AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

84 Sm2
. . 2

Marketing Research Report No. 312

REFRIGERATED STORAGE OF CRANBERRIES

L
★ APR 23 1959 ★
U. S. DEPARTMENT OF AGRICULTURE

MARKETING RESEARCH DIVISION
AGRICULTURAL MARKETING SERVICE
U.S. DEPARTMENT OF AGRICULTURE

CONTENTS

March 1959

ACKNOWLEDGMENTS

Acknowledgment is made to the National Cranberry Association, South Hanson, Mass. which contributed the fruit and other materials; Mr. W. Atwood of the A. D. Makepeace Company and Dr. B. Zuckerman of the Massachusetts Cranberry Experiment Station who jointly selected the cranberries; and Dr. B. A. Friedman, U. S. Dept. Agriculture, New York, N. Y. who helped plan the storage experiment.

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 15 cents

REFRIGERATED STORAGE OF CRANBERRIES

By S. M. Ringel, J. Kaufman, and M. J. Jaffe[1]

SUMMARY

Three lots of Massachusetts-grown Howes cranberries, selected from the 1957 crop, were stored for varying periods up to 19 weeks in cold storage at 40° F. and compared with fruit kept in simulated common storage. The significant findings were:

1. Cranberries kept in field boxes cooled down more rapidly than prepackaged fruit in master cartons.

2. Weight losses were minimized when cranberries were held in cold storage.

3. Minimum handling before and after storage reduced the amount of spoilage.

4. In cold storage, 96 percent of the unscreened cranberries appeared sound after 6 weeks, 95 percent after 12 weeks, and 88 percent after 19 weeks. For fruit held in common storage, the results were 93, 89, and 76 percent for corresponding intervals.

5. Cold storage, as compared with common storage, not only reduced spoilage during storage, but also extended the subsequent shelf life of cranberries.

6. Cranberries kept in cold storage for 12 weeks and then screened and prepackaged, were considered salable after holding 3 additional weeks at 40° F. (7.4 percent of spoilage). At the end of 19 weeks cold storage and following the additional 3-week holding period, there was twice as much spoilage.

7. Freshly harvested fruit when screened or screened and prepackaged, kept in cold storage for 6 weeks without requiring further rescreening.

8. Over 1,700 decayed cranberries were cultured and the principal fungi found were Penicillium spp., Acanthorhyncus vaccinii, Phoma sp., and Sporonema oxycocci.

INTRODUCTION

In Massachusetts, the bulk of the cranberry crop is harvested during September. Of the 2 principal varieties grown, the Early Blacks are harvested first, followed by the late variety Howes which may be harvested up to the first part of October. The cranberries are harvested into field boxes and then held in nearby ventilated common storage houses without refrigeration. The fresh cranberry trade extends from mid-September to the end of December, and throughout this season the cranberries are taken from storage, screened to remove the chaff (vines, leaves, and other field debris) and decayed berries, and are then prepackaged for shipment to market.

During the first half of the cranberry harvest, it is not unusual for fruit to arrive at the storage houses with high pulp temperatures. On September 19, 1957, the average berry temperature was 86° F. for field boxes received at the storage and packing plant located at Onset, Mass. It may take several weeks for cranberries held in common storage to cool down to the desired storage temperature of 40° F. (9)[2] and, during this time, substantial amounts of spoilage may develop.

---

[1] S. M. Ringel and J. Kaufman are pathologists, M. J. Jaffe is a junior pathologist, with Biological Sciences Branch, Agricultural Marketing Service, New York, N. Y.

[2] Underscored figures in parentheses refer to Literature Cited, p. 17.

Previous studies indicate that refrigeration extends the keeping quality of cranberries. Thus the benefit of refrigerated storage was reported by Wright et al in 1937 (8) and also by Levine and his coworkers in 1940 (6). The value of refrigeration in transit was discussed by Kaufman et al in 1955 (4) and that of precooling cranberries immediately before shipment in 1958 (5); while the retail aspect of refrigeration was evaluated by Hruschka and Kaufman in 1949 (3) and by Beattie and Demoranville in 1958 (1). No published data, however, have been found on the aspect of continuous refrigeration; that is, starting at the time the cranberries are placed in storage and ending with the commodity on the retail shelf. The Massachusetts cranberry industry has expressed an interest in the possibility of using cold storage instead of common storage in the producing area. Accordingly, an integrated study was made of the continuous refrigeration of cranberries from the 1957 crop, involving their storage, followed by prepackaging, and their subsequent holding qualities.

MATERIALS

Three lots of unscreened fruit of the Howes variety were selected for study from the 1957 crop at Cape Cod, Mass. On the basis of previous records of the bogs involved, the lots represented fruit classified as good, fair, and poor. The lots are designated as A, B, and C respectively. The cranberries were harvested during the first week of October, held in common storage for 1 week and had, at the time of removal from storage, an average pulp temperature of 63° F. They were transported in an unrefrigerated truck to New York City in an 8-hour period. The berries had an average temperature of 62° F. when they arrived at the laboratory.

A commercially built cranberry separator was used to screen the cranberries. Essentially this machine contains a blower which removes the chaff consisting of vines, leaves, and other field debris; bounding boards to separate the soft from the sound fruit; and a grading device for sizing.

Field boxes, 16 by 22-1/2 by 9-1/4 inches, were used in storage. These were made of wood, slotted, and had a capacity of about 37 pounds of fruit in the chaff. One-pound window boxes, 7-1/4 by 4 by 2-1/2 inches, with non-adhesive flaps, were used for prepackaging screened fruit. The master shipping cartons, 16-5/8 by 14-3/4 by 8-1/2 inches, were slotted and had a capacity of 24 one-pound window boxes.

