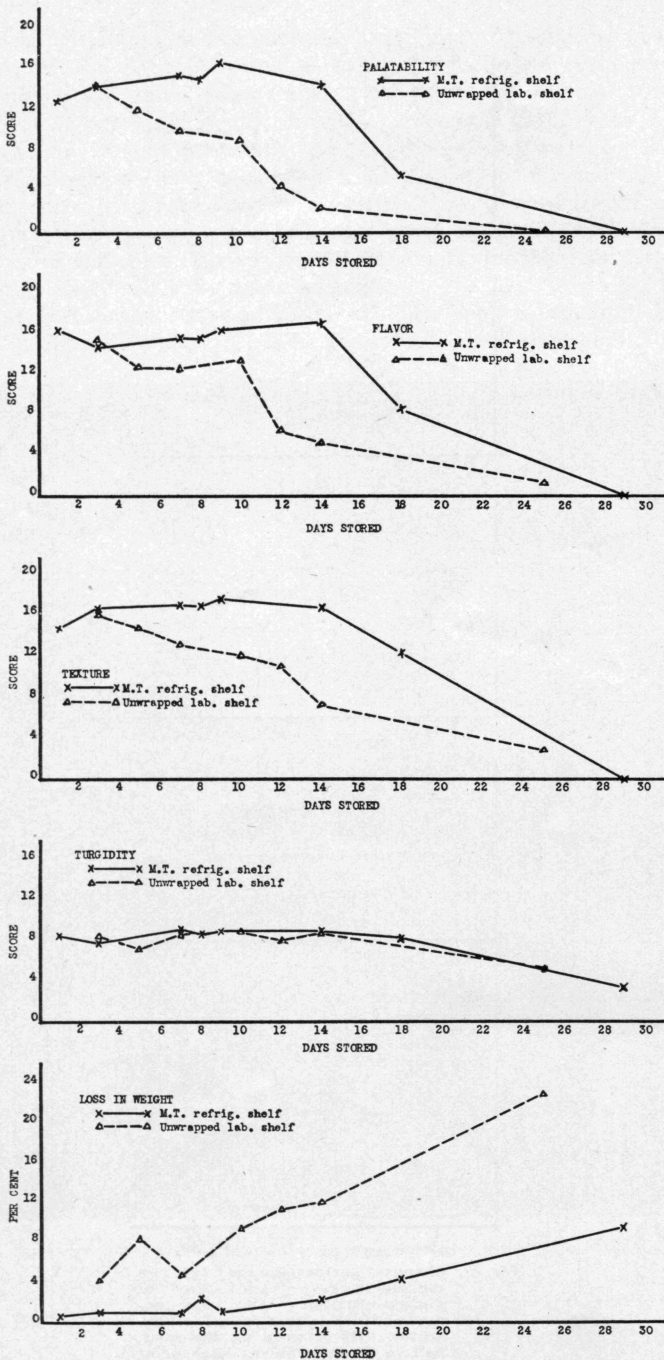


Fig. 3. Changes in cucumbers during storage, 1937. Cucumbers grown at Winter Haven and stored at College Station. Each point located on the graphs represents one fruit except the average of results with two fruits at one storage period in each treatment—7 days for those on the laboratory shelf and 8 days for those wrapped in M. T. Cellophane and on the refrigerator shelf.

