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MARKET STORAGE STUDIES OF HONEY DEW MELONS AND CANTALOUPS

WIANT, P. S.

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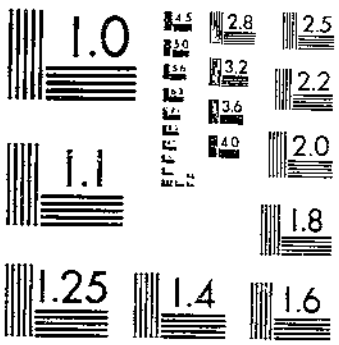

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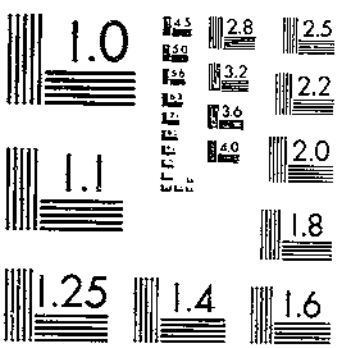

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MARKET-STORAGE STUDIES OF HONEY DEW MELONS AND CANTALOUPS

By

JAMES S. WIANT

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Bureau of Plant Industry

UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

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By JAMES S. WIANT

Associate pathologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry

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INTRODUCTION

The present study was suggested by the need for information concerning a peculiar type of break-down that was found from time to time during the fall of 1931 in commercial lots of Honey Dew melons that had recently been removed from cold storage in New York City. The condition of the melons together with their history suggested that they had been adversely affected by being held in storage, yet there was no reason to believe that they had been frozen. Through conversations with managers of cold-storage warehouses at New York it was learned that this type of trouble was of more or less regular occurrence on stored Honey Dew melons, but that little was known concerning it. Attention was then directed to the broader problem of storage methods. It was found that the usual commercial practice was to store these melons (as well as all other types of muskmelons) at a temperature ranging between 32° and 34° F., but that considerable uncertainty existed regarding the length of time they could be successfully held at this temperature.

A search of the literature revealed no description of the storage break-down here encountered and indicated a paucity of information on the more general problem of muskmelon storage. Such experiments

[1] Received for publication November 1, 1937.

[2] Although a strict taxonomic usage of the term "cantaloup" would limit it to members of *Cucumis melo* var. *cantalupensis*, it has come to be generally used in the United States to designate the small, green-skinned, netted muskmelons, *C. melo* var. *reticulatus*, and it is employed in the latter sense in this bulletin. "Muskmelon" is a group name used to designate all kinds of melons other than watermelons and includes cantaloups, Honey Dew, Honey Ball, Casaba, Persian, Spanish, and other related melons.

as were described dealt chiefly with melons that had been placed in storage soon after the time of harvest. It appeared desirable, therefore, to conduct storage tests with both Honey Dew melons and cantaloups after their arrival on the New York market from Western States, and consequently after they had been subjected to a sweating period following their removal from refrigerated cars.[3] Such experiments were begun in the latter months of 1931 and continued at irregular intervals until the late fall of 1936. This bulletin, therefore, brings together the results obtained over this 5-year period. Its purpose is (1) to describe in detail and to illustrate the low-temperature breakdown of Honey Dew melons and to indicate what decays are commonly encountered in the storage of these melons and of cantaloups, and (2) to suggest on the basis of the tests that were made what storage practices are likely to be successful in the holding of Honey Dew melons and cantaloups after their receipt on the market.

REVIEW OF LITERATURE

Chace, Church, and Denny (*3*)[4] found that cantaloups stored for 10 days at temperatures of about 35° to 40° F. did not change materially in composition either during storage or immediately afterward.

Rosa (*9*) reported tests in which cantaloups picked at the "half-slip" stage of maturity were stored for 10 days at 38° F. Although there was some yellowing of the rind, the flesh remained firm and sweet during the storage period, and the cantaloups ripened normally following their removal to 72°.

Rose, Wright, and Whiteman (*10*) state that cantaloups tended to become pitted and to deteriorate in flavor when stored for about a week at 32° to 36° F. Honey Dew and Honey Ball melons likewise developed some pitting at these temperatures. These investigators recommend storage at 50° to 55° (with a relative humidity of 75 to 85 percent) for all types of muskmelons.

Plafenius, Jamison, and Thompson (*6*) report that in a single cantaloup storage test mature melons were successfully held for a month at 32° F. Beyond that time mold and decay caused a rapid deterioration of the fruit.

Wardlaw, Leonard, and Baker (*12*) found that cantaloups when held at 45° or 50° F. for 15 to 20 days developed a poor flavor and were affected with various decays.

A report from the Arizona Agricultural Experiment Station (*1*) states that cantaloups stored below 40° F. developed an objectionable flavor and were rubbery in texture. At 40° to 50° hard ripe melons were held successfully for more than a week. Owing to the development of storage diseases, temperatures above 50° were not found practicable.

Harvey, Combs, Landon, and Child (*4*) have shown that cantaloups and Honey Dew melons can be successfully held for long periods in a frozen condition at or near 0° F.

Ramsey, Wiant, and Link (*7*) have recently called attention to and briefly described the low-temperature break-down of Honey Dew melons.

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[3] Practically all of the domestic Honey Dew melons and approximately 60 percent of the cantaloups annually received on the New York market are grown in California, Arizona, Colorado, and Utah and are shipped to this market by rail, usually under standard refrigeration. Honey Dew melons and cantaloups together constitute about 80 percent of all muskmelons annually received by rail at New York.

[4] Italic numbers in parentheses refer to Literature Cited, p. 18.

METHODS

All of the melons used in the tests were produced in Arizona, California, Colorado, or Utah, and shipped to the New York market by rail mostly under standard refrigeration. The test crates were obtained on the sales pier from commercial carlots within a few hours after the cars were unloaded. An attempt was made to secure melons only from cars that were unloaded promptly upon arrival.

The melons for a given test were carefully selected from a single carlot for uniformity in brand, size, general appearance, and degree of ripeness. One or two crates were set aside for removal to the laboratory, where they were later examined; the others were taken directly to a commercial cold-storage warehouse where they were divided into the proper number of lots and each stored at the desired temperature. From 2 to 8 hours usually elapsed between the time of unloading and that of placing the crates in storage. During that period the melons had become wet with moisture condensed from the air and had warmed up several degrees.

Much of the work was carried out with comparatively small lots and during the late summer months when little commercial fruit was in storage, hence it was found necessary to use only such temperatures as were available at the time. The use of comparatively small rooms in which commercial lots of produce were constantly being moved in and out necessarily prevented holding the temperatures constant in the neighborhood of the small lot of test melons. Sufficient records were obtained, however, to insure that the temperature did not fluctuate beyond the limits indicated. Three temperature ranges were employed, namely, 32° to 34°, 36° to 38°, and 40° to 42° F., supplemented occasionally with the 38° to 40° range. The temperature ranges in all cases refer to actual fruit temperatures. The relative humidity of the air in the several storage rooms varied between 75 and 85 percent.

At varying intervals one or more crates were removed from each temperature and brought to the laboratory for observation. The methods of examining the melons, either those set aside as typical of the entire lot prior to initiating the test or those removed after a certain period of storage, were the same at all times. With cantaloups this consisted in first noting the condition of the unopened crate, especially the general appearance of the melons and any evidence of slackness in the pack. The cantaloups were then removed and individual records were taken on general appearance, color, firmness, mold, and decay. After this the melons were cut to determine the internal appearance and to test the flavor. The cantaloups were usually kept under observation for 1 to 3 days; however, most of them were cut and tasted on the particular day when they appeared to be at their prime for consumption. Much the same method was used with Honey Dew melons except that most of them were kept for 3 to 7 days and some were held even longer.