METHODS

Two sets of storage temperatures were selected; walk-in boxes were used as storage rooms. In one series, the cranberries were kept in "cold storage" under continuous refrigeration at 40° F. (9). The fruit in the other series was held in "common storage" at temperatures simulating those found in Massachusetts in non-refrigerated storage houses. According to the packing house manager at Onset, Mass., inside air temperatures usually run 10 degrees lower than the outside air through October. During November, the temperature equals that of the outside air, and from December on, it is at least 10 degrees warmer than the outside air, usually stabilizing at around 40° F. The fruit in the series used to simulate common storage conditions, therefore, was held for 4 weeks at 60° F., followed by 5 weeks at 50°, and 10 weeks at 40° (2).

Approximately 1,400 pounds of cranberries were placed in storage. The cranberries in each of the 3 test lots were randomized and stored in 3 sublots consisting of: (1) unscreened berries, in the chaff and in the original field boxes; (2) screened berries[3] which were replaced in the field boxes; and (3) screened berries which were prepackaged in 1-pound window boxes and placed into master shipping cartons. Inspections were made at the time the lots were placed in storage and after they were removed at the end of varying storage periods. After storage, the unscreened sublots were screened and

[3] Screening involves machine separation (see p. 7) followed by hand sorting.

prepackaged, the screened sublots were prepackaged without further screening, and the prepackaged sublots were left undisturbed. All lots now prepackaged were placed in master shipping cartons and held 1 week at 40° F. to simulate a transit period. At the end of this period, 1 set of the prepackaged fruit was held for 1 week at 70° F. and then inspected; and, another set was inspected after holding for 2 weeks at 40° F. The relative humidity was maintained at about 85 percent during the storage and holding tests.

Cooling rates, averaged from 3 sets of readings, were determined with the aid of thermocouple leads. These were inserted either into individual berries at the center of the field boxes or into individual berries at the center of 1-pound window boxes in the middle of shipping cartons.

Inspections for spoilage were based on randomized fruit in triplicated 1-pound window boxes. For this study the types of spoilage were categorized as: fungal decay; bruising, which was scored if indentations on the berry, often associated with softening and reddening of the underlying flesh, materially affected the appearance of the berry; physiological breakdown, which was indicated by a rubbery softening of the entire berry and accompanied by red discoloration of the flesh; and insect damage.

Flavor tests were conducted by 6 to 8 people. After each inspection, a 1-pound sample of sound fruit remaining from each treatment was cooked according to the following recipe: Place 1 pound of washed cranberries in a saucepan, add 1 cup of water, cover, and heat to boiling. Add 1-1/2 cups sugar, cover, and cook 10 minutes or until berries have burst.

RESULTS

Cooling Rates

At the start of the test, the screened fruit in field boxes as well as the prepackaged fruit in window boxes, because of the handling procedure, registered 77° F. The unscreened fruit (in the chaff), on the other hand, was 70° F. The fruit was then placed in a walk-in refrigerator held at 40° F. The results show that cranberries left in the field boxes cooled down more rapidly than prepackaged fruit placed in master shipping cartons (fig. 1). The greatest drop in temperature took place within 24 hours. At the end of this time, the fruit in the field boxes cooled down to about 46° F. whereas prepackaged cranberries in shipping cartons were 53°. After 48 hours, cooling in the field boxes had almost been completed, the fruit registering 42° F. It took 66 hours, however, for prepackaged cranberries to reach the same temperature.

Weight Losses in Storage

Refrigeration slowed down weight losses in storage (table 1). The losses for fruit in common storage at the end of 6 weeks equalled those for fruit held in cold storage for 19 weeks. This was 3.4 percent for unscreened and 4 percent for screened and prepackaged cranberries. Weight losses were consistently less for unscreened fruit when compared with screened and prepackaged fruit for both the common and the cold storage series. Fruit held in common storage showed the greatest acceleration in weight loss between the second and sixth week.

Effect of Storage Temperature on Keeping Quality

Approximately 323,000 cranberries were examined and, in all instances, the berries in cold storage at 40° F. kept better than those in common storage.

Table 1.--Weight losses during storage[1] (based on initial weights)

Treatment	Type of storage[2]	Lot	Initial net weight	Weight loss during storage of:			
				2 weeks	6 weeks	12 weeks	19 weeks
			Pounds	*Percent*			
Unscreened (in the chaff)	Cold	A	172.3	[3] 0	1.1	2.4	3.7
		B	168.7	[3] 0	1.2	2.3	3.6
		C	180.4	[3] 0	0.8	1.7	2.8
		Average		0	1.0	2.1	3.4
	Common	A	102.3	1.0	3.4	4.4	5.9
		B	102.9	0.9	3.2	4.4	5.4
		C	109.1	0.9	3.5	4.8	5.8
		Average		0.9	3.4	4.5	5.7
Screened and prepackaged	Cold	A	3.0	1.0	2.0	3.0	4.3
		B	3.0	1.7	2.0	2.7	4.0
		C	3.0	1.0	---	2.2	3.7
		Average		1.2	2.0	2.6	4.0
	Common	A	3.0	2.0	4.0	6.3	8.7
		B	3.0	2.0	4.3	5.3	7.7
		C	3.0	2.0	---	6.3	7.1
		Average		2.0	4.2	6.0	7.8

[1] Relative humidity approximately 85 percent.
[2] Cold storage is at 40° F. and common storage equivalent to Mass. non-refrigerated storage temperatures.
[3] Initially there was an increase in weight; A = 0.3 percent, B = 0.1, C = 0.1, and an average of 0.2 percent.