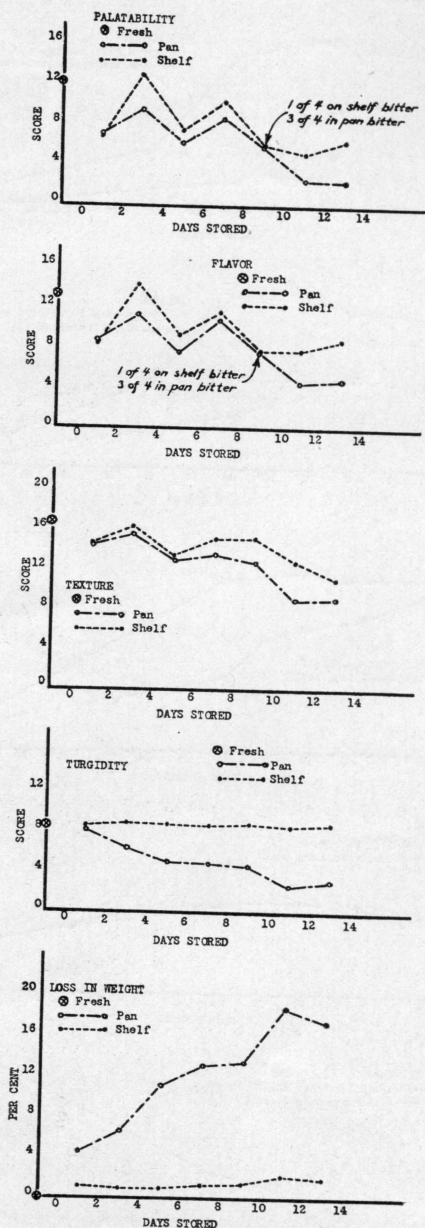


Fig. 4. Changes during storage, 1937, in cucumbers grown and stored at College Station. All were unwrapped and stored in the refrigerator, half of them on the shelf, half in the humidifier. Each point on the graph represents the average for the number of fruits judged, 20 fresh, and 64 stored—2, 4, or 6 at each storage period.

That loss in weight is not directly associated with eating quality so long as fruits are desirable at all is evident in both the cucumbers from Winter Haven and those from College Station (Tables 4 and 5). With the latter, the scores of fruits on the refrigerator shelf were as good for texture, flavor, and palatability at 10 days storage when the loss was 13.9% of original as at 2 days with a 4.7% loss. The range of loss of weight in three of the treatments of fruits from Winter Haven is practically the same, and the other two treatments resemble each other; but differences in the time during which the fruits in the five treatments remained in good condition are clear cut.

Lack of correlation between rating of odor and palatability is noteworthy. Although many of the fruits with low palatability scores,

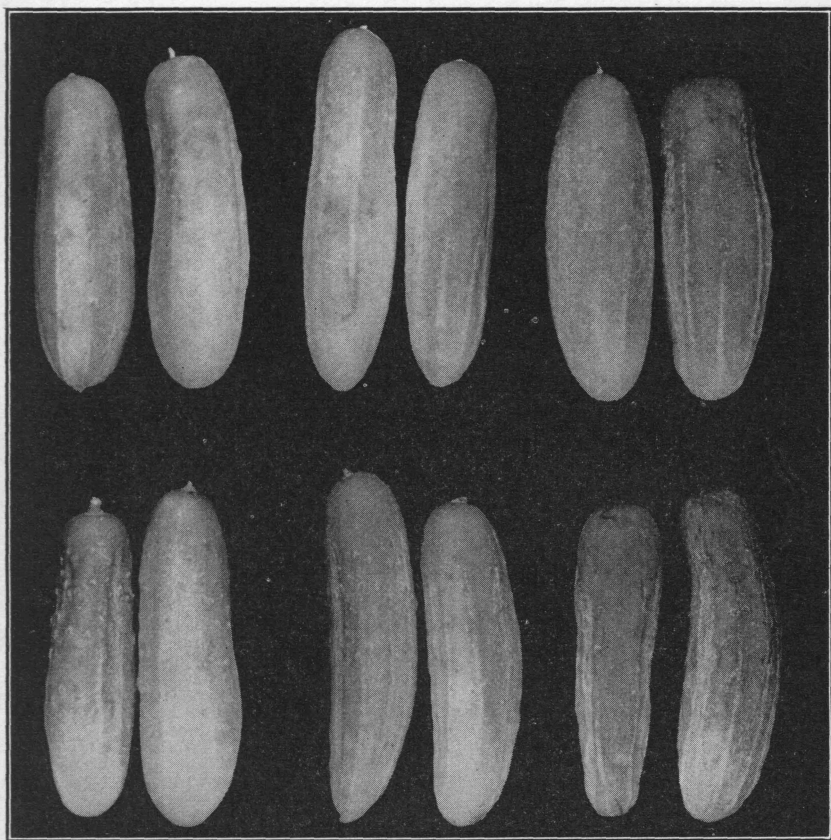


Fig. 5. Appearance of fresh cucumbers (left) compared with fruits stored 4 days (middle) and 15 days (right). Fruits stored in refrigerator pan, top row; on refrigerator shelf, bottom row. Note the similarity of all fruits in top row and the wrinkling, especially marked at 15 days, of those stored on the refrigerator shelf.

especially those stored long periods had a low rating on odor, this was not consistently so. A number of fruits with high palatability had low odor rating, and high odor rating sometimes accompanied a low palatability score.

