Quality of Brussels Sprouts

low temperatures during handling operations retarded quality deterioration in study of temperature effects on respiration

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About 75% of the Brussels sprouts grown for fresh market in the United States are produced in California, where the crop has a farm value of about $4 million annually.

The bulk of sprouts for shipments within the state are prepackaged in the growing areas and transported by truck with little or no refrigeration. Shipments from California go by rail with the sprouts packed with ice in wooden drums that are covered with top ice after loading. Except for prepackaging few changes have been made in methods of handling and transporting Brussels sprouts. Problems associated with the holding and shipping of Brussels sprouts suggested a detailed study of the effect of temperature on quality loss.

Brussels sprouts—in a commercial field near Half Moon Bay—were harvested in the morning and passed over a mechanical grader to remove loose outer leaves. Only sprouts of high quality, between 1″–1½″ in diameter, were selected for the experiments. They were then packed in crushed ice and taken to Davis, where they were placed at 32°F until the following morning. To simulate commercial handling, the sprouts were trimmed by cutting a slice from the stem end and removing two or three outer leaves. Only sprouts free from defects were used. Beyond this initial preparation, there was no trimming of the sprouts during the experiment.

Uniform samples of 100 sprouts each were placed in respiration chambers at temperatures of 32°, 41°, 50°, 59°, and 68°F. Since all correlation coefficients —r values—for linear regression of quality on time in storage were about 0.97 in both experiments and the slopes of the regression lines—b values—were almost identical, only the data from the first experiment are reported in this article.

Quality, determined by visual rating of the samples, was scored on a scale of 1-to-9. Each sprout was rated and an average calculated for the sample.