Unscreened cranberries (in the chaff)

An initial spoilage of 3 percent was present at the time the cranberries were placed in storage. Thereafter, unscreened fruit held in cold storage showed additional spoilages of 0.1 percent after 2 weeks, 0.5 percent after 6 weeks, 2.2 percent after 12 weeks, and 9.2 percent after 19 weeks storage (table 2 and fig. 2). The figures for additional spoilage were much greater for cranberries held in common storage; and for corresponding intervals these were: 2.7, 4, 8.3, and 20.7 percent. When comparing the 2 storages, therefore, cold storage reduced losses by: 96 percent after 2 weeks, 88 percent after 6 weeks, 74 percent after 12 weeks, and 56 percent after 19 weeks storage. Spoilage under both conditions of storage was mostly due to decay.

It is interesting to note how storage affects the subsequent shelf life of cranberries. Unscreened berries held in common storage for only 2 weeks had about the same amount

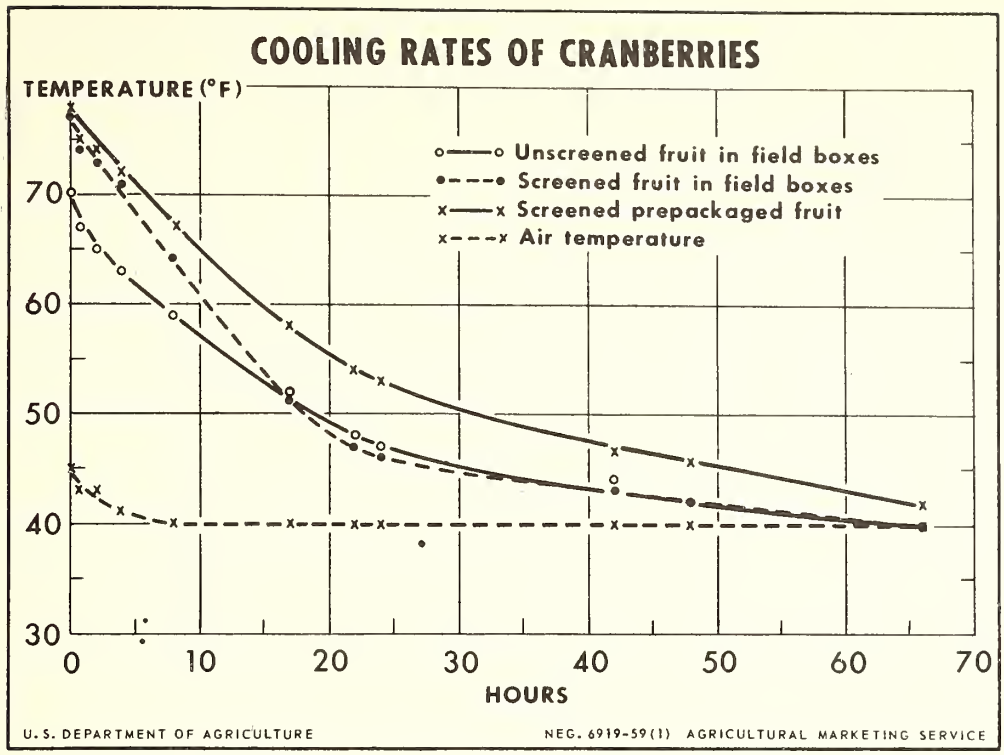

Figure 1

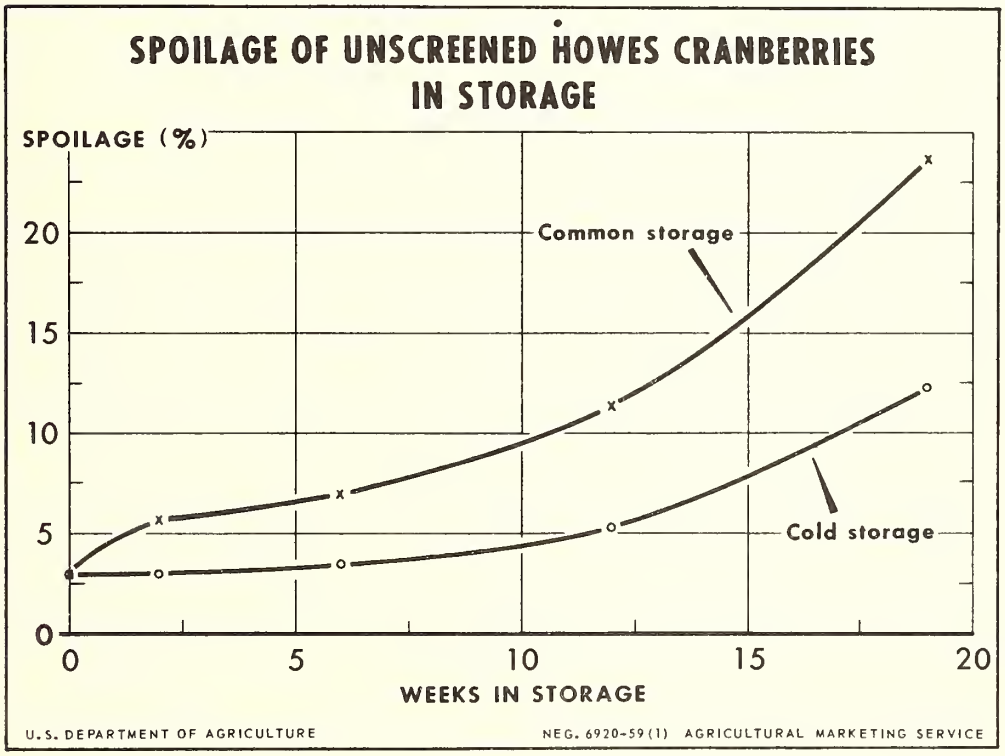

Figure 2

Table 2.--Keeping quality of unscreened cranberries (in the chaff) (combined data from lots A, B, and C)

