maintenance of quality of prepackaged CRANBERRIES during retail display

maintenance during retail

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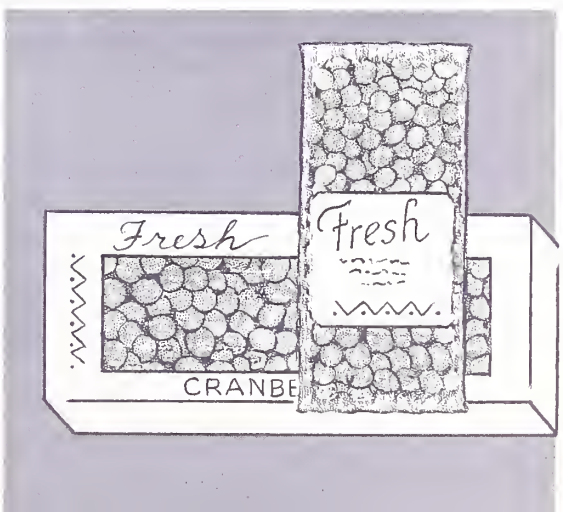

PREFACE

Acknowledgment is due R. E. Hardenburg, P. H. Heinze, and J. M. Lutz, of the Agricultural Marketing Service, for their help in planning this research. E. J. Koch, of the Agricultural Research Service, collaborated in evaluation of the data. Clyde McGrew and G. T. Beaton, of the National Cranberry Association, compiled an essential field history of the cranberries used.

This study on maintenance of quality of produce in retail food stores is part of a broad program of continuing research aimed at reducing the cost of marketing farm products.

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MAINTENANCE OF QUALITY OF PREPACKAGED CRANBERRIES DURING RETAIL DISPLAY

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SUMMARY

Cranberry sales may be seasonal and limited in volume partly because high quality berries are not offered for longer market periods. Storage studies have shown that cranberry quality can be maintained for long periods of time, but satisfactory storage evidently is unusual in commercial practice. Other surveys have suggested that retail handling of cranberries can be improved. To this end, nine retail display methods were studied under controlled conditions to determine causes of fruit quality loss.

Consumer packages from each retail method were examined at intervals of 3, 8, 14, and 21 days. Determinations were made of weight losses, shrivelling, and decay, in two types of commercial packages, and over three replications of the experiment.

All losses increased with time, under all methods of display, in both boxes and bags. The amount of loss differed, however, with the display method, the length of time the cranberries were held before and during display, and the position of the package in the display. Losses were slightly greater in cellophane bags than in window boxes and losses were half as much with refrigeration as without it. Losses under the different methods varied from 6 to 10 percent by the end of 3 days and reached 15 to 51 percent in 8 days. Total losses for 21 days under the best method (cranberries kept in mechanically refrigerated case continuously) and the poorest method (nonrefrigerated continuously) amounted to 44 and 87 percent, respectively.

On the basis of this study, retail display methods for cranberries are recommended in the following order: (1) Mechanically refrigerated case continuously; (2) false rack in mechanically refrigerated case continuously; (3) nonrefrigerated counter in daytime, 40° F. room at night; (4) crushed-ice display continuously; and (5) nonrefrigerated counter continuously.

Suggestions are made how to retard loss of quality and to increase sales.

All data are statistically evaluated.

INTRODUCTION

Fresh cranberries account for an estimated annual sales of $10 million by our Nation's retailers (6, 36); and the demand is slowly growing, as indicated by the increase in production, shown in figure 1.[1] It is possible that this growth has not been more rapid partly because cranberries have been offered only during the autumn and early winter months (27), and partly because the quality of berries has not always been acceptable to the consumer.

A small survey in one of our larger cities during 1957 showed that all interviewed retailers were displaying cranberries without refrigeration. Where cranberries had been on display for more than 2 days, several customers sorted through the packages and finally turned away without making a purchase. In the instances observed, it appeared that cranberry sales were limited because the quality was unsatisfactory. Had high quality cranberries been displayed, many more purchases probably would have been made.

[1] Underscored figures in parentheses refer to Literature Cited, p. 18.