RESULTS WITH HONEY DEW MELONS

TESTS OF 1931–33

Five small-scale tests were made with Honey Dew melons during the period 1931–33. Although these tests were of a limited nature,

and therefore are not reported here in detail, they indicated that Honey Dew melons are subject to a type of low-temperature disease that develops on stored stock after about 2 weeks at temperatures in the neighborhood of 32° to 34° F. It was also brought out in these tests that storage at temperatures appreciably above the 40° to 42° range is not practicable because of the more rapid development of mold and decay.

Cladosporium rot, and to a lesser extent other decays, were found active at and somewhat below 40° to 42° F. A description of the two chief storage diseases, low-temperature break-down and cladosporium rot, is therefore presented below. Following this there are presented in detail the results of tests conducted in the period 1934–36 in which an attempt was made to learn more about the conditions conducive to the development of storage diseases and therefore to determine what practices are desirable for the storage of Honey Dew melons.

DESCRIPTION OF STORAGE DISEASES

LOW-TEMPERATURE BREAK-DOWN

Low-temperature break-down of Honey Dew melons, as indicated by the name, is a breaking down of the epidermis and rind of the melon resulting from continued exposure to low (cold-storage) temperatures.[5] It is distinct from and in no way related to freezing injury, inasmuch as it develops at temperatures well above the freezing point of Honey Dew melons.[6] Although it is frequently followed by decay, low-temperature break-down does not result from the action of fungi, bacteria, or other organisms. The disease may therefore be considered as a functional disorder resembling in certain respects soggy break-down or soft scald of apples (*5*), watery break-down, pitting, and scald of grapefruit (*2*), and pitting or blotching of limes (*11*).

The symptoms of low-temperature break-down vary considerably with different lots of melons and with the time that has elapsed since their removal from cold-storage temperatures. Although there may be no evidence of break-down at the time of removal, the reverse is more frequently true. After removal of the melons, however, the symptoms become more pronounced with time.

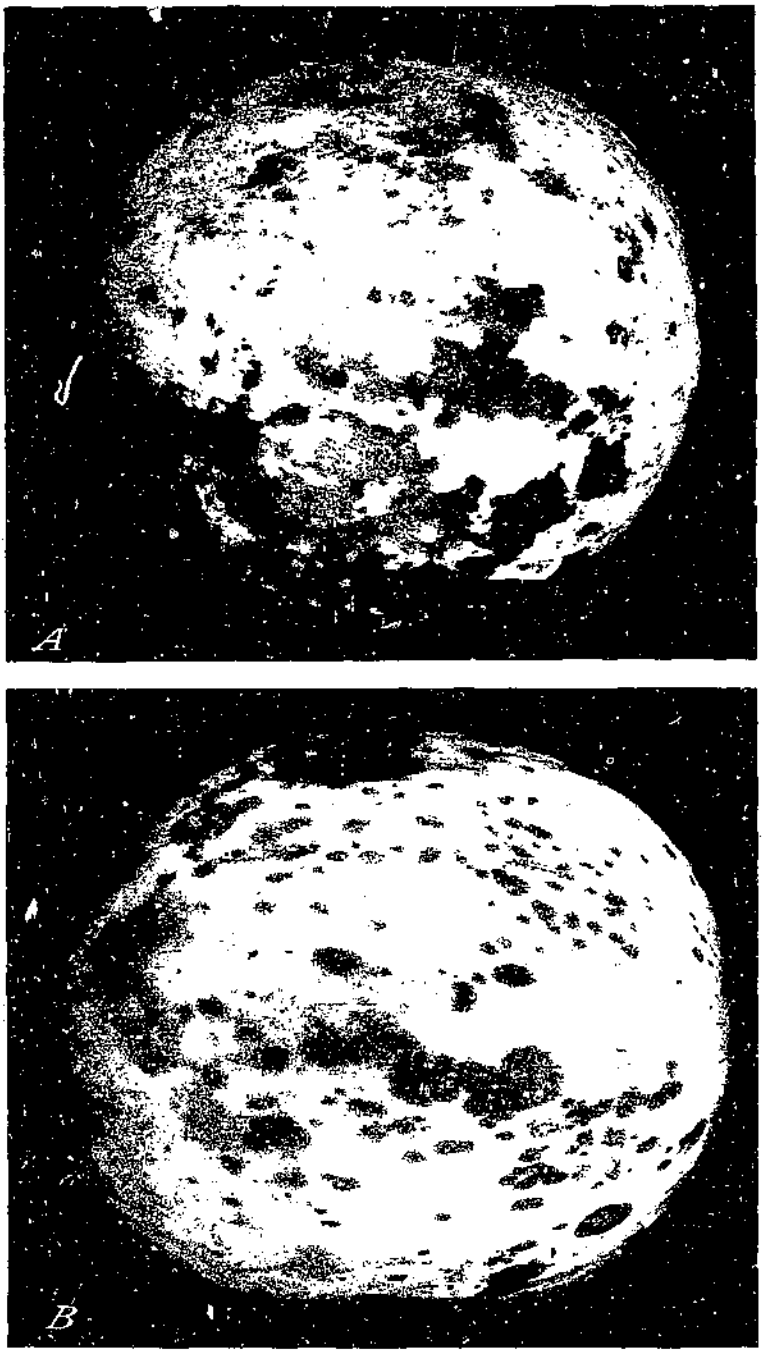
The disease may occur in the form of scattered areas of relatively small size (pls. 1 and 2) or in the form of large continuous areas (pls. 3 and 4) covering from a third to nearly all of the melon surface.

The first symptom is usually a faint water soaking of the rind accompanied by the oozing out of the melon juice so that the rind feels moist and sticky. This is most pronounced in severe cases where most of the surface of the melon is affected (pl. 3, *B*). In such cases the entire melon becomes softer, so that it exudes juice abundantly and flattens out gradually under the pressure of its own weight.

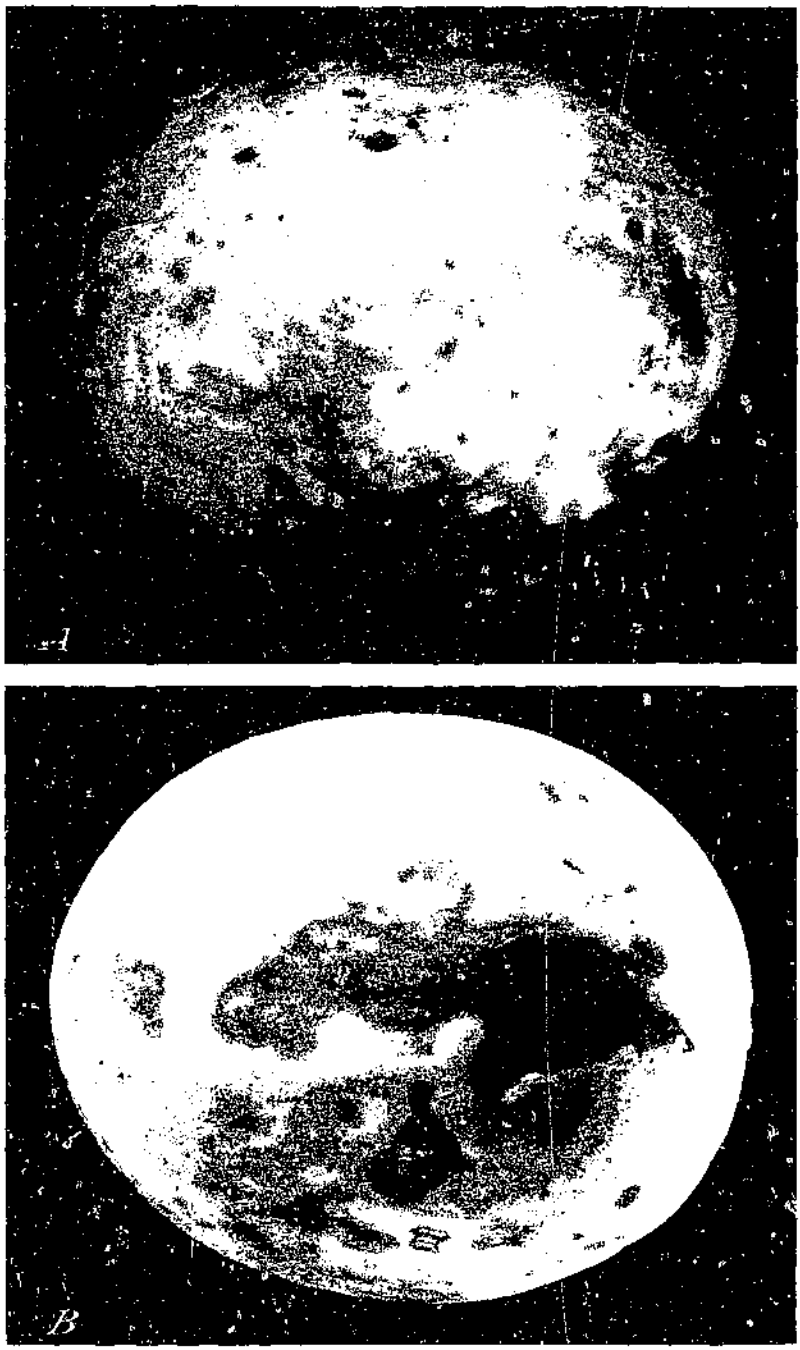
The initial faint water-soaked areas may develop a definite deep water-soaked appearance (pls. 1, *A* and *B*; pl. 3, *A*) and remain so without further color change. Although the term "water-soaked" is most descriptive, the color can be more accurately referred to as