Type of storage	Weeks in storage	After removal from storage				Followed by screening, prepackaging, and "transit" for 1 week at 40° F.							
						After 1 week at 70° F.				After 2 weeks at 40° F.			
		Total no. berries	Decayed	Other breakdown	Spoiled[1]	Total no. berries	Decayed	Other breakdown	Spoiled[1]	Total no. berries	Decayed	Other breakdown	Spoiled[1]
			Percent	*Percent*	*Percent*		*Percent*	*Percent*	*Percent*		*Percent*	*Percent*	*Percent*
Cold	0	3,984	2.1	0.9	3.0	3,568	2.9	0.4	3.3	3,646	2.5	0.6	3.1
	2	3,830	2.1	1.0	3.1	3,741	2.8	0.2	3.0	3,849	1.9	0.0	[b] 1.9
	6	3,847	2.5	1.0	[a] 3.5	3,880	3.6	0.0	3.6	3,836	2.2	0.0	2.2
	12	4,044	4.2	1.0	5.2	3,927	10.4	0.3	10.7	3,832	3.9	3.5	[a] 7.4
	19	3,874	7.8	4.4	12.2	3,940	20.4	6.6	27.0	3,872	3.3	11.1	14.4
Common	0	3,984	2.1	0.9	3.0	3,568	2.9	0.4	3.3	3,646	2.5	0.6	3.1
	2	3,895	4.3	1.4	5.7	3,920	3.7	0.1	3.8	3,865	2.6	0.0	2.6
	6	3,980	5.5	1.5	7.0	4,023	9.3	0.3	9.6	3,977	2.0	0.1	2.1
	12	4,148	10.4	0.9	11.3	4,029	14.3	1.5	15.8	4,020	4.6	5.7	10.3
	19	4,113	15.3	8.4	23.7	4,117	27.0	11.9	38.9	4,076	4.8	15.0	19.8

[1] At any given storage interval, differences between cold and common storage significant at the 1 percent level ("t" test) unless preceded by:
[a] significant at the 5 percent level.
[b] not statistically significant.

of spoilage as fruit in cold storage for 12 weeks. After the 2-week period in common storage, the unscreened berries were screened and prepackaged and then held an additional 1 week at 70° or 2 weeks at 40° F.[4] Such prepackaged fruit, however, had only one third the amount of spoilage when compared with prepackaged berries derived from unscreened fruit held in cold storage for 12 weeks. The significance of these observations will be explained later.

Unscreened fruit kept either in common or cold storage for 6 weeks and then screened and prepackaged, held up equally well after an additional 2 weeks at 40° F. On the other hand, when the additional holding period for such fruit was 1 week at 70° F., the berries originally from cold storage showed 3.6 percent of spoilage as compared with 9.3 percent from common storage. Fruit kept for a prolonged storage period of 19 weeks, although refrigerated, did not hold up after being screened and prepackaged; the amount of spoilage after 2 additional weeks at 40° F. being 14.4 percent and mostly caused by physiological breakdown.

Screened cranberries

Fruit in cold storage held up well for 6 weeks (table 3). The total spoilage was 2.9 percent upon removal from storage and 4.5 percent after an additional 2-week holding period at 40° F. After 12 weeks, the fruit in cold storage had 5.9 percent of decay, which is greater than the grade standard of 3 percent allowed at shipping point (10). Fruit in common storage developed 4.4 percent of decay after only 2 weeks, and would have failed to meet grade standards unless rescreened.

Screened and prepackaged cranberries

At the end of 12 weeks in cold storage, spoiled fruit totaled 3.9 percent, and of this, 3.8 percent was due to decay (table 4). At the end of this storage period, fruit held 1 additional week at 70° F. showed 7.4 percent spoilage, while after 2 additional weeks at 40°, the figure was 8 percent. Screened and prepackaged cranberries held in common storage for only 2 weeks gave approximately the same results as the fruit in cold storage for 12 weeks.

The Effect of Handling on Keeping Quality

Fungal decay

The results in tables 5, 6, and 7 show that unscreened cranberries, not disturbed by handling, keep better in storage than fruit which had been screened or screened and prepackaged prior to storage. At the end of 6 weeks in cold storage, increases in decay for lots A, B, and C [respectively] were: unscreened berries 0.0, 1.2, and 0.4 percent and screened berries 2.3, 3.8, and 2 percent. At the end of 12 weeks of cold storage, increases in decay for lots A, B, and C [respectively] were: unscreened berries 1, 2.9, and 2.5 percent and screened berries 4.1, 7.4, and 6.3 percent. At the end of 19 weeks, again there was less increase in decay for the unscreened as compared with the screened fruit.

Handling fruit upon removal from storage increased its susceptibility to decay, and the older the fruit the greater the susceptibility. This can be seen after holding an additional 1 week at 70° F. (tables 5, 6, and 7). Thus, cranberries which were screened and prepackaged before going into storage, and not subjected to further handling, consistently showed less increases in decay than fruit that was screened or prepackaged upon removal from storage.

---

[4] Preceded by a simulated transit period of 1 week at 40° F.