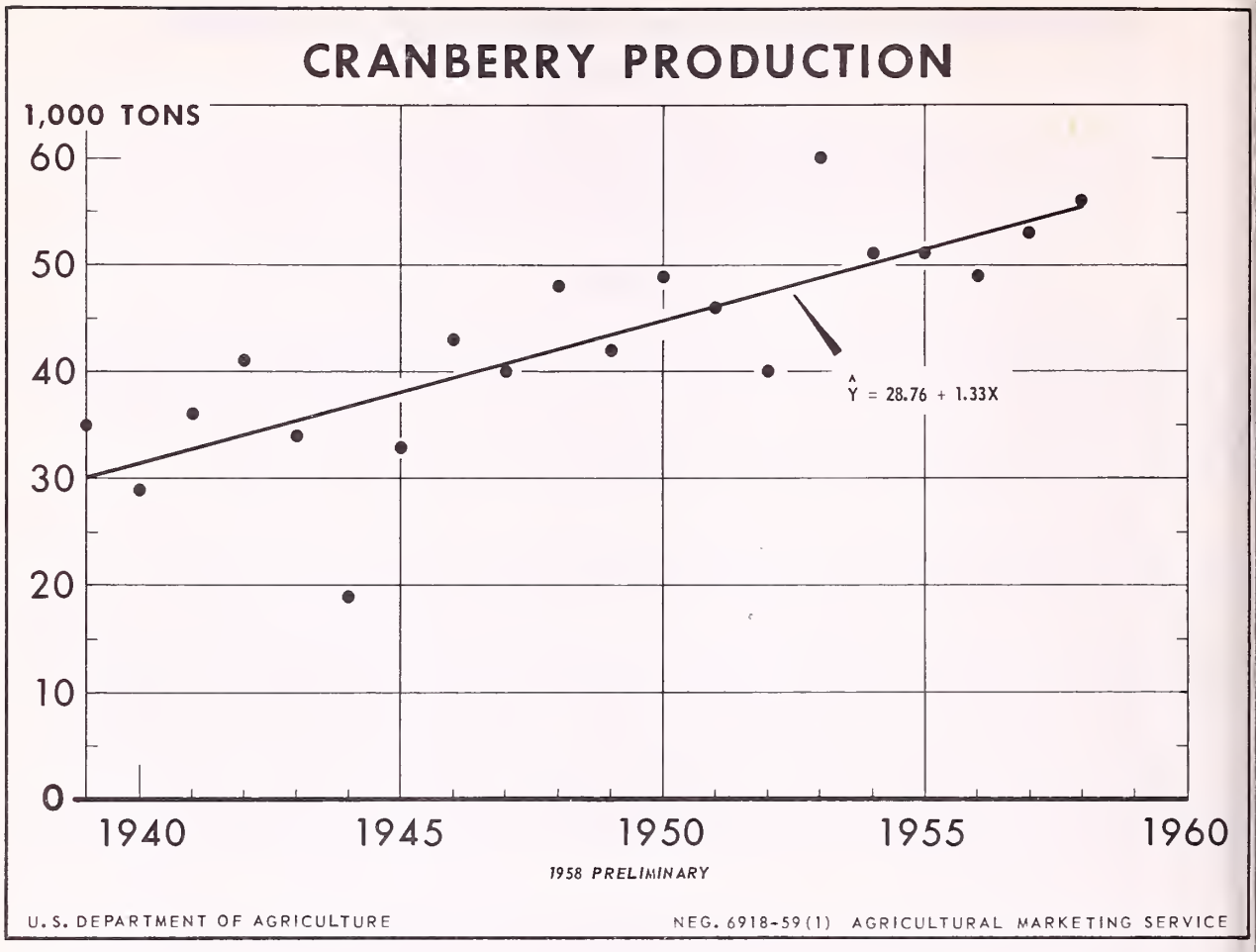

Figure 1

Approximately 55 percent of the cranberries produced in the United States are processed (6, 36). This could indicate that a longer market period of high quality fresh cranberries might be welcomed by the consumer. A longer market period would require continued observance of good growing and transportation practices (2, 4, 7, 8, 10, 16). It would require that the produce be stored and displayed at favorable temperature, relative humidity, and ventilation. Much data are available on these storage conditions for cranberries (6, 12, 13, 16, 18, 20, 24, 30).

Hruschka and Kaufman (13, 14, 15) have indicated that the quality of prepackaged Early Black and Late Howes cranberries may be maintained fairly well for 8 or more weeks when stored at 36° to 38° F. and at a relative humidity of 70 to 75 percent. Goldenfield (11), Hayes, Fellers, and Esselen (12) have reported similar results. Wright, Demaree, and Wilcox (37) reported that cranberries were preserved in a marketable condition for 4 months at 36° F. Ringel and Kaufman (25) found prepackaged cranberries 95 percent salable after 14 weeks at 40° F. There seems little doubt that more favorable holding conditions at grower, wholesale, and retail levels would result in better cranberries.

No study has been published on the shelf life of packaged cranberries under varied retail display methods. This information has been needed as a further step toward higher quality produce and increased retail sales. This report is concerned with a retail display study made at the Plant Industry Station at Beltsville, Maryland.

MATERIALS AND METHODS

A total of thirty-four 1/4-barrel boxes of Late Howes variety cranberries were received at Beltsville in 3 shipments, 10 boxes in November and 12 each in December 1957 and January 1958. The berries had been harvested the first week in October and then stored commercially at one location in Massachusetts. The shipper stated that the berries had been screened and sorted under less careful supervision than would be commercial practice; but the berries were termed average quality. The 3 shipments came from the same bog and were handled similarly, except that the storage periods varied because of the spaced shipments. The berries were shipped in unventilated nonrefrigerated trucks. The transit time varied from 2 to 6 days.

The cranberries of each shipment were thoroughly mixed and carefully graded. Grade A or better berries were weightd into 1-pound window boxes and 1-pound cellophane bags.[2] The boxes were folded stock of 022-gauge white patent-coated paper, with 10 slotted vents along the bottom edges. The windows were 100-gauge cellulose acetate (fig. 2). The bags were 450 LSAD (semi-moistureproof) cellophane, with four 1/4-inch vents on one side. The ends and one side were heat sealed (fig. 3).

From each of the 3 shipments, 24 or more packages of berries were displayed under each retail method given in table 1. Each lot was displayed for 21 days. All displays were maintained 2 packages high in each case throughout the experiment. The display surfaces were made equal in area by use of dummy blocks. Figure 4 illustrates the arrangement of the displays.

The cases varied from 5 to 8 feet long, but all were approximately the same width and height above the floor. All displays were in the same room with the temperature automatically maintained at 70° to 72° F. The relative humidity of the room varied from 40 to 50 percent and was not regulated. Air within the room was kept in motion at all times to equalize atmospheric conditions. A hygrothermograph provided a continuous check upon the room temperature and relative humidity. Previous tests proved the displays were affected uniformly by these controlled conditions.

Thermocouples for temperature measurements were taped in place, as shown in figure 5, in both bags and boxes, and in both layers of packages. Except in the packages which received 40° refrigeration at night, the thermocouples were left in place during the 21-day period of each test. However, the packages containing the thermocouples were shifted within the cases each morning. The thermocouple temperatures were recorded automatically each 10 minutes by an electronic potentiometer (fig. 6). Temperatures were measured both within the fruits and within the air of the packages. To indicate any occurrences of power failures which might influence mechanical refrigeration temperatures and the operation of the potentiometer, a recording thermometer was kept in one of the display cases at all times.

At intervals of 3, 8, 14, and 21 days, for each of 3 replications[3], 4 bags and 4 boxes of cranberries were randomly selected from each method of display for shelf-life tests. These tests concerned net weight loss, shrivelling, and slight and severe decay of the berries.

The net weight loss was determined to the nearest gram per package. Shrivelling and decay were determined by count. Shrivelling was any obvious wrinkling of the berry surface unaccompanied by visible decay. Decayed fruit was defined as that which contained discernible defects other than shrivelling which would affect salability of the produce. All berries of questionable quality were bisected longitudinally. If the cut surface showed 25 percent or less decay, the berry was classed as slightly decayed; if more decay than this was present, it was classed as severe. If the fruit was both shrivelled and decayed, it was classed as decayed fruit. Berries with physiological breakdown were

[2] The packages averaged 391.9 ± 1.5 berries each.

[3] In this paper, "replication" means that the test or experiment was repeated additional times with additional test materials. The replications were approximately one month apart.

Figure 2.--Type of commercial box used in all experiments. Ten vents are located near points A and B on the longer bottom edges of the box.