[5] Symptoms indistinguishable from those of low-temperature break-down were observed on several occasions on Honey Dew melons that had been shipped under standard refrigeration and held under these conditions either in transit or on the truck at destination for a total of 17 days before unloading.

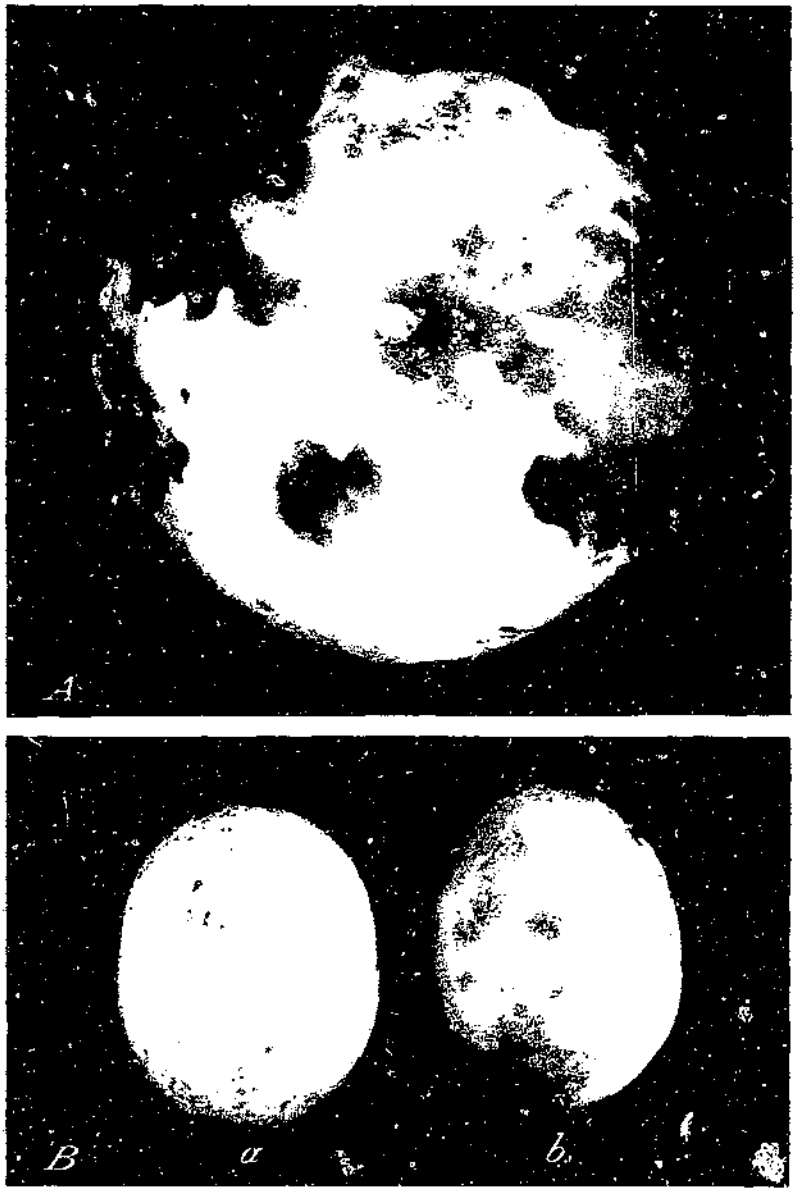
[6] The average freezing-point temperatures of Honey Dew melons are 28.8° F. for the rind and 29° for the flesh (*14*).



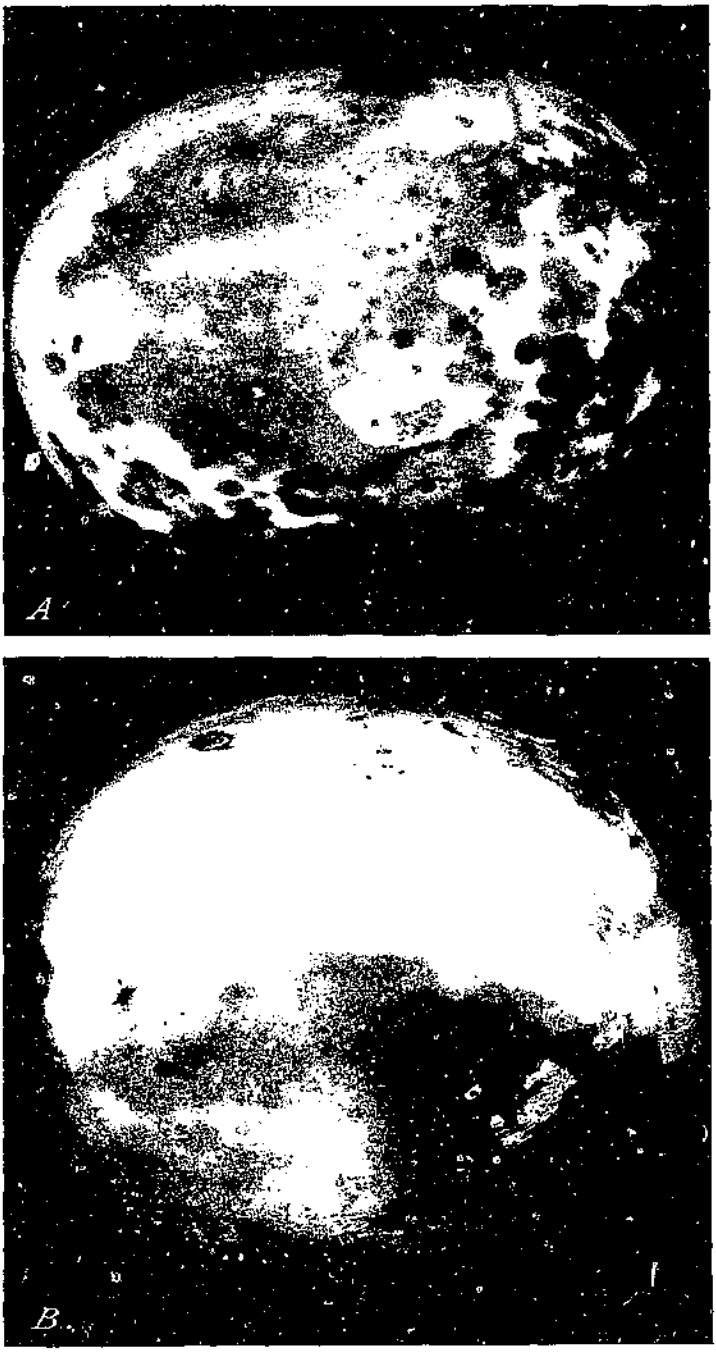
Low-temperature break-down of Honey Dew melons: *A*, Irregular water-soaked, slightly depressed areas; *B*, definite water-soaked spots with surface not depressed. Both melons photographed 3 days after removal from 4 weeks' storage at 32° to 34° F.