Table 3.--Keeping quality of screened cranberries (combined data from lots A, B, and C)

Type of storage	Weeks in storage	After removal from storage				Followed by prepackaging and "transit" for 1 week at 40° F.							
						After 1 week at 70° F.				After 2 weeks at 40° F.			
		Total no. berries	Decayed	Other breakdown	Spoiled[1]	Total no. berries	Decayed	Other breakdown	Spoiled[1]	Total no. berries	Decayed	Other breakdown	Spoiled[1]
			Percent	*Percent*	*Percent*		*Percent*	*Percent*	*Percent*		*Percent*	*Percent*	*Percent*
Cold	2	3,612	3.0	0.2	[b] 3.2	3,601	5.7	0.2	[b] 5.9	3,671	3.9	0.1	[a] 4.0
	6	3,627	2.7	0.2	2.9	3,648	7.5	0.1	7.6	3,678	4.4	0.1	4.5
	12	3,766	5.9	0.1	[b] 6.0	3,944	16.5	0.7	17.2	3,858	8.1	5.3	13.4
	19	3,888	8.3	3.0	11.3	[2] 2,665	26.8	6.5	33.3	[2] 2,724	12.3	8.0	20.3
Common	2	3,790	4.4	0.3	4.7	3,844	6.9	0.3	7.2	3,891	5.9	0.3	6.2
	6	4,048	6.8	0.5	7.3	3,962	14.0	0.9	14.9	3,969	9.7	0.9	10.6
	12	4,037	8.2	0.2	8.4	4,090	30.8	8.3	39.1	4,083	14.4	16.1	30.5
	19	4,146	15.3	13.2	28.5	[2] 2,737	37.0	10.7	47.7	[2] 2,753	17.0	21.9	38.9

[1] At any given storage interval, differences between cold and common storage significant at the 1 percent level ("t" test) unless preceded by:
[a] significant at the 5 percent level.
[b] not statistically significant.

[2] Footnote 2 applies to the 4 figures for 19 day storage followed by 1 week at 70° and 2 weeks at 40°. Data from lots A and C only.

Table 4.--Keeping quality of screened prepackaged cranberries (combined data from lots A, B, and C)

Type of storage	Weeks in storage	After removal from storage				Followed by "transit" for 1 week at 40° F.							
						After 1 week at 70° F.				After 2 weeks at 40° F.			
		Total no. berries	Decayed	Other breakdown	Spoiled[1]	Total No. berries	Decayed	Other breakdown	Spoiled[1]	Total no. berries	Decayed	Other breakdown	Spoiled[1]
			Percent	*Percent*	*Percent*		*Percent*	*Percent*	*Percent*		*Percent*	*Percent*	*Percent*
Cold	2	3,693	2.3	0.4	[a] 2.7	3,674	4.6	0.4	[a] 5.0	3,706	4.0	0.6	[a] 4.6
	6	3,667	2.8	0.3	3.1	3,765	4.4	0.3	4.7	3,777	4.9	1.4	6.3
	12	3,776	3.8	0.1	3.9	3,802	7.2	0.2	7.4	3,905	6.0	2.0	8.0
	19	3,834	6.0	4.3	10.3	3,778	12.9	5.0	17.9	3,764	8.4	5.5	13.9
Common	2	3,703	3.3	0.8	4.1	3,655	7.8	0.4	8.2	3,663	5.3	1.0	6.3
	6	3,863	5.4	0.1	5.5	3,615	8.3	0.3	8.6	3,714	10.3	0.1	10.4
	12	3,706	8.8	0.1	8.9	3,651	14.5	0.2	14.7	3,663	11.0	4.4	15.4
	19	3,639	10.7	11.4	22.1	3,701	21.9	13.7	35.6	3,651	14.4	14.2	28.6

[1] At any given storage interval, differences between cold and common storage significant at the 1 percent level ("t" test) unless preceded by:
[a] significant at the 5 percent level.

Table 5.--Increase in decay due to handling after 6 weeks cold storage at 40° F.

Lot	Storage treatment	Decay			Treatment after storage	Decay		
		Before storage	After storage			Before holding	After holding 1 week at 70° F.[1]	
			Increase	Total			Increase	Total
		Percent					*Percent*	
A	None (unscreened)	1.5	0.0	1.1	Screened and prepackaged	0.0	2.8	2.8
	Screened	0.0	2.3	2.3	Prepackaged	2.3	4.2	6.5
	Screened and prepackaged	0.0	2.4	2.4	None	2.4	1.3	3.7
B	None (unscreened)	2.9	1.2	4.1	Screened and prepackaged	0.0	4.5	4.5
	Screened	0.0	3.8	3.8	Prepackaged	3.8	5.5	9.3
	Screened and prepackaged	0.0	3.2	3.2	None	3.2	1.2	4.4
C	None (unscreened)	2.0	0.4	2.4	Screened and prepackaged	0.0	3.4	3.4
	Screened	0.0	2.0	2.0	Prepackaged	2.0	4.8	6.8
	Screened and prepackaged	0.0	2.9	2.9	None	2.9	2.2	5.1

[1] Following "transit" for 1 week at 40° F.

Table 6.--Increase in decay due to handling after 12 weeks cold storage at 40° F.

Lot	Storage treatment	Decay			Treatment after storage	Decay		
		Before storage	After storage			Before holding	After holding 1 week at 70° F.[1]	
			Increase	Total			Increase	Total
		Percent					*Percent*	
A	None (unscreened)	1.5	1.0	2.5	Screened and prepackaged	0.0	10.8	10.8
	Screened	0.0	4.1	4.1	Prepackaged	4.1	12.4	16.5
	Screened and prepackaged	0.0	3.1	3.1	None	3.1	3.9	7.0
B	None (unscreened)	2.9	2.9	5.8	Screened and prepackaged	0.0	11.0	11.0
	Screened	0.0	7.4	7.4	Prepackaged	7.4	9.2	16.6
	Screened and prepackaged	0.0	4.1	4.1	None	4.1	2.3	6.4
C	None (unscreened)	2.0	2.5	4.5	Screened and prepackaged	0.0	9.5	9.5
	Screened	0.0	6.3	6.3	Prepackaged	6.3	10.0	16.3
	Screened and prepackaged	0.0	4.0	4.0	None	4.0	4.1	8.1

[1] Following "transit" for 1 week at 40° F.