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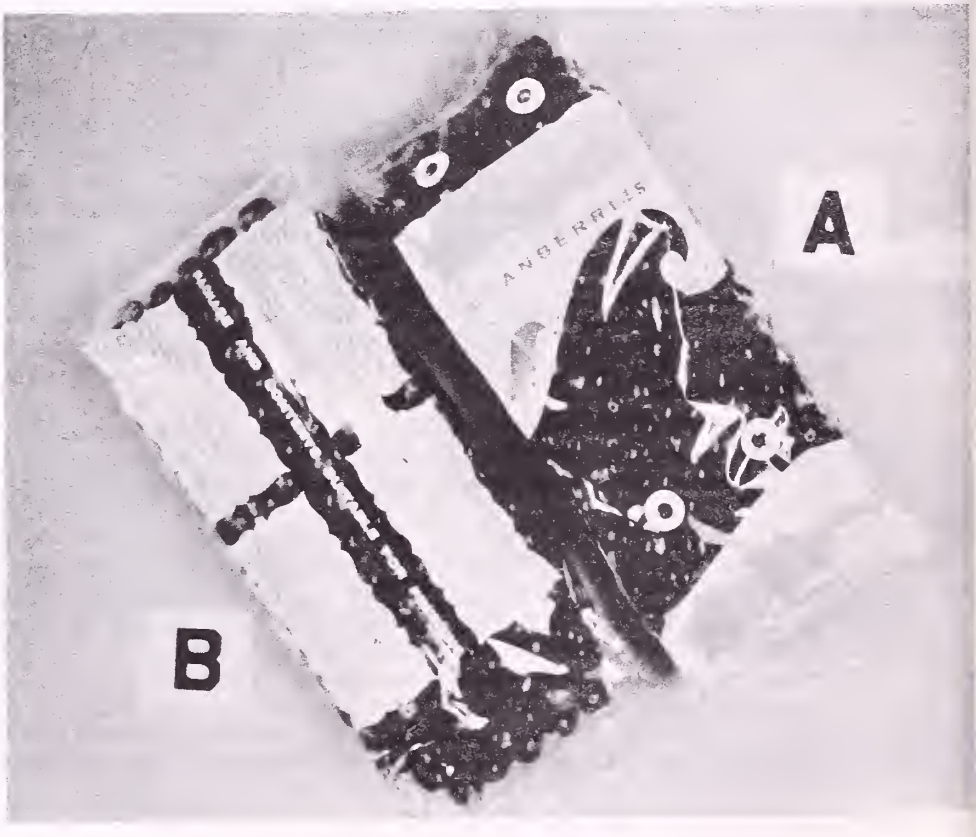

Figure 3.--Type of commercial bag used in eight of the display methods. The vents on side A are outlined in white to show their locations. There were no vents on side B.

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Table 1.--Retail methods and temperatures under which cranberries were displayed

Package type	Method of display	Average temperature[1]
		°F.
Box	Nonrefrigerated continuously	70.5 ± 0.2
Bag	Same	70.6 ± 0.2
Box	Nonrefrigerated from 8 a.m. to 6 p.m., and then stored overnight at 40°	62.2 ± 0.3
Bag	Same	62.0 ± 0.3
Box	Ice-bed continuously, with the packages separated from the ice by one sheet of 0.005-inch thick kraft paper	49.6 ± 0.3
Bag	Same	51.6 ± 0.2
Box	Displayed continuously in mechanically refrigerated case, set to give a temperature of 38° F. at lower surface of display	49.9 ± 0.2
Bag	Same	51.7 ± 0.1
Box	Same, but with the boxes displayed on a false rack 5 inches over the regular rack	50.7 ± 0.1

[1] Temperature ranges within packages during the experiment. See figure 5 for location of thermocouples within the packages.

placed in the severe decay class. Figure 7 illustrates these classifications of damage. An additional 10 percent of the berries of each inspection were bisected as a supplementary check upon the sample.

Approximately 1,590 berries from each of the 9 methods of display were examined at the first 3-day interval. An 800-berry sample gave results that were statistically non-significantly different from those obtained with a 1,500-berry sample. Thereafter the smaller sample was used.

During many of the inspections berries were examined also in a dark booth under ultraviolet light of 3660 angstroms. Berries from a package were poured into a 13-inch metal pan and swirled under light directed at a 45° angle to the plane of the pan. Berries which fluoresced either bright blue or dull red were taken from the sample and further examined for decay. These berries were then added to the others that showed readily visible decay.

Another attempt to find a rapid means of sorting and grading berries for quality concerned flotation of the fruits in liquids of different specific gravities. Little progress was made with this method. The results were not promising and are not included in this study.

Tare weights were rounded to the nearest gram. Temperatures were rounded to the nearest 0.1° F. All data were tested for statistical significance.[4]

[4] In this paper, the terms "significance" or "significant difference" infer that a similar circumstance would occur by chance alone only 5 times in 100 (odds 19 to 1). "High significance" or "highly significant difference" infer that chance occurrence of similar data would be limited to 1 time per 100 (odds of 99:1).

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Figure 4. --Package arrangements and locations of the dummy blocks in the iced display case. The overhead cable connected thermocouples in packages to the electronic temperature recorder. All methods of display were similarly arranged. The hygrothermograph above the case recorded display room temperatures and relative humidities.

RESULTS AND DISCUSSION

Measurement of the results of the experiment required the individual handling and inspection of approximately 93, 500 cranberries that were displayed under the 9 retail methods. The inspection of the fruits under ultraviolet light proved to be a rapid means of detecting decayed berries of certain types but it was of limited application.

Early rot caused by Guignardia vaccinii fluoresced bright blue. Injury such as red-spot caused by Exobasidium vaccinii sometimes fluoresced pale blue or a mixture of dull red and blue flecks. Berries apparently damaged by Sporonema oxycocci, as well as those that were overmature and soft, fluoresced dull red. Sound berries, and shrivelled berries not damaged by decay, did not fluoresce but appeared almost black.

Glare from the berry surfaces was troublesome unless the berries were viewed from an angle that minimized this effect. The lamp temperature affected the amount of incident light, and it was necessary to operate the lamp continuously to secure the best results. A principal drawback of the method was that the difference in visual purple or dark adaptation of the inspectors caused some of them to see the fluorescence less easily.

The method was thus not used during all inspections of the first two replications and was not used during inspection of the last replication. Figure 8 shows the appearance of some of the berries under ultraviolet light as well as can be shown in a black and white print. (See also references 26, 28, and 29.)

The effect of display time and method is summarized in table 2. Examinations of the cranberries included both slight and severe forms of decay, but these figures were combined for table 2. The examinations were not more critical than might be made by the careful housewife. The figures shown as "total fruit loss" included both shrivelling and decay and indicate the amount of fruit which the housewife probably would discard.

Net weight losses of fruit in either bags or boxes were less than 2.0 percent at the end of 8 days under all methods of display, except display in the dry case without refrigeration. The loss was 3.7 to 4.0 percent under the latter method. Cranberries, in both types of packages, displayed under refrigeration lost 2.9 percent or less weight in 14 days, while berries without refrigeration lost an average of 6.8 percent. The apparent gain in weight of fruit displayed in boxes on ice for 3 to 8 days was not a true gain but was due to water adsorbed from the wet packages (33). This absorbed water could not safely be removed from the berries to obtain a true final weight. The true losses under the ice method probably would have been greater for the rest of the display periods had the packages and the berries remained dry. Weight losses under all methods of display, except the one in which the packages were displayed continuously without refrigeration, were 5.4 percent or less for a display time of 21 days.

Shrivelling damage of cranberries displayed 8 days or less was greatest in packages on crushed ice; but thereafter shrivelling was most extensive in packages on the false-rack refrigerated case. This would indicate that shrivelling was not mere dehydration of the fruits but often was due in part to advancing decay, and such fruits ultimately would be lost. While the U. S. Consumer Standards for Fresh Cranberries (34) do not refer to shrivelling as damage, the standards do specify that U. S. Grade A berries shall be "firm."