As shown by total number of objections by judges. A summary was made of the frequency in use of adjectives to describe the judges' objections to the fruits which were rated in 1937. The data for the cucumbers from Winter Haven were inspected critically to determine at what point in storage, if any, the number of objections separated the more acceptable from the less acceptable fruits taken as samples. The time limits for few objections as distinguished from many objections for the several treatments were: M. T. wrapped—on refrigerator shelf 18 days, on laboratory shelf 10 days; unwrapped—in the refrigerator pan 16 days (no fruit receiving many objections), on the refrigerator shelf 10 days, and on the laboratory shelf 10 days. It will be noted that refrigeration made no difference in the number of objections to unwrapped fruits outside of the pan. For the cucumbers grown and stored at College Station, the average frequency of use of each adjective was determined for the fruits in each storage period of the two treatments. Marked increase in the number of objections to turgidity, texture, and flavor was found for the fruits stored 12 and 14 days either in the refrigerator pan or on the refrigerator shelf. The well marked increase in the number of objections to all of the longer-stored cucumbers shows that with sufficiently long storage, originally turgid cucumbers became progressively limber, soft, and spongy; a once crisp and tender solid portion became soft, spongy, and pithy, or rubbery; a tender gelatinous seed portion became watery and slimy or sometimes dry, and the pleasant characteristic flavor of a fresh fruit was replaced by one distinctly stale and queer, or possibly either too mild, or too intense, or by a bity flavor. Bitterness when present was no worse after longer storage than shorter. Nothing in the appearance of the fruit gave forewarning of the bitterness; only tasting detected it.

On the whole, the findings based on the use of objections are in close agreement with those employing numerical scores. Both approaches show that wrapping the fruits individually in moisture-proof Cellophane and placing them unwrapped in a humidifier under refrigeration are equally good methods of preserving fresh cucumbers. Both descriptive terms and scores indicate that under these treatments fresh cucumbers remain in quite good condition in *all aspects* of eating quality for from 8 or 10 days to 2 weeks.

No detailed scoring was done on the fruits stored in bulk in the containers lined with moisture-proof Cellophane and held in the refrigerator, but their external condition was noted at the times of regular weighing and, when discarded, several of the fruits were tasted by two of the regular judges. Using those in the crate as example, at 9 to 15 days of storage, out of 90 fruits all but 6 which by accident were frosted in the

refrigerator, appeared to be in excellent condition. When discarded, after 19 to 25 days of storage all were salable but a few which had a very little mold or bacterial growth. The turgidity was good and the color good except for slight yellowing of a very few. The seed portion was becoming watery. The few fruits tasted were rated fair in palatability.

Similar results with the use of moisture-proof Cellophane wrappers have been obtained by the Georgia Experiment Station (1) with fresh asparagus and by Stahl and Fifield (3) with citrus fruit in tests at the Florida Experiment Station. The Florida workers also found the moisture-proof lining of containers to be as efficient in preserving quality as the individual wrappers.

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### SUMMARY AND CONCLUSIONS

In this study extending over five seasons, cucumbers grown at Winter Haven and at College Station have been stored for varying periods of time.

Out of eighteen treatments tried, three were found equally satisfactory for preservation at once of weight, color, turgidity, texture, flavor, and palatability of cucumbers held in storage at 40°F. In one treatment the fresh cucumbers were wrapped individually in moisture-proof Cellophane; in another packed unwrapped in large light-weight wood or corrugated paper containers lined with moisture-proof Cellophane; in the third the unwrapped fruits were placed in a refrigerator humidifier. For at least 8 to 10 days these methods kept cucumbers practically as good as fresh and up to 2 weeks quite acceptable though not all of them were in excellent condition. Since cucumbers constitute a decidedly seasonal crop, satisfactory methods of preserving freshness may have considerable value to producer, distributor, and consumer. Use of moisture-proof Cellophane as individual wrappers or liners in shipping containers may be recommended for commercial purposes; the refrigerator humidifier for use in the home.

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