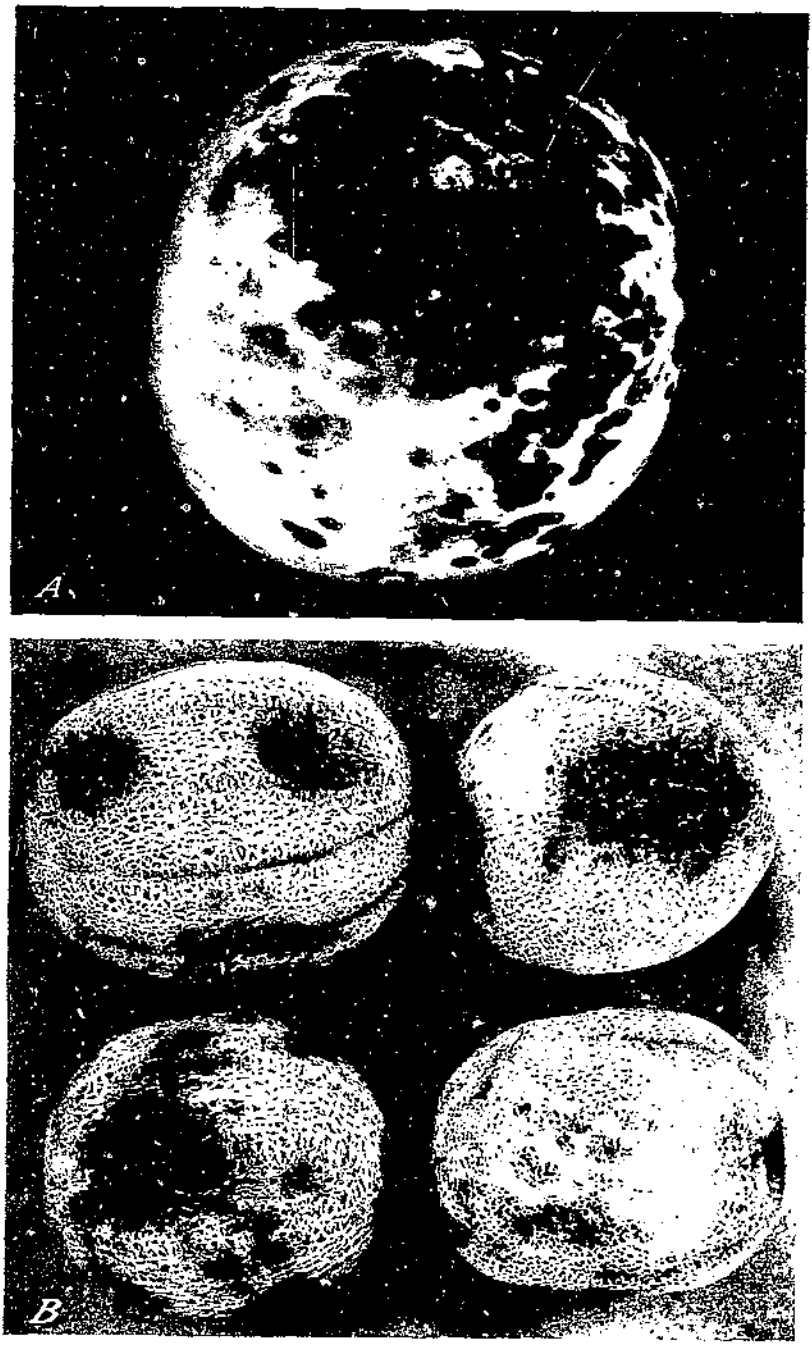
Low-temperature break-down of Honey Dew melons: *A*, Irregular "pale olive-buff," definitely sunken areas surrounding islands of unaffected tissue (right center); *B*, "tawny-olive" colored, sharply delimited, deeply sunken pitting. Both melons photographed 5 days after removal from storage at 32° to 34° F. for 2 weeks (*A*) and 4 weeks (*B*), respectively.



Low-temperature break-down of Honey Dew melons: *A*, Sharply delimited, definitely sunken water-soaked areas; *B*, nearly complete surface of melon (*b*) slightly sunken, somewhat discolored, and oozing sticky melon juices; unaffected melon (*a*) for comparison. Several black spots of rhodosporium rot evident on each of the stored melons. Both melons photographed 2 days after removal from 2 weeks' storage at 32° to 34° F.



Low-temperature break-down of Honey Dew melons: *A*, Large area of melon covered with "tawny-olive," definitely sunken, sharply delimited scaldlike lesion; *B*, similar to *A* except lesion is "clay color" and only slightly depressed. Melons photographed 2 days (*A*) and 5 days (*B*), respectively, after removal from 4 weeks' storage at 32° to 34° F.



Cladosporium rot. *A*, Honey Dew melon photographed 2 days after removal from 4 weeks' storage at 38° to 40° F. (Blue mold rot lesion conspicuous midway between center and top.) *B*, group of cantaloups photographed shortly after removal from 4 weeks' storage at 32° to 34° F.

"light mineral gray" [7] or "pale smoke gray." More frequently the lesion colors are either "drab" (along with the several tints of drab), "pale olive-buff" (pl. 2, *A*), "clay color" (pl. 4, *B*), "tawny olive" (pls. 2, *B*; 4, *A*), or various browns. A given lesion frequently changes in color, usually becoming darker or browner with age.

The lesions may be either indefinite in boundary (pls. 1, *A*; 2, *A*; 3, *B*) or sharply delimited (pls. 1, *B*; 2, *B*; 3, *A*; 4, *A* and *B*). The edges of the lesion may be either fairly regular or highly irregular.

The surface of the lesions varies from normal (pl. 1, *B*), to slightly sunken (pls. 1, *A*; 3, *B*; 4, *B*), to definitely sunken (pls. 2, *A*; 3, *A*; 4, *A*), or finally deeply sunken (pl. 2, *B*).

The net result of this pronounced variation in the size, shape, boundary, color, and depth of the lesions is a wide variety of symptoms. The disease, therefore, takes the form at times of spotting (pl. 1, *B*), pitting (pl. 2, *A* and *B*), watery break-down (pl. 3, *B*), and scald (pls. 3, *A*; 4, *A* and *B*). Frequently a given melon shows a combination of several types of symptoms. It is chiefly for this reason that the more general term "low-temperature break-down" has been adopted as the name for this disease.

Melons affected with low-temperature break-down show no internal symptoms of the disease. The flesh remains normal in appearance and texture, and except in severe cases the flavor is not affected. The disease affects directly only the epidermis and the rind tissues.

CLADOSPORIUM ROT AND OTHER DECAYS

Cladosporium rot (caused by the fungus *Cladosporium cucumerinum* Ell. and Arth.) was by far the most common decay present on Honey Dew melons at the time of their removal from cold storage or that developed on them soon after their removal. The disease has been discussed at length in a previous publication (*13*), consequently only a brief description of it will be given here.

Cladosporium rot can be recognized on stored Honey Dew melons (pls. 3; 4, *A*; 5, *A*) by the presence of numerous relatively small, scattered black spots that develop within the outer tissues of the rind. The epidermis at first is unbroken, so that the lesions have a smooth, shiny, black appearance; later the epidermis becomes broken and the causal fungus develops over the lesions as a low, velvety mold varying in color with age from "Vetiver green" to "Lincoln green," "deep olive," and finally black. The lesions, which are circular to oval in shape, vary in size from tiny specks to spots somewhat over an inch in diameter. They frequently coalesce to form large areas of shallow decay. Cladosporium rot is closely associated with low-temperature break-down. This relationship will be discussed more completely later on.