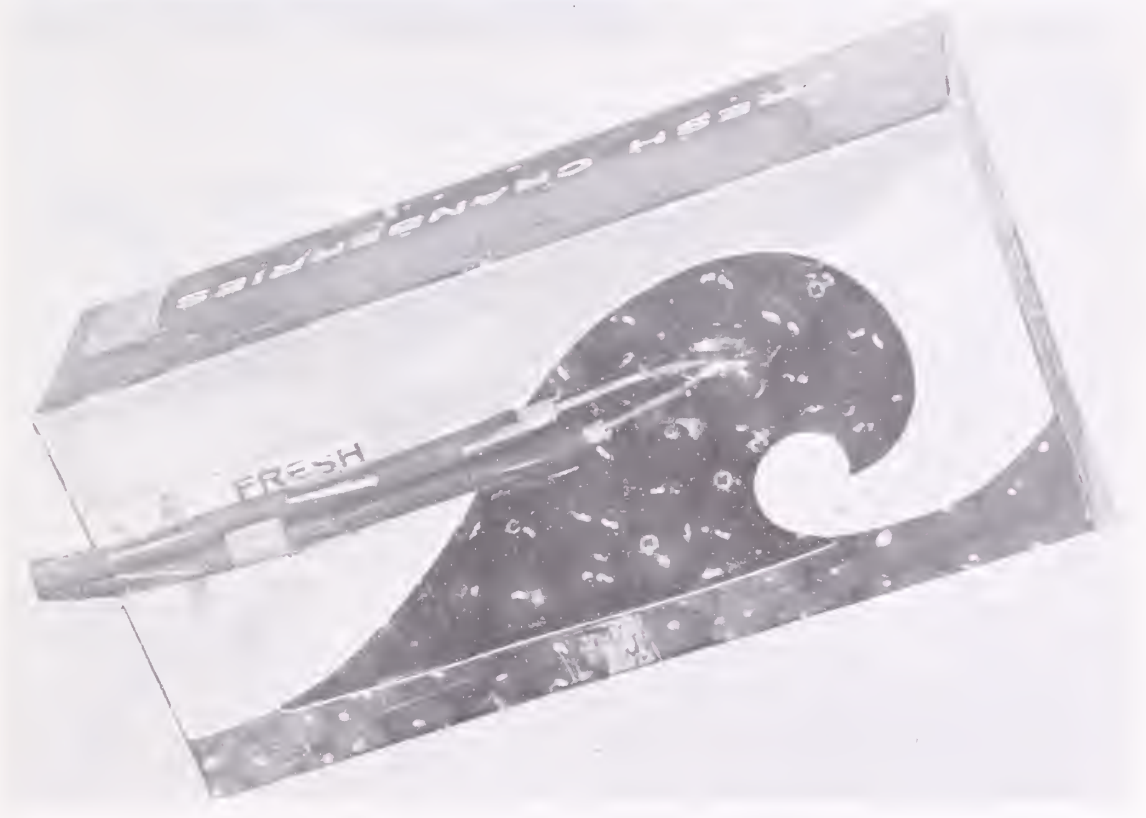

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Figure 5.--Thermocouples were taped in place just beneath the upper surface of the boxes. One thermocouple was placed in the fruit; the other was exposed to the package air immediately adjacent. Thermocouples were placed in bags in a similar manner.

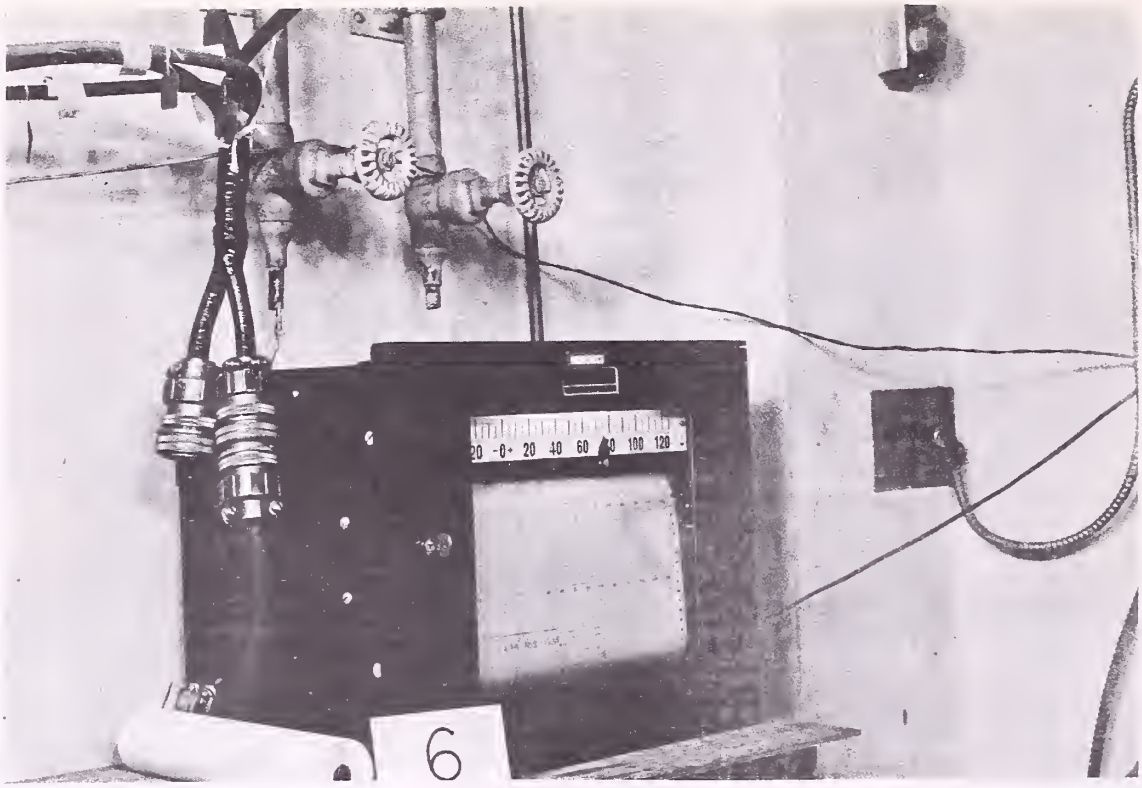

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Figure 6.--Electronic potentiometer used to record fruit and air temperatures within the packages. The two heavy bayonet connections permitted switching 20 thermocouple connections within seconds of time.

In the interest of expansion of the cranberry market through better quality fruit, it is recommended that shrivelled berries be classed as damaged and not offered for sale.

Total losses under the various retail methods were 6 to 10 percent in 3 days and reached 15 to 51 percent in 8 days. Total losses under the best method (mechanically refrigerated continuously) amounted to 43.8 percent in 21 days. Losses under the poorest method (nonrefrigerated continuously) totaled 87 percent in the same time. Total losses under all methods of display, and for the average of the display periods, for both boxes and bags averaged 31.9 percent. These losses included 26.5 percent due to decayed fruits, and 5.4 percent due to shrivelling. All types of loss, under all methods of display, in both boxes and bags, increased with time. This trend was later demonstrated by storage of small lots of cranberries at temperatures of 30°, 33°, 38°, 40°, 45°, 50°, 55°, 60°, 65°, 70°, 75°, and 80° F. for periods of 3 to 43 days. Figure 9 shows some of these results and illustrates this trend. (See also references 22, 23, and 24.)