Table 7.--Increase in decay due to handling after 19 weeks cold storage at 40° F.

Lot	Storage treatment	Decay			Treatment after storage	Decay		
		Before storage	After storage			Before holding	After holding 1 week at 70° F.[1]	
			Increase	Total			Increase	Total
		Percent					*Percent*	
A	None (unscreened)	1.5	3.3	4.8	Screened and prepackaged	0.0	22.8	22.8
	Screened	0.0	7.1	7.1	Prepackaegd	7.1	17.3	24.4
	Screened and prepackaged	0.0	5.8	5.8	None	5.8	4.5	10.3
B	None (unscreened)	2.9	8.6	11.5	Screened and prepackaged	0.0	19.6	19.6
	Screened	0.0	9.1	9.1	Prepackaged	---	---	---
	Screened and prepackaged	0.0	5.2	5.2	None	5.2	7.5	12.7
C	None (unscreened)	2.0	5.6	7.6	Screened and prepackaged	0.0	18.5	18.5
	Screened	0.0	8.7	8.7	Prepackaged	8.7	20.5	29.2
	Screened and prepackaged	0.0	7.0	7.0	None	7.0	8.3	15.3

[1] Following "transit" for 1 week at 40° F.

Bruising and physiological breakdown

Spoilage by bruising and physiological breakdown was evident after 19 weeks of cold storage; and for lots A, B, and C bruising ranged from 1.6 to 4.7 percent and physiological breakdown ranged from 0.2 to 1.3 percent (table 8). There was no apparent difference between unscreened and screened fruit. However, when such fruit was handled by screening and prepackaging, and then held 2 additional weeks at 40° F., there were great increases in bruising and physiological breakdown. Prepackaged berries, on the other hand, stored for 19 weeks and then held without further handling showed only slight increases in bruising or physiological breakdown. The results for 1 week at 70° F. are not presented, since the great amount of decay which developed at this temperature obscured the spoilage pattern for bruising and physiological breakdown.

Keeping Quality Between Different Lots

Figure 3 shows the amount of decay developed in common storage during 19 weeks. This confirms the selection categories that lot A consisted of good keepers, lot B fair keepers, and lot C poor keepers. The results for the cold storage series are not presented since, under refrigeration, decay and other types of spoilage were generally held down and the differences between lots were not outstanding. After keeping unscreened berries in common storage for 19 weeks, lot A had the least decay whereas lot C had the most (fig. 4). However, after screening and prepackaging and holding for 1 additional week at 70° F., lot A had the most amount of decay and physiological breakdown, while lot C had the least.

Other Observations

Screening cold berries

Throughout the 19-week cold storage period, unscreened fruit kept at 40° F. were allowed to warm up overnight to about 65° before screening and prepackaging. The subsequent 1- and 2-week holding periods showed no differences between such fruit and cranberries which were screened immediately after being removed from refrigerated storage.

Center discoloration

When some berries are cut, a red area can be seen around the seed cavity. The amount of discoloration can vary from slight to moderate. Hruschka and Kaufman (3) refer to this condition as slight or moderate physiological breakdown. Such berries are otherwise sound and, therefore, commercially acceptable. Red centers in cranberries may be due to several factors, one of which is aging. Since refrigeration retards the aging processes, cranberries kept in cold storage showed less center discoloration than fruit held in common storage. For both types of storage, the greatest increase in the number of berries showing center discoloration occurred between the second and sixth week. Because of the increase in decay and severe physiological breakdown, fewer cranberries were detected with center discoloration after 19 weeks than after 12 weeks storage. Only lot C (poor keepers) showed that handling before storage increased the amount of center discoloration.

Insect damage

Spoilage from insect damage was of field origin, and did not increase during storage. For the 3 lots of fruit the range of spoilage was 0.5 to 1 percent.