Several other decays of Honey Dew melons were met with during the storage studies, but none approached cladosporium rot in significance. In the order of the frequency of their occurrence, they are alternaria rot, fusarium rot, rhizopus soft rot, and blue mold rot. Early stages of all have been found at one time or another on melons at the time of their removal from cold storage. Complete descriptions of all have been published elsewhere (*13*).

[7] Color designations in quotations are according to Ridgway (*8*).

TABLE 1.—*Storage tests with Honey Dew melons, 1934–36*

Test No.	Date of storage	Flats stored	Melons per flat	Storage period	Condition after removal from storage at temperatures of—			
					32°–34° F.	36°–38° F.	38°–40° F.	40°–42° F.
		Number	*Number*	*Weeks*				
1	July 31, 1934.	6	9	3	(1 flat.) Half of melons disfigured by severe low-temperature break-down. No mold nor decay. Flavor nearly normal.	(1 flat.) A few melons slightly disfigured by low-temperature break-down. Practically no mold nor decay. Flavor nearly normal.	.....	(1 flat.) No low-temperature break-down. Considerable surface mold and early stages of shallow decay. Riper than those at the lower temperatures. Flavor nearly normal.
				4	(1 flat.) More low-temperature break-down than at 3 weeks. Flavor nearly normal.	(1 flat.) Practically no low-temperature break-down. Practically no mold nor decay. Flavor nearly normal.	.....	(1 flat.) No low-temperature break-down. More decay than at 3 weeks. Flavor impaired by decay.
2	Aug. 28, 1934.	8	8	2	(2 flats.) No low-temperature break-down. No mold nor decay. Flavor normal.	(2 flats.) No low-temperature break-down. No mold nor decay. Flavor normal.		
				4	(2 flats.) Nearly half of melons had from ¼ to ½ of the surface affected with low-temperature break-down, followed by decay several days after removal. Flavor impaired.	(2 flats.) ¼ of melons had large areas of surface affected with low-temperature break-down, followed by decay soon after removal. Flavor impaired.		
				2	(4 flats.) ¾ of the melons severely affected with low-temperature break-down. Practically no mold nor decay. Flavor nearly normal.	(2 flats.) No evidence of low-temperature break-down. Nearly all severely affected with mold and shallow decay. Flavor impaired.		
3	Oct. 9, 1934.	18	12	3	(4 flats.) Low-temperature break-down more severe than at 2 weeks. Practically no mold nor decay. Flavor impaired.	(2 flats.) Practically no low-temperature break-down. Mold and decay more severe than at 2 weeks. Flavor seriously impaired.		
				4	(4 flats.) Practically entire surface of all melons affected by low-temperature break-down, followed by decay soon after removal from storage. Practically inedible.	(2 flats.) Very slight amount of low-temperature break-down. Mold and decay worse than at 3 weeks. Inedible.		

				1	(1 flat.) No change resulting from storage.	(1 flat.) No change resulting from storage.		(1 flat.) No change resulting from storage.
				2	(1 flat.) No low-temperature break-down. ⅓ of the melons affected by moderate amounts of mold and shallow decay. Flavor normal.	(1 flat.) No low-temperature break-down. Practically no mold nor decay. Flavor normal.		(1 flat.) No low-temperature break-down. ⅙ of melons showed severe decay several days after removal from storage. Flavor impaired.
4	July 23, 1935.	12	12	3	(1 flat.) Half of the melons showed slight to severe low-temperature break-down. ⅓ showed a slight amount of mold and shallow decay. Flavor impaired.	(1 flat.) 1/10 showed a severe amount of low-temperature break-down. Nearly all of the melons were slightly to severely affected with early stages of decay. Flavor impaired.		(1 flat.) No low-temperature break-down. ⅔ of the melons showed moderate to severe amounts of mold and decay. Flavor seriously impaired.
				4	(1 flat.) Nearly all melons affected with low-temperature break-down, about half of which was slight to moderate and half severe. A few were seriously decayed. Flavor impaired.	(1 flat.) Practically no low-temperature break-down. All melons moderately to severely affected with mold and decay. Practically inedible.		(1 flat.) No low-temperature break-down. Practically all melons showed slight to severe decay. Inedible.
				2	(2 flats.) ¼ of the melons slightly to severely affected with low-temperature break-down. No mold nor decay. Flavor normal.	(2 flats.) A few melons had a slight amount of low-temperature break-down. Practically no mold nor decay. Flavor normal.		(2 flats.) No low-temperature break-down. Practically no mold nor decay. Flavor normal.
5	Sept. 18, 1935.	12	8	4	(2 flats.) Somewhat over half of the melons slightly to severely affected with low-temperature break-down. Practically no mold nor decay. Flavor somewhat impaired.	(2 flats.) Nearly half of the melons moderately to severely affected with low-temperature break-down. Somewhat over ¼ of them slightly to severely spotted with early stages of decay. Flavor impaired.		(2 flats.) No low-temperature break-down. ⅓ of the melons severely decayed, ⅓ slightly decayed. Many inedible; flavor of others impaired.
				2	(2 flats.) A few slightly affected with low-temperature break-down. A few overripe. Considerable decay developed soon after removal from storage. Flavor impaired.	.....	(2 flats.) No evidence of low-temperature break-down. A few overripe. About half of the melons showed decay. Many inedible. Flavor of others impaired.	
6	June 25, 1936.	8	12	4	(2 flats.) Approximately ½ of the melons moderately to severely affected with low-temperature break-down. Considerable decay developed within several days after removal from storage. Flavor seriously impaired.	.....	(2 flats.) No low-temperature break-down. Nearly all of the melons seriously decayed. Inedible.	

[1] The mold and decay referred to throughout the table were for the most part caused by *Cladosporium cucumerinum*.

TABLE 1.—*Storage tests with Honey Dew melons, 1934–36*—Continued

Test No.	Date of storage	Flats stored	Melons per flat	Storage period	Condition after removal from storage at temperatures of—			
					32°–34° F.	36°–38° F.	38°–40° F.	40°–42° F.
		Number	*Number*	*Weeks*				
				2	(2 flats.) A little low-temperature break-down present. Some decay occurred. Flavor nearly normal.	(1 flat.) No low-temperature break-down. Some decay developed several days after removal from storage. Flavor nearly normal.	.....	(1 flat.) No low-temperature break-down. Some decay present. Flavor nearly normal.
				3	(2 flats.) A few of the melons showed severe low-temperature break-down. Practically all of them developed decay during the first several days after removal from storage. Flavor somewhat impaired.	(1 flat.) No low-temperature break-down. Nearly half of the melons seriously decayed. Flavor seriously impaired.	.....	(1 flat.) No low-temperature break-down. About ¾ of the melons seriously decayed. Flavor seriously impaired.
7	Aug. 9, 1936.	12	12	4	(2 flats.) Nearly half of the melons seriously affected with low-temperature break-down. ½ of them showed early stages of decay at time of removal, with more developing during first several days after removal. Flavor seriously impaired.	(1 flat.) Practically no low-temperature break-down. Practically all the melons showed decay. Inedible.	.....	(1 flat.)[2] No low-temperature break-down. A few melons showed decay. Inedible.
				2	(2 flats.) A few melons slightly affected with low-temperature break-down. Practically no mold nor decay. Flavor normal.	.....	(2 flats.) No low-temperature break-down. ½ of the melons showed moderate to severe decay. Flavor impaired.	
8	Sept. 14, 1936.	8	9	4	(2 flats.) ½ of the melons slightly to severely affected with low-temperature break-down. Nearly all melons showed moderate to severe decay. Flavor seriously impaired.	.....	(2 flats.) No low-temperature break-down. All melons showed severe decay. Inedible.	