Table 4, Appendix, gives an analysis of variance of total fruit losses. There were high significant differences in methods, replications or shipments, display periods, and losses in bottom and top packages. Chance occurrence of these differences would have been probable considerably less than 1 time in 100. Each of the items of the analysis has importance in pointing out causes for loss of quality in cranberries, and thus certain observations are in order.

Package temperatures compared with fruit temperatures.--It was foreseen that the comparative value of any 2 methods probably would depend principally upon which method would maintain the more suitable display temperature. Since the temperature of the air surrounding a display is usually accepted as the display temperature in commercial practice, there was the question whether a suitable package temperature was also a

suitable fruit temperature. Throughout the experiment thermocouple measurements were recorded for both air temperatures in the packages and adjacent fruit temperatures for all methods, periods, replications, and in both top and bottom packages. A summary of these data showed that the air in the packages averaged 55.7° ± 1.3° F., and the adjacent fruit temperatures averaged 55.4° ± 1.3° F. An equal difference between the two temperature averages could have occurred by chance alone 89 times in 100. Thus there is reasonable assurance that there was no significant difference between package temperatures and fruit temperatures. The average temperatures of the different display methods are given in table 1.

Top and bottom package temperatures.--The presence of large carpels in cranberries forecast a low rate of heat transfer by the fruits. It seemed probable that a suitable temperature in packages in the bottom layer of the display rack would not necessarily mean a suitable temperature in packages above the bottom layer. The total fruit losses in top-layer packages averaged 23.3 percent higher than those in the bottom layers. This difference was highly significant. It strongly suggests that a better method of stacking packages in displays might decrease losses. Stacking packages on ends, for instance, might prove helpful by permitting more efficient cooling currents in and about the packages.

Cranberry losses in boxes and in bags.--Total fruit losses were greater in bags than in boxes under all methods and periods of time, except under the continuously nonrefrigerated method. Although the differences in losses were small, the presence of a consistent difference merited consideration whether there was a possible cause and whether an improved package design might lessen fruit losses.

Bergman (3) cautioned that in an atmosphere with as little as 2.5 percent carbon dioxide, cranberry losses are greater than in normal ventilated storage. The unoccupied

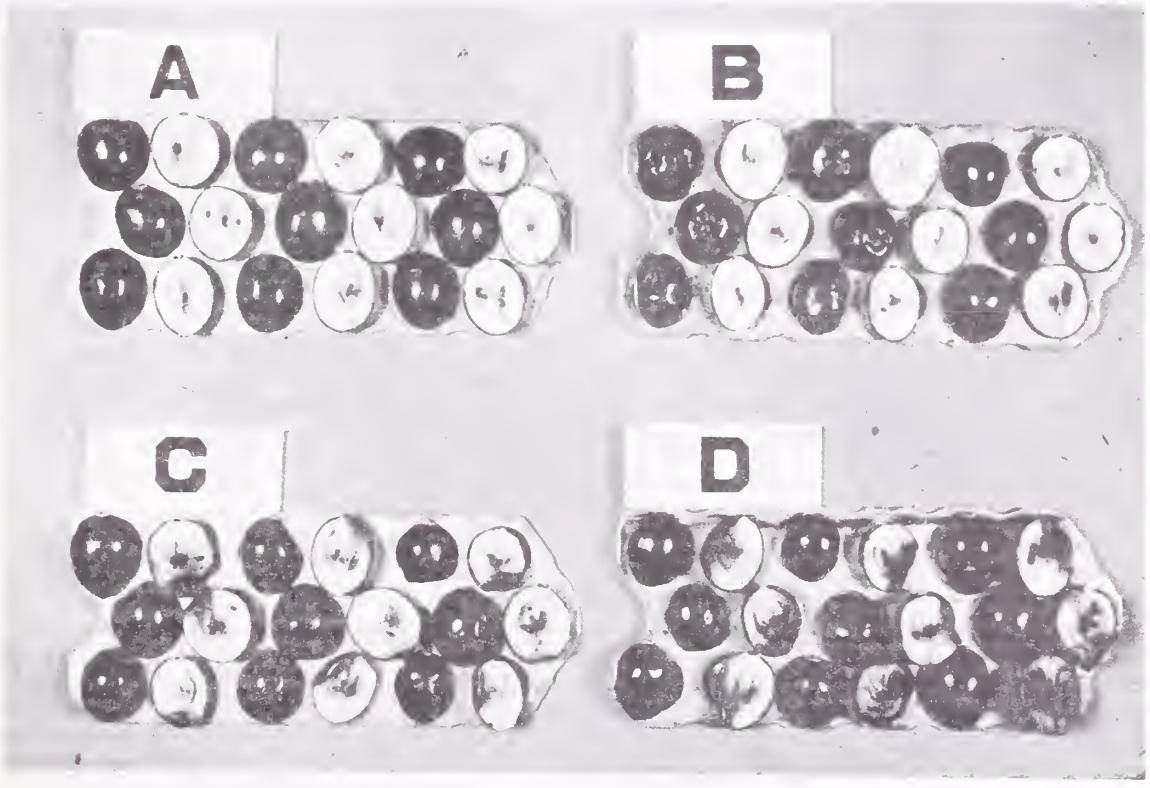

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Figure 7.--Cranberry damage classifications by which display methods were evaluated. Halves of 9 berries in each classification are shown: A undamaged, B shrivelled only, C slightly decayed, D severely decayed. See text for definitions of damage classes.