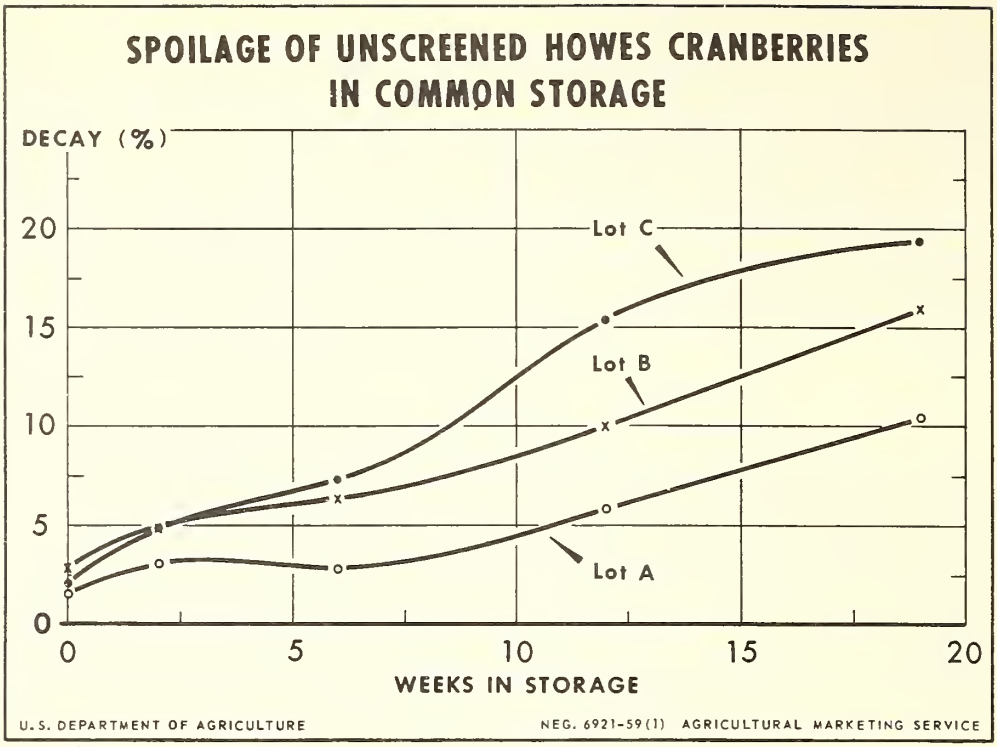

Figure 3

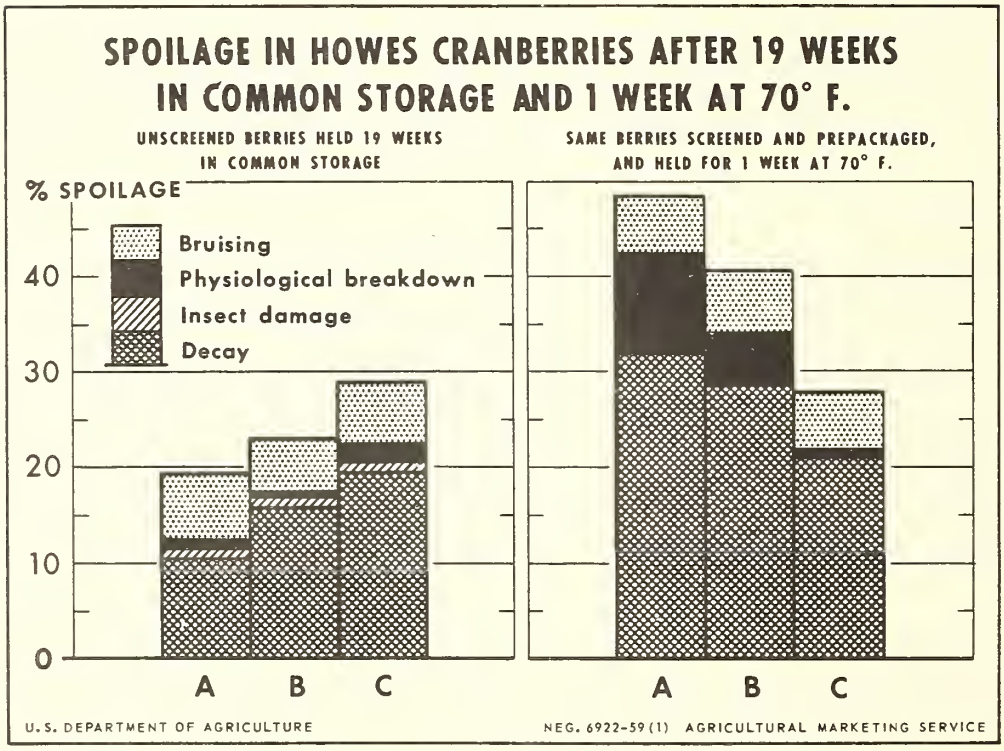

Figure 4

Table 8.--Increase in bruising and physiological breakdown due to handling after 19 weeks cold storage at 40° F.

Lot	Storage treatment	After storage		Treatment after storage	Bruising			Physiological breakdown		
		Bruising	Physiological breakdown		Before holding	After holding 2 weeks at 40° F.[1]		Before holding	After holding 2 weeks at 40° F.[1]	
						Increase	Total		Increase	Total
		Percent	*Percent*			*Percent*			*Percent*	
A	None (unscreened)	2.4	0.4	Screened and prepackaged	0.0	5.0	5.0	0.0	9.5	9.5
	Screened	1.6	0.5	Prepackaged	1.6	5.2	6.8	0.5	4.0	4.5
	Screened and prepackaged	3.0	0.7	None	3.0	1.2	4.2	0.7	0.6	1.3
B	None (unscreened)	1.7	0.2	Screened and prepackaged	0.0	2.1	2.1	0.0	5.1	5.1
	Screened	1.6	0.8	Prepackaged	---	---	---	---	---	---
	Screened and prepackaged	3.8	0.4	None	3.8	1.6	5.4	0.4	0.3	0.7
C	None (unscreened)	4.7	1.0	Screened and prepackaged	0.0	5.6	5.6	0.0	5.5	5.5
	Screened	2.7	1.3	Prepackaged	2.7	0.0	[2] 1.7	1.3	1.7	3.0
	Screened and prepackaged	3.6	0.6	None	3.6	0.0	[2] 2.6	0.6	1.2	1.8

[1] Following "transit" for 1 week at 40° F.
[2] Probably the originally bruised fruit became decayed, while the incidence of new bruising was very low.

Fungi causing decay

Cultures were made from over 1,700 decayed cranberries comprising representative samples of lots A, B, and C from all the storage intervals as well as the subsequent 1- and 2-week holding periods. The principal decay fungi and the percentages found were: Penicillium spp., 21.8 percent; Acanthorhyncus vaccinii Shear, 13 percent; Phoma sp., 12.3 percent; Sporonema oxycocci Shear, 11.4 percent; Godronia cassandrae Pk., 7.2 percent; Pestalotia vaccinii (Shear) Guba, 6.7 percent; and Ceuthospora lunata Shear, 2.8 percent.