[2] This crate of melons was not typical of the general storage test lots. The melons were less mature, which probably accounts for the low amount of decay. The low flavor was largely the result of the immaturity.

STORAGE TESTS OF 1934-36

The results of eight storage tests conducted during the 3-year period 1934–36 are brought together in a condensed form in table 1. The statements made in the table regarding the condition of the melons after their removal from storage do not indicate for the most part just when the symptoms of low-temperature break-down and those of mold and decay first appeared. Therefore, in the absence of specific statement, they may have been in evidence at the time of removal or they may have developed afterwards.

Usually the earliest symptoms were evident, to some extent at least, when the melons were withdrawn and then rapidly became more prominent during the next several days. In all cases the observations reported in the table indicate the net effects of storage as determined by the condition of the melons during a holding period approximately equivalent to that required for normal commercial distribution.

It will be seen from table 1 that in test 1 low-temperature break-down was prevalent at 32° to 34° F. and mold and decay at 40° to 42°. The melons held up best at 36° to 38°, where actually the temperature was near the minimum point (36°) most of the time. There was little difference between the results of 3 weeks' and those of 4 weeks' storage at this middle temperature range.

Only the temperature ranges 32° to 34° and 36° to 38° F. (near 36° for most of the storage period) were used in test 2. The results of 2 weeks' storage were entirely satisfactory with either. Owing to the development of low-temperature break-down, however, 4 weeks' storage was detrimental to the melons at both temperature ranges, although it was more so at the lower one.

Test 3 was comparable to test 2 except that smaller-sized melons were used and sample flats were withdrawn at the end of 2 weeks as well as after 3 and 4 weeks. As in the two preceding tests, low-temperature break-down was serious at 32° to 34° F., whereas at 36° to 38° only a little occurred. Mold and decay, however, were serious at the higher temperature range. Storage at either temperature range was therefore decidedly unsatisfactory.

Storage for 1 week at any of the three temperature ranges was without effect in test 4. Much the same was true for the 2 weeks' storage except that mold and decay developed to some extent during the several-day holding period following removal from storage. Storage for 3 and 4 weeks was injurious to the melons at all three temperature ranges because of the development of low-temperature break-down (followed by decay) at 32° to 34° F. and of mold and decay at 36° to 38° and 40° to 42°.

In test 5 low-temperature break-down was a factor of importance in 2 weeks' storage at 32° to 34° F., whereas melons held at the two higher temperature ranges were practically unaffected in any way. Storage for 4 weeks was entirely unsatisfactory because of the development of low-temperature break-down at 32° to 34°, of mold and decay at 40° to 42°, and of a combination of the two at 36° to 38°.

Because of decay development, 2 weeks' storage was not entirely satisfactory in test 7 at any of the three temperature ranges. Three and four weeks' storage likewise was unsatisfactory because of the development of low-temperature break-down and decay at 32° to 34° F. and of decay at the other two temperature ranges.

The temperature ranges 32° to 34° and 38° to 40° F. were used in tests 6 and 8. In both tests low-temperature break-down developed only at the lower temperature range, very slightly in 2 weeks, and extensively in 4 weeks. Because of the development of decay either in storage or shortly after removal therefrom, 4 weeks' storage was not satisfactory at either temperature range in either of the two tests. For the same reason, 2 weeks' storage at 38° to 40° was unsatisfactory in both tests, and only in test 8 was it satisfactory at 32° to 34°.

Considerable variation exists among the results of these eight storage tests. This is to be expected in view of the fact that little was known regarding the history of the melons either in the field or in transit and that the tests were conducted over a 3-year period. Nevertheless, the tests do indicate within limits the relation of storage time and temperature to the development of low-temperature break-down, and they suggest what may be expected in the way of a storage life of Honey Dew melons under conditions similar to those met with in these tests. Thus low-temperature break-down was most prevalent at 32° to 34° F.; occasionally it occurred at 36° to 38°. It never developed at 40° to 42°, nor at 38° to 40° in the two tests where this temperature range was used. At the 32° to 34° range low-temperature break-down was of increasing importance with increasing length of the storage period, so that storage for longer than 2 weeks at this temperature range did not appear practicable. Not only did this storage disease detract from the appearance of the melons, even when present in small amounts, but when seriously present it was soon followed by mold and decay during the holding period.

Storage for periods longer than 2 weeks at 36° to 38° F. (particularly at the upper limit of this range), or at the higher temperature ranges used, would undoubtedly lessen or avoid losses from low-temperature break-down. Unfortunately, however, the greater prevalence of cladosporium mold and decay at these temperatures (particularly 38° to 40° and 40° to 42°) makes them impracticable for commercial storage. For 2 weeks' storage there was little net difference between 32° to 34° and 36° to 38°.

RESULTS WITH CANTALOUPS

TESTS OF 1931-33

During the 3-year period 1931–33 four small-scale storage tests were conducted with cantaloups. These tests indicated that cantaloups are not subject to a low-temperature break-down such as has been described for Honey Dew melons. They were, however, subject to mold and decay when stored for a longer period than 1 to 2 weeks even at temperatures as low as 32° to 34° F. Storage at temperatures much above 40° to 42° was found unsatisfactory because of rapid overripening and decay.

STORAGE DISEASES

The storage disease of chief importance on cantaloups during the tests reported in this bulletin was cladosporium rot, caused by *Cladosporium cucumerinum*, and described in detail elsewhere (*13*). Briefly, the decay is a shallow one that is confined to the rind and outer flesh immediately beneath. It may be found scattered over any portion of the cantaloup. Frequently it occurs at the stem scar,

where it develops as a thin, black, cushionlike pad that is easily removed. It develops most often at chafed and bruised spots where cantaloups come in contact with the crate or with one another.

This cladosporium decay can be recognized externally by the sparse "deep olive" to black mold that is scattered over the affected portions of the rind (pl. 5, *B*). The diseased rind is easily slipped off of affected cantaloups. The rot is frequently followed by bacterial soft rot and by rhizopus soft rot after the cantaloups have been removed from storage (*13*). Alternaria rot and fusarium rot (*13*) are also met with in cantaloups under such conditions.

STORAGE TESTS OF 1934-36

The results of six storage tests conducted during the period 1934-36 are summarized in table 2.

The melons used in test 1 (table 2) were representative of the less mature cantaloups that are received on the market. The test showed that a temperature range of 40° to 42° F. was too high for even 1 week's storage. Storage for 1 week at either 32° to 34° or 36° to 38° was fairly satisfactory, but 2 weeks' storage at the same temperature ranges was not.

Only the two lower temperature ranges were used in test 2. The cantaloups used represented about the average condition met with in western cantaloups on eastern markets. There was no difference in results between the two temperature ranges. Storage was satisfactory for 1 week but not for 2 weeks or longer. During this test the temperature of the 36° to 38° F. lot remained close to the minimum (36°) throughout most of the test, which may account for the close similarity of results with the two ranges.

In test 3 the crates removed from storage at the end of 1 week were allowed to stand in the laboratory, unopened, for 2 days. Some of the cantaloups were enclosed in paper wraps. The removal from storage was made during a period of high temperatures and high humidity. This combination of circumstances was conducive to the development of decay and may therefore account for that found in one of the two crates of each lot stored at either of the two lower temperature ranges. Two weeks' storage at 32° to 34° and 36° to 38° F. was generally satisfactory, although there were some slight defects evident. The test indicated again that a temperature range of 40° to 42° was too high for the storage of cantaloups under the conditions of these tests. And again, there was little difference in results between a range of 32° to 34° and one of 36° to 38°.