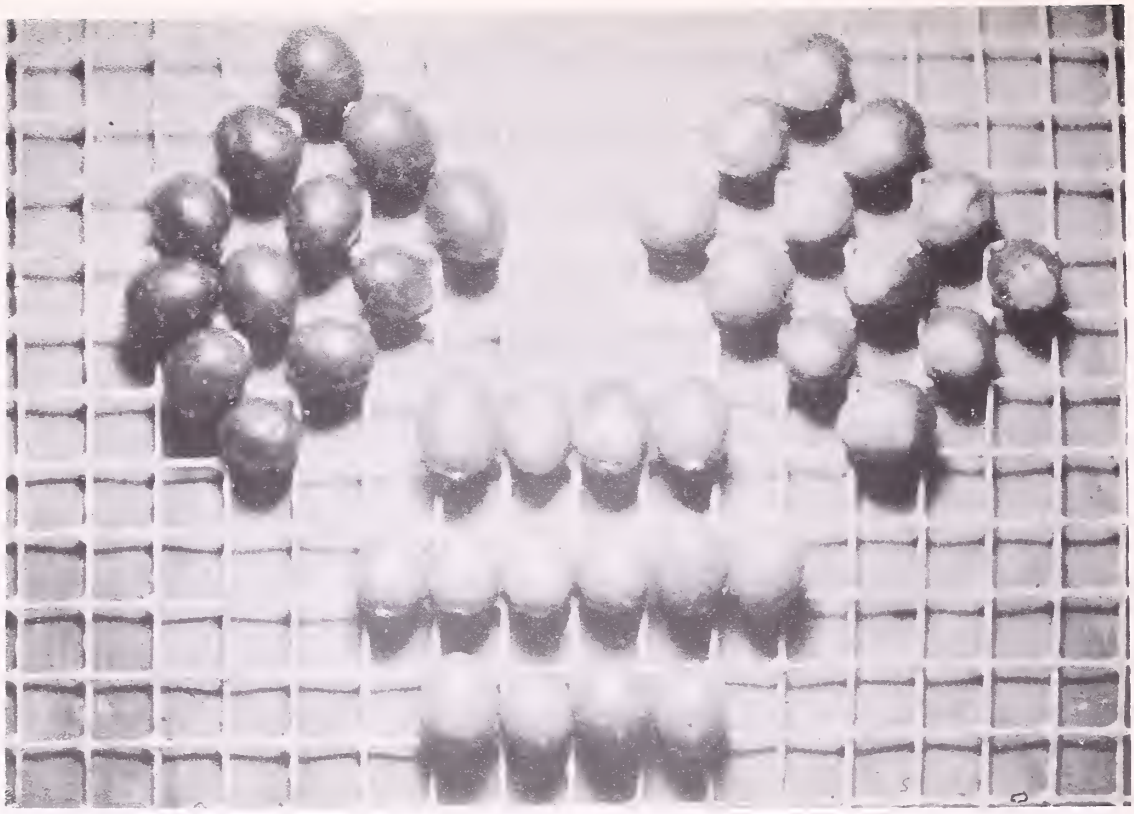

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Figure 8.--Major differences in cranberries discernible under ultraviolet light. Upper left: Mature berries without decay. Upper right: Decayed berries which fluoresced bright blue. Lower center: Decayed or overmature berries which fluoresced dull red.

air spaces of the boxes and bags used in this experiment were respectively 440 cc. and 530 cc. at the start of the storage periods. As the tests progressed, the air spaces increased in each type of package at a different rate. From the data, however, it appears probable that the volume of air space within the packages was less important than ventilation. (See also references 5, 20, and 37.)

A hose was tightly fitted into a display box containing 1 pound of cranberries, and smoke was forced inside. The smoke made exit almost wholly through the 10 vents along the bottom edges of the box. Practically no smoke came from either end or through the 7 scorings along one of the upper edges of the box. (These vents and scorings are shown in figure 2.) Four additional boxes were similarly tested and similar results were found. It seems probable that most of the respiratory gases likewise would diffuse through the 10 lateral vents.

A comparison was made of the 10 vents in the boxes with the 4 round vents in the bags. The box vents were approximately 2 x 12 millimeters with a total area of 2.4 square centimeters per box. Each of the holes in the bags was about 5 millimeters in diameter, and the total area of the openings in each bag was thus about 0.8 square centimeters, or approximately one-third the area of the openings in each box. This does not mean that the boxes have 3 times the ventilation possible in bags, but it does mean that the boxes very probably have more ventilation. Also, it has been observed many times that one or more bag vents may be completely closed by berries pressing against them, while the location of the box vents prevents the closure of any of them by berries.

Table 2.--Effect of display time and method on cranberries

Display time and method	Net weight loss in--		Shrivelled fruits in--		Decayed fruits in--		Total fruit loss in--[1]	
	Boxes	Bags	Boxes	Bags	Boxes	Bags	Boxes	Bags
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
3 days:								
Mech. refrig., reg. rack.....	0.6	0.4	2.1	2.1	4.1	4.8	6.2	6.9
Mech. refrig., false rack[2]...	.6	---	1.9	---	4.9	---	6.8	---
Ice-bed, continuously.....	+.2	.2	2.4	2.7	4.9	6.3	7.3	9.1
No refrig. day + 40° night...	.5	.4	1.4	2.0	5.5	5.8	6.9	7.8
No refrig. continuously.....	1.3	1.1	1.7	1.8	7.8	6.4	9.5	8.2
8 days:								
Mech. refrig., reg. rack.....	1.6	1.3	3.3	4.7	12.4	11.1	15.7	15.8
Mech. refrig., false rack[2]...	1.6	---	4.3	---	11.2	---	15.4	---
Ice-bed, continuously.....	+.8	1.0	5.4	8.6	12.9	14.1	18.4	24.0
No refrig. day + 40° night...	1.8	1.6	4.8	3.6	12.4	16.8	17.2	20.4
No refrig., continuously.....	4.0	3.7	.6	1.4	47.7	48.7	48.3	51.2
14 days:								
Mech. refrig., reg. rack.....	2.8	2.6	5.8	6.6	17.5	20.6	23.2	30.4
Mech. refrig., false rack[2]...	2.9	---	9.9	---	10.3	---	31.4	---
Ice-bed, continuously.....	.5	2.0	8.9	11.9	27.1	31.3	36.0	43.2
No refrig. day + 40° night...	2.9	2.8	5.4	5.4	28.5	33.4	33.9	38.9
No refrig., continuously.....	7.0	6.6	3.0	1.1	71.7	72.7	74.7	73.8
21 days:								
Mech. refrig., reg. rack.....	4.7	4.0	12.0	12.7	31.8	35.4	43.8	48.1
Mech. refrig., false rack[2]...	5.4	---	15.8	---	30.8	---	46.6	---
Ice-bed, continuously.....	.7	3.8	10.7	15.7	39.2	44.7	49.9	60.4
No refrig. day + 40° night...	4.6	4.6	7.5	8.5	46.4	52.1	53.9	60.6
No refrig., continuously.....	10.6	9.4	3.0	3.7	84.0	81.1	87.0	84.8
Period average:								
Mech. refrig., reg. rack.....	2.4	2.0	5.5	6.2	15.5	17.7	21.0	23.9
Mech. refrig., false rack[2]...	2.6	---	7.5	---	16.9	---	24.5	---
Ice-bed, continuously.....	---	1.7	6.5	9.2	19.8	23.0	26.3	32.2
No refrig. day + 40° night...	2.5	2.4	4.5	4.6	21.8	25.4	26.4	30.0
No refrig., continuously.....	5.7	5.2	2.0	2.0	49.5	49.1	51.5	51.1
Method average:								
Both packages.....	2.7		5.4		26.5		31.9	

[1] Total fruit loss means sum of losses due to shrivelling and decay.
[2] There were no bags displayed under this method.

Additional vents in bags may be needed, in view of the greater fruit loss in bags compared with that in boxes.