Decays due to Penicillium and Phoma increased with the length of time in storage. The amount due to Godronia increased during cold storage but tended to decrease in common storage, whereas, the reverse was true for Pestalotia. Sporonema remained constant throughout. Acanthorhyncus increased up to 6 and 12 weeks in storage and thereafter decreased sharply.

Flavor

All fruit classified as salable, regardless of treatment or length of time in storage, was acceptable in flavor when cooked.

DISCUSSION

This study demonstrated the benefit of refrigeration in prolonging the storage life of cranberries and confirms reports made by earlier workers (6, 8). In addition, it was observed that cranberries from cold storage also had an extended shelf life. It has been shown that prestorage handling increased the amount of decay, bruising, and physiological breakdown during storage, and was in agreement with the findings of Shear et al (7). Beattie and Demoranville (1) in a recent survey reported that retail store samples had much more bruising than samples examined at the packing house (the length of time in storage and the holding periods were not specified). In the present study, post-storage handling of aged fruit also increased the incidence of spoilage, due mostly to bruising and physiological breakdown. For unscreened cranberries stored up to 12 weeks, such spoilage was not great. However, fruit held in common or cold storage for 19 weeks was markedly predisposed to spoilage following screening and prepackaging. Therefore, although cranberries held up well in cold storage for a period of 19 weeks, it is not advisable to ship such fruit to distant markets. A further study should determine whether such old fruit can be safely shipped to nearby markets for immediate consumption.

Hruschka and Kaufman (3) reported 8.5 percent of spoilage in prepackaged Howes stored for 12 weeks at 38° F., and 20.5 percent after holding for 1 additional week at 70° F. In the present study, prepackaged Howes, under the same storage and holding conditions, showed spoilages of only 3.9 and 7.4 percent respectively. It is not difficult to account for the higher spoilage losses encountered by the afore-mentioned workers. Hruschka and Kaufman reported that their fruit was commercially packaged during the middle of November. Before packaging, the fruit presumably had been held in common storage for at least 1 month following harvest. On the basis of the current study, such fruit would be considered more prone to spoilage than berries which had been stored under refrigeration immediately after harvest (although the fruit in the present study actually was held 1 week in Massachusetts common storage prior to refrigeration).

Beattie and Demoranville (1) stated that refrigeration at the retail store did not appear effective in reducing weight losses. It is not mentioned whether this conclusion is based on a short or prolonged holding period. In the present study, refrigeration is of slight value in cutting down weight losses when considered only at the end of 2 weeks of storage. However, at the end of 6 weeks, the benefit of refrigeration is quite apparent. Adequate refrigeration diminishes weight losses during prolonged storage by curtailing the metabolic rate of sound fruit as well as retarding decay development.

Some interesting results showed up when comparing the keeping quality of 3 different lots of fruit. The unscreened fruit in common storage held up just as originally designated, that is, lot A was good, lot B was fair, and lot C was of poor keeping quality. However, when held in cold storage, there were no appreciable differences between the keeping quality of the 3 lots. Unscreened fruit designated as poor keepers, after 19 weeks in common storage and followed by prepackaging, held up at least as well as or better than fruit designated as fair or good keepers. Hence, it would seem that the keeping quality in common storage is not necessarily related to shelf life quality. Of course, this evaluation is based only on the present study. A further investigation should be made, at least for another season, and also should involve various lots of fruit known to be poor keepers in storage.

LITERATURE CITED

(1) Beattie, J. R., and Demoranville, I. E.
1958. A Fresh Cranberry Market Survey. Mass. Agr. Expt. Sta. Bul. 501. 12 pp.

(2) Franklin, H. J., and Stevens, N. E.
1946. Weather and Water as Factors in Cranberry Production. Mass. Agr. Expt. Sta. Bul. 433. 51 pp.

(3) Hruschka, H. W., and Kaufman, J.
1949. Storage of Prepackaged Cranberries. Pre-pack-age 3: 18, 20, 22, and 32.

(4) Kaufman, J., Benfield, P. L., and Harding, P. R. Jr.
1955. Shipping Tests with Massachusetts-Grown Cranberries in Conventional Refrigerator Cars with Standard Ventilation and in Mechanically Refrigerated Cars. U. S. Dept. Agr. AMS-187 (Processed).

(5) _____, Ringel, S. M., Hamer, A. A., and others.
1958. Effect of Precooling on Market Quality of Cranberries Shipped by Rail and Truck. Mktg. Res. Rpt. No. 287, U. S. Dept. Agr., Dec.

(6) Levine, A. S., Fellers, C. R., and Gunness, C. I.
1940. Carbon Dioxide-Oxygen and Storage Relationships in Cranberries. Amer. Soc. Hort. Sci. Proc. 38: 239-242.

(7) Shear, C. L., Stevens, N. E., Wilcox, R. B., and Rudolph, B. A.
1918. Spoilage of Cranberries After Harvest. U. S. Dept. Agr. Dept. Bul. 714. 20 pp.

(8) Wright, R. C., Demaree, J. B., and Wilcox, M. S.
1937. Some Effects of Different Storage Temperatures on the Keeping of Cranberries. Amer. Soc. Hort. Sci. Proc. 34: 397-401.

(9) _____, Rose, D. H., and Whiteman, T. M.
1954. The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks. U. S. Dept. Agr. Handbook 66. 77 pp.

(10) United States Agricultural Marketing Service.
1956. U. S. Consumer Standards for Fresh Cranberries, Effective August 7, 1956. Federal Register 21: 5031.

☆U. S. GOVERNMENT PRINTING OFFICE : 1959 O -499914