The melons used in test 4, although fully ripe and ready for immediate consumption, were representative of the better quality of cantaloups received on eastern markets. Their flavor was very good. Although slightly affected by 1 week's storage, it was still good in the melons from all three temperature ranges. Except in the matter of shriveling, there was very little difference among the melons held at any of the three temperatures after 1 week's storage. There was apparently some variation in the crates stored at 32° to 34° F., inasmuch as those removed after 2 weeks were not as far advanced as those of the 1-week removal. The results suggest, however, fairly satisfactory storage for 2 weeks at this temperature range and unsatisfactory storage at the two higher temperature ranges.

TABLE 2.—*Storage tests with cantaloups, 1934–36*

Test No.	Date of storage	Condition when stored	Containers stored	Cantaloups per container	Length of storage period	Condition after removal from storage at temperatures of—			
						32°–34° F.	36°–38° F.	38°–40° F.	40°–42° F.
				Number	*Weeks*				
1	July 15, 1934.	Maturity, half slip; green in color; mostly hard to firm; flesh crisp; flavor fair; variety, Perfecto, from Arizona.	6 jumbo crates.	45	1	(½ crate.) Practically normal in appearance and flavor. A very slight shriveling was the only noticeable effect of storage.	(½ crate.) Practically normal in appearance and flavor. A very slight shriveling was the only noticeable effect of storage.	.....	(½ crate.) Shriveled; disfigured where bruised; misshapen from pressure against crate and adjacent cantaloups. Some surface mold [1] present. Too soft for retail trade.
					2	(½ crate.) Flavor normal and unaffected by storage. ⅔ of the cantaloups were somewhat affected with surface mold,[1] ⅓ were slightly shriveled and disfigured where bruised and were misshapen from pressure against crate and adjacent cantaloups.	(½ crate.) Flavor normal and unaffected by storage. Surface mold seriously present in flattened and depressed spots where cantaloups came in contact with crate and with one another. Unsalable.	.....	(½ crate.) Unsalable because of surface mold and early stages of decay.
					3	(½ crate.) Unsalable because of surface mold and dry flesh.	(½ crate.) Unsalable because of mold and shallow decay.	.....	(½ crate.) Unsalable because of mold and decay.
					4	(½ crate.) Unsalable.	(½ crate.) Unsalable.	.....	(½ crate.) Unsalable.
2	Sept. 19, 1934.	Maturity, little beyond half slip; green to yellow in color; mostly firm; flavor fair; variety, Hale Best, from Utah.	12 flats	11	1	(2 flats.) Flavor normal and unaffected by storage. Flesh slightly dry and cantaloups slightly shriveled at bruised and chafed spots, but neither was of commercial importance.	(2 flats.) Flavor normal and unaffected by storage. Flesh slightly dry and cantaloups slightly shriveled at bruised and chafed spots, but neither was of commercial importance.	.....	.....
					2	(2 flats.) Flavor normal. Some shriveling, causing looseness of the pack. Some surface mold present, which advanced sufficiently during a 2-day ripening period at room temperature to affect the appearance adversely.	(2 flats.) Flavor normal. Some shriveling, causing looseness of the pack. Some surface mold present, which advanced sufficiently during a 2-day ripening period at room temperature to affect the appearance adversely.	.....	.....
					3	(2 flats.) Unsalable because of surface mold and shallow decay.	(2 flats.) Unsalable because of surface mold and shallow decay.	.....	.....

3	June 16, 1935.	Maturity, half slip to full slip; green in color; mostly hard; flavor fair; from Imperial Valley, Calif.[2]	10 crates.	36	1	(2 crates.) Flavor normal. Cantaloups unaffected by storage except that in 1 of the crates ⅕ of the melons were affected with rhizopus soft rot.	(2 crates.) Flavor normal. Cantaloups unaffected by storage except that in 1 of the crates ⅕ of the melons were affected with rhizopus soft rot.	.....	(1 crate.) All cantaloups moldy; soft from overripeness; worthless.
					2	(2 crates.) Cantaloups somewhat flabby and flesh slightly dry. Several melons in each crate had a little surface mold. Neither defect of great importance. Flavor normal.	(2 crates.) Cantaloups in practically the same condition as those stored at 32°-34°.	.....	(1 crate.) Soft, moldy, overripe; commercially worthless.
4	Sept. 3, 1935.	Maturity, mostly full slip; yellow in color; mostly ripe, a few soft; flavor very good; variety, Hale Best, from Utah.	12 flats	11	1	(2 flats.) Mostly yellow in color. Many ripe, but most soft and a few inedible on account of overripeness. Nearly all the cantaloups were affected with mold at the stem scar, although this was not of much importance. Flavor good.	(2 flats.) Condition much the same as that of the 32°-34° lot except that the cantaloups were somewhat further advanced in color and softness and were slightly inferior in flavor.	.....	(2 flats.) This lot had the least desirable appearance of any, owing to the large amount of shriveling. In other respects the cantaloups were similar to the 32°-34° lot.
					2	(2 flats.) Cantaloups mostly yellow, mostly ripe, many soft, several overripe. ¾ had slight stem-scar mold of little importance. Flavor good. As a lot, not as far advanced as that removed at the end of 1 week.	(2 flats.) Unsalable because of mold and shallow decay. Approximately ⅞ of the cantaloups were overripe. Neither defect was as severe as in the 40°-42° lot.	.....	(2 flats.) Commercially worthless because of abundant surface mold accompanied by early stages of decay and because of overripeness.
5	May 27, 1936.	Maturity, half slip to full slip; color green to yellow green; firm to ripe and somewhat spongy; flavor fair; from Imperial Valley Calif.[2]	11 flats	11	1	(4 flats.) Green to yellow green in color. Ripe (but spongy). Slightly shriveled. No mold nor decay. Flavor unaffected by storage.	.....	(2 flats.) Mostly yellow green in color. All ripe, a few spongy. No mold nor decay. Flavor unaffected by storage.	
					2	(3 flats.) Green to yellow green in color. Ripe, many spongy. Some shriveling. ⅔ of the cantaloups were affected with severe mold at the stem scar, in many instances followed by early stages of decay. Flavor practically unaffected by storage.	.....	(2 flats.) Commercially worthless because of mold and shallow decay.	

[1] The mold and decay referred to throughout the table were for the most part caused by *Cladosporium cucumerinum*.
[2] 1 of the partially resistant selections grown in the Imperial Valley before Mildew-Resistant No. 45 was widely available.

TABLE 2.—*Storage tests with cantaloups, 1934–36*—Continued

Test No.	Date of storage	Condition when stored	Containers stored	Cantaloups per container	Length of storage period	Condition after removal from storage at temperatures of			
						32°–34° F.	36°–38° F.	38°–40° F.	40°–42° F.
				Number	*Weeks*				
6	June 25, 1936.	Maturity, mostly full slip; green to yellow green in color; firm to ripe; flavor fair; from Imperial Valley, Calif.[2]	12 flats	9	1	(4 flats.) Yellow green to yellow in color. Practically all ripe. ¼ of the cantaloups either slightly decayed or affected with moderate amounts of mold. Flavor practically unaffected by storage.	----------	(2 flats.) Yellow green to yellow in color. All ripe. ¾ of the cantaloups were unsalable because of moderate amount of mold, shallow decay (chiefly at the stem scar), and overripeness. Flavor practically unaffected by storage.	
					2	(4 flats.) About ¾ of the cantaloups were unsalable because of mold, decay, and shriveling.	----------	(2 flats.) Commercially worthless because of mold, decay, and overripeness.	

Tests 5 and 6 were fairly comparable in variety used and in the substitution of a 38° to 40° F. range for the two higher temperature ranges of the previous tests. In test 5 the cantaloups at either temperature range were stored satisfactorily for 1 week but not for 2 weeks. In test 6, 1 week's storage was only partly satisfactory at 32° to 34° and was unsatisfactory at 36° to 38°. Storage was unsatisfactory for 2 weeks at either temperature range.