Researchers in the Department of Agriculture (35) interviewed 1,758 customers who bought cranberries in Boston or Topeka during 1953. Boston market observers and produce managers alike thought the berries in boxes deteriorated more rapidly than those in bags. Similarly trained observers in the Topeka market thought the opposite was true, but managers thought there was no difference. Some retailers mentioned that when damp boxes were displayed they tended to come open more often than bags did. The customers were free to choose either bags or boxes in each of the stores where the interviews were held, yet 70 percent of all customers bought berries in bags. Of the customers who chose bags, 57 percent said it was because they could see the berries better. Of those who chose boxes, 51 percent said it was because boxes protected the berries from damage. A

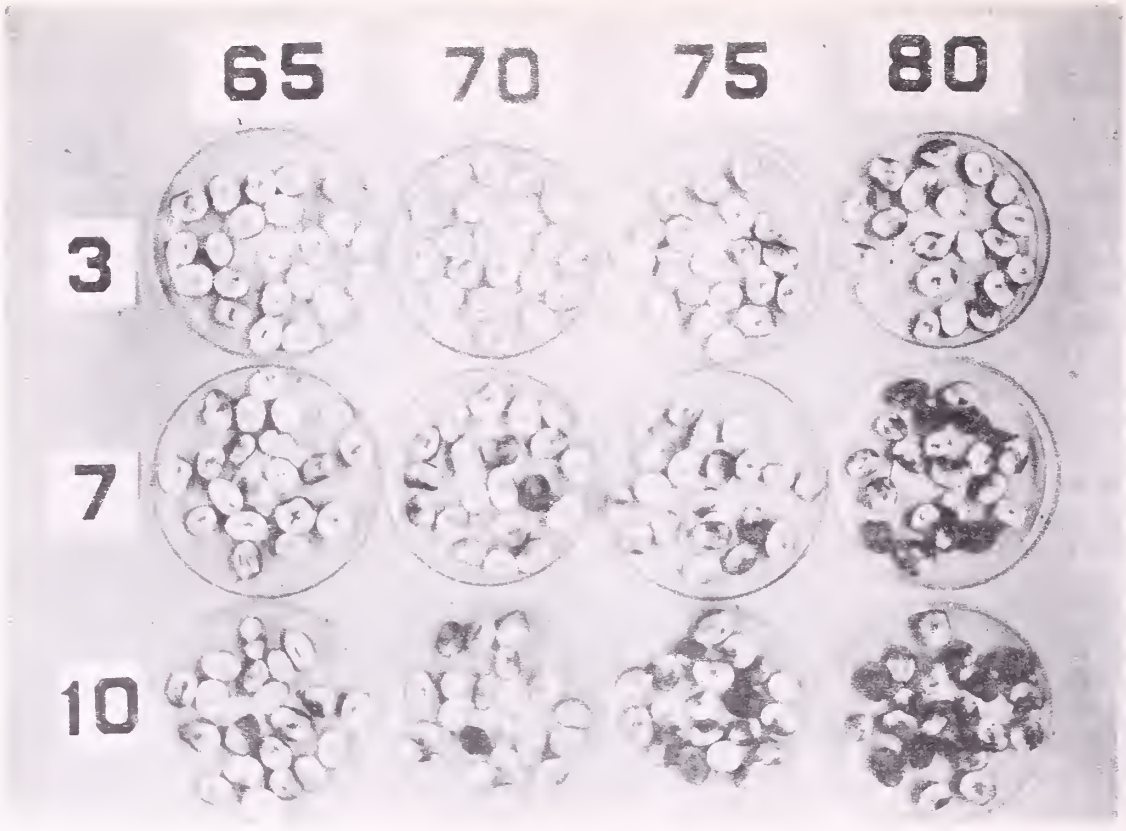

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Figure 9.--This photograph shows a trend of fruit damage with temperature and time. The darkened halves of the cranberries indicate decay. All fruits were of equal ripeness and without visible decay at the start of the storage periods of 3, 7, and 10 days at 65° to 80° F. Nearly half of the berries started to decay in 3 days at 65°, and would have been unsalable on the 7th day.

similar survey in Chicago, Cleveland, Kansas City, Boston, and Denver gave almost identical results (1). In view of the results of the present experiment and survey comments, a transparent box might overcome the major objections of both dealers and customers, maintain quality more satisfactorily, and increase cranberry sales. (See also reference 17.)

Differences in fruit losses among replications.--The very high significant difference in replications may have been due largely to different lengths of storage at the shipping point at possibly unfavorable temperature and relative humidity. The cranberries used in this study were commercially stored in Massachusetts at uncontrolled relative humidity, and the storage temperatures were not positively known. There could also have been other reasons for the differences. Figure 9 illustrates that cranberries held at 65° or more for as little as 3 days may develop incipient damage regardless of previous satisfactory handling. Too, overfilled cases of cranberries, as shown in figure 10, may be the cause of much damage to berries after they leave the shipper. The causes of damaged fruits are not always easily detected.

However, all cranberries received for use in this experiment were sorted upon arrival, and only visibly undamaged and firm berries were used in any of the tests. This pre-experiment sorting revealed that the berries that had to be removed because of bruising, shrivelling, damage of any kind, and either immaturity or overmaturity, averaged 23.98 percent of the shipped weight. This loss was not equally distributed among