The results of the six storage tests are in fairly close agreement in indicating that cantaloups stored under the conditions described, unlike Honey Dew melons, were not affected by low-temperature breakdown but were subject to cladosporium mold and decay, both in storage and after removal therefrom. In each of the three tests where a 40° to 42° F. range was used this decay was seriously prevalent even in 1 week. Decay was likewise prevalent in 1 week on cantaloups at 38° to 40° in one of the two tests in which this temperature range was used. One week's storage at either 32° to 34° or 36° to 38° was for the most part satisfactory, although the lower range was the more desirable. At either of these two lower temperature ranges cladosporium rot was serious in 2 weeks in most of the tests, although again the 32° to 34° range offered greater hope for storage for this length of time. The results as a whole suggest that cantaloups that have been removed from refrigerated cars should not be held at 32° to 34° for longer than 1 to 2 weeks.

DISCUSSION AND CONCLUSIONS

The commercial storage of Honey Dew melons and cantaloups on the market has never been an extensive practice. Therefore, although the practical absence of information on storage diseases and storage behavior well justified the present studies, the problem was recognized to be one of only limited economic importance. Consequently it has seemed desirable to work with comparatively small lots of melons at a time, but to carry along the storage tests in conjunction with other studies for some years. Observations have now been made over a 5-year period, during the last 3 years of which considerable information has been obtained.

Aside from the brief report by Ramsey, Wiant, and Link (*7*), based on the present studies, this is the first time that low-temperature break-down of Honey Dew melons has been described in the literature. The much greater prevalence of the disease at 32° to 34° F. than at 36° to 38°, together with its absence at higher temperatures, leads to the conclusion that it is essentially the result of exposure to low storage temperatures. Further studies should be made on possible contributing factors, using melons of known field and transit history.

A relation has been indicated between cladosporium rot, which has been shown to be the chief decay of stored Honey Dew melons, and low-temperature break-down. Melons affected with low-temperature break-down frequently show early stages of cladosporium rot the day after they are removed from storage. The decay then advances rapidly over the affected areas. This has prompted the question whether at the higher temperatures where low-temperature breakdown has not been recognized as such there is not some localized temperature effect (other than the direct effect on the growth of the causal organism) that facilitates the more abundant development of cladosporium rot at those temperatures. It has frequently been

observed that melons allowed to remain at room temperature during summer and early fall months, although more subject to such decays as fusarium rot, alternaria rot, and rhizopus soft rot, were not subject to cladosporium rot; whereas identical melons held, for example, at 40° to 42° F. for 2 weeks developed abundant cladosporium rot partly during storage but mostly during the first few days after removal. Stated differently, the question is whether or not the numerous lesions of cladosporium rot that developed so abundantly on melons removed from the higher temperature ranges were not actually scattered spots of incipient break-down in which *Cladosporium* developed secondarily. Many such spots were therefore examined in their earliest stages. It was found by microscopic examination of the subepidermal tissues that a fungus was constantly associated with the spots even when they were first discernible. Likewise by culturing bits of the affected tissue from melons showing the first beginnings of spotting it was found that *Cladosporium cucumerinum*, or much less frequently an *Alternaria* species, was usually present. However, when similar studies were made with well-recognized lesions of low-temperature break-down, neither these fungi nor any other organism were found to occur, with the exception, of course, of older lesions in which *Cladosporium* had developed in well-defined, isolated areas as an obvious secondary invader. It would appear, therefore, that the question must be answered in the negative.

It is possible that the explanation of this increased development of cladosporium rot on Honey Dew melons that have been removed from cold storage lies in their having been exposed to more humid conditions resulting from their "sweating" after removal from refrigerator cars. Melons of the sizes used are usually packed with the stem ends resting on a thin layer of excelsior in the bottom of the crate. Moisture condensing on the surface of the melons would naturally find its way to the packing material and be retained there in contact with the melons for some time. This would certainly increase the possibilities for inoculation by any *Cladosporium* spores that might be present on the surface of the melon. It is interesting to note in this connection that cladosporium rot is frequently much more abundant on areas of the melon surface that are in contact with the excelsior padding than elsewhere.

Likewise in the tests with cantaloups, consideration was given to the possibility that low-temperature break-down was overlooked because of its being followed secondarily by cladosporium rot as fast as it developed. Repeated observations on cantaloups in storage and after their removal failed, however, to show anything suggesting low-temperature break-down.

The rind of stored cantaloups tends to shrivel and dry out with time, so that a kind of indentation or shallow pitting is produced wherever the netting has been injured. This is, however, readily recognized as such. Wherever any other type of lesion developed, either at such injured areas or elsewhere, such fungi as *Cladosporium cucumerinum*, *Alternaria* sp., or *Fusarium* sp. were readily isolated. Cladosporium rot developed most abundantly at the stem scar and in the bruised areas where melons came in contact with one another or with the slats of the crate. For the most part these areas are the ones most likely to retain moisture for the longest time.

The results of the present studies offer little encouragement for the successful storage of either cantaloups or Honey Dew melons on the market for more than a short time after they have been removed from refrigerator cars. It appears that under such conditions cantaloups can be held at 32° to 34° F. for 1 week and with a reasonable degree of safety for several days longer. Storage for as long as 2 weeks may be very detrimental to certain lots of cantaloups, and in no event should storage for longer than 2 weeks be attempted. The riper the cantaloups are, the shorter the storage period should be. Cantaloups stored at 32° to 34° for 2 weeks showed no evidence of failure to ripen properly after removal from storage.

Honey Dew melons can be held safely for 2 weeks at either 32° to 34° or 36° to 38° F. Storage for 3 or 4 weeks will undoubtedly result in the development of either low-temperature break-down or cladosporium rot. The former predominates at the lower temperature range and the latter at the higher range.

With both cantaloups and Honey Dew melons an inspection should be made of the stock in storage at frequent intervals. At the same time sample crates should be removed and held for observation after standing several days at prevailing outdoor temperatures. This will serve to indicate how the particular lots are reacting to storage and will suggest the maximum advisable length of the storage period. Such observation should include a flavor test, inasmuch as both types of melons tend to lose flavor the longer they are held after arrival on the market.

SUMMARY

The occurrence of peculiar surface blemishes on Honey Dew melons removed from commercial cold-storage warehouses at New York, N. Y., during the fall of 1931 prompted an investigation of the effects of cold storage on both Honey Dew melons and cantaloups grown in Western States and shipped to market in refrigerator cars under standard refrigeration.

Five storage tests were made with Honey Dew melons and four with cantaloups during the period 1931–33. The results of these tests showed that Honey Dew melons were subject to a low-temperature break-down that occurred after 2 weeks' storage at 32° to 34° F. and to a lesser extent at somewhat higher temperatures. Cantaloups, however, were not subject to this storage disease. Neither type of melon was found to store well at temperatures above 40° to 42°, because of the rapid development of decay.

A more detailed study was made during the period 1934–36 of melons in storage at three temperature ranges, namely, 32° to 34°, 36° to 38°, and 40° to 42° F. A range of 38° to 40° was also used in a few tests. The investigation comprised 8 tests with Honey Dew melons in which 84 flats were used and 6 tests with cantaloups in which 63 crates were used.

Low-temperature break-down was again found to occur on Honey Dew melons and not on cantaloups. It developed most abundantly at 32° to 34° F. but also to some extent at 36° to 38°. It did not develop at either 38° to 40° or 40° to 42°. The disease is described and illustrated in considerable detail.

Cladosporium rot, caused by *Cladosporium cucumerinum*, was the most important decay found on stored melons of either type. It is

briefly described and illustrated and the relation between it and low-temperature break-down is discussed.

The results of the storage tests indicate that cantaloups removed from refrigerator cars can be held for 1 week or slightly longer at 32° to 34° F. Honey Dew melons, however, can be safely held for 2 weeks at either 32° to 34° or 36° to 38°, and longer storage may be practicable with certain lots. With both types of melons the effects of storage will vary with the degree of ripeness, the riper ones decaying more readily. Periodic examinations should be made of stored melons so that they can be removed if any injurious effects of storage begin to appear.

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