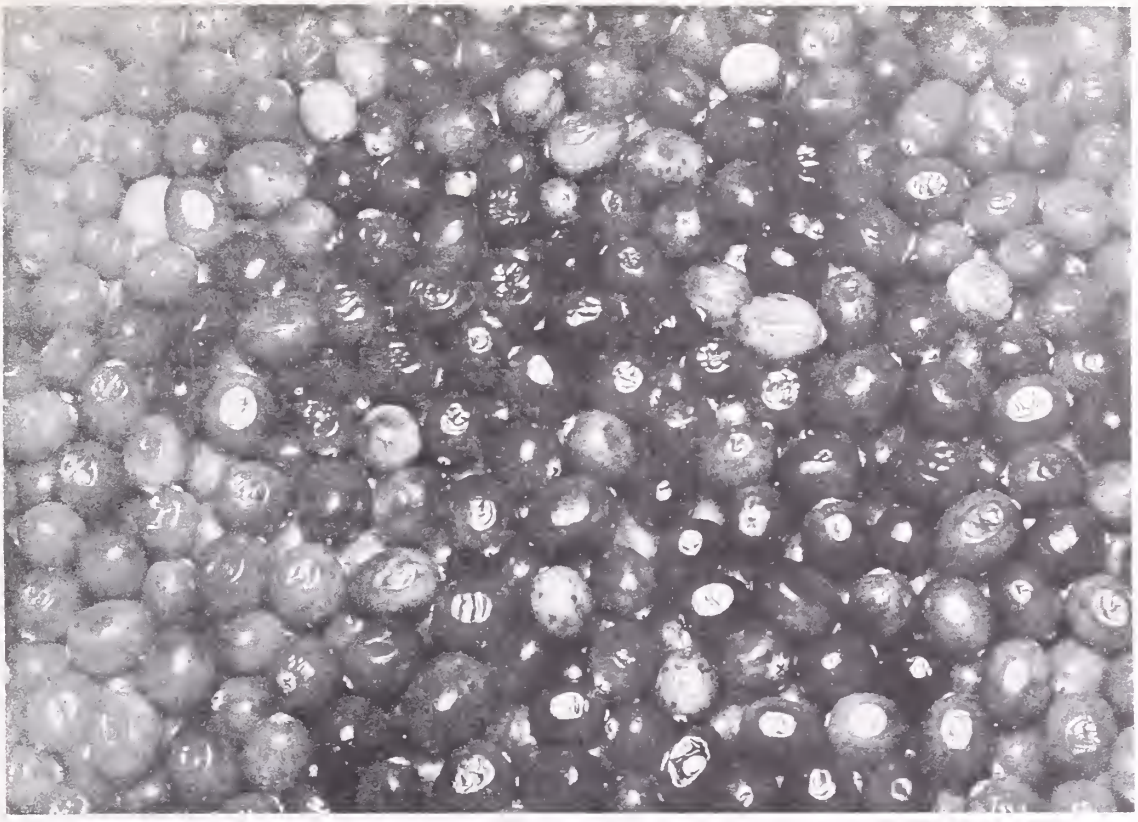

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Figure 10.--A typical portion of the surface of an overfilled 1/4-barrel cranberry case. Flattened surfaces indicate bruised berries. This causes much decay in storage and during retail display. Overfilling causes waste and gains nothing. (See reference 3.)

the shipments. The loss in the second shipment was 29.6 percent, while that of the final shipment was 18.2 percent of the shipped weight.

In view of the careful sorting and the fact that the fruit losses increased with successive repititions of the experiment, it seems highly probable that replication significance was principally due to previous storage conditions. (See also references 31, 32.)

Losses of fruit due to length of time displayed.--It was expected that storage time and display time would be large factors in the maintenance of quality of the berries. The effect of display time accounted for the largest source of variation that was measured. There was an increase of fruit loss with time under all methods and for all replications. Total losses by all methods of display, except the worst, averaged 7.3 percent in 3 days and increased to 18.1 percent by the end of 8 days, 33.8 percent in 14 days, and 51.9 percent in 21 days. The point emphasized is that while decay of cranberries eventually occurs under any method of display, this decay of quality probably can be greatly delayed by proper handling by grower, warehouseman, common carrier, and retailer. Proper handling by the retailer suggests handling under the most satisfactory temperature, for the shortest display time, and by the best display method available. Proper handling by others to present high quality berries to the retailer has been given much attention, and much literature is available for guidance.

Losses of fruit due to method of display.--The method of display of cranberries by the retailer has been assigned considerable importance, but the analysis of variance in appendix table 4 shows that methods possibly rank only fourth in responsibility for total fruit losses. Nevertheless, the experiment proved that there were differences in fruit

losses among nine display methods commercially used by retailers, and these differences were highly significant.

Tests were made for significance of the data by Duncan's multiple range test (19). A summary of these results is given in table 3. The display methods are ranked in order of total fruit losses. The least loss of fruit occurred in boxes displayed continuously under mechanical refrigeration, and thus this method heads the list as most desirable. The greatest loss of fruit occurred in boxes displayed continuously without refrigeration, and this method is placed at the bottom of the list. The presentation in table 3 provides 36 possible comparisons of the display methods.

Table 3.--Comparison of display methods and packages based on total fruit loss

Method of display	Package type	Desirability rating	Statistical significance[1]
Mechanically refrigerated case continuously, 38° at lower surface of display	Box	Good	
Same	Bag	Good	
Mechanically refrigerated case continuously, on false rack raised 5 inches	Box	Good	
Ice bed continuously, with packages separated from ice by kraft paper	Box	Good to fair	
Nonrefrigerated during daytime, stored overnight at 40° F.	Box	Good to fair	
Same	Bag	Fair	
Ice bed continuously, with packages separated from ice by kraft paper	Bag	Fair	
Nonrefrigerated continuously	Bag	Very poor	
Same	Box	Very poor	

[1] Any two methods NOT followed by the same vertical bar were significantly different (odds of 19 to 1).

To keep total fruit losses at a minimum, based on tables 2 and 3, retail methods for the display of either boxes or bags of cranberries would rank in the following order of preference: (1) Mechanically refrigerated case continuously, (2) false rack in mechanically refrigerated case continuously, (3) nonrefrigerated counter in the daytime with 40° F. storage at night, (4) crushed-ice display case continuously, and (5) the poorest method, nonrefrigerated counter continuously. There was no significant difference in total fruit loss between methods 3 and 4, but the crushed-ice method caused damage to the packages due to absorbed water (33). With a better method of displaying paper-packaged produce on ice, the crushed-ice method would rank higher.

While the mechanically refrigerated case gave the best results in this experiment, this does not mean that the retailer may not use iced displays to good advantage in many instances. Lewis (21, pp. 8-9) showed that produce on ice, even without top garnishment, averaged only 4 degrees higher than produce displayed to the same depth in a mechanically refrigerated case. The slight variance in results between those which Lewis obtained and those here reported may be accounted for by the fact that the present study used a less deep display.

A final observation concerns the variety of cranberries used in this experiment. Two of the oldest varieties are Late Howes and Early Black, and both are grown extensively in Massachusetts and New Jersey.[5] The Early Black variety was not available for this experiment, and Late Howes was the alternative. In keeping quality, the Early Black and the Late Howes, on the average, have rated about equally well (9, 11, and 12). It is thus probable that the values found for the Late Howes variety may not differ materially from those which would be found for the Early Black. Records over a long period show that the keeping quality of cranberries from individual bogs and from an entire region varies from year to year (3, 9). It is also known that the keeping quality of Late Howes is less correlated with weather than is the Early Black variety. The interaction of variables is difficult to forecast. The data in this study were subject to interactions, and they were accounted for within the analysis of variance to the extent possible.

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[5] These States accounted for 76 percent of the acreage and 62 percent of United States crop in 1955 (36).

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APPENDIX

Table 4.--Analysis of variance of total fruit loss

Source of variation	Degrees of freedom	Mean square
Total	431	---
Methods[1]	8	[2] 7,540.61
Replications[3]	2	[2] 17,299.90
Error (a)	16	78.35
Periods[4]	3	[2] 50,338.15
Periods x methods	24	[2] 782.22
Periods x replications	6	[2] 786.66
Error (b)	48	66.09
Tops vs. bottoms[5]	1	[2] 5,432.93
Tops vs. bottoms x methods	8	[2] 416.81
Tops vs. bottoms x replications	2	59.46
Tops vs. bottoms x periods	3	[2] 864.95
Tops vs. bottoms x periods x methods	24	[2] 113.65
Tops vs. bottoms x periods x replications	6	20.17
Error (c)	280	36.14

[1] This refers to the display methods.
[2] The variation within these items could have occurred by chance alone only 1 time in 100. It is probable, therefore, that true differences among the data were due to treatment and not to chance.
[3] These are the three shipments. See text.
[4] Displays of 3, 7, 14, and 21 days.
[5] Displays were two packages high. "Tops vs. bottoms" refers to top layer vs. bottom layer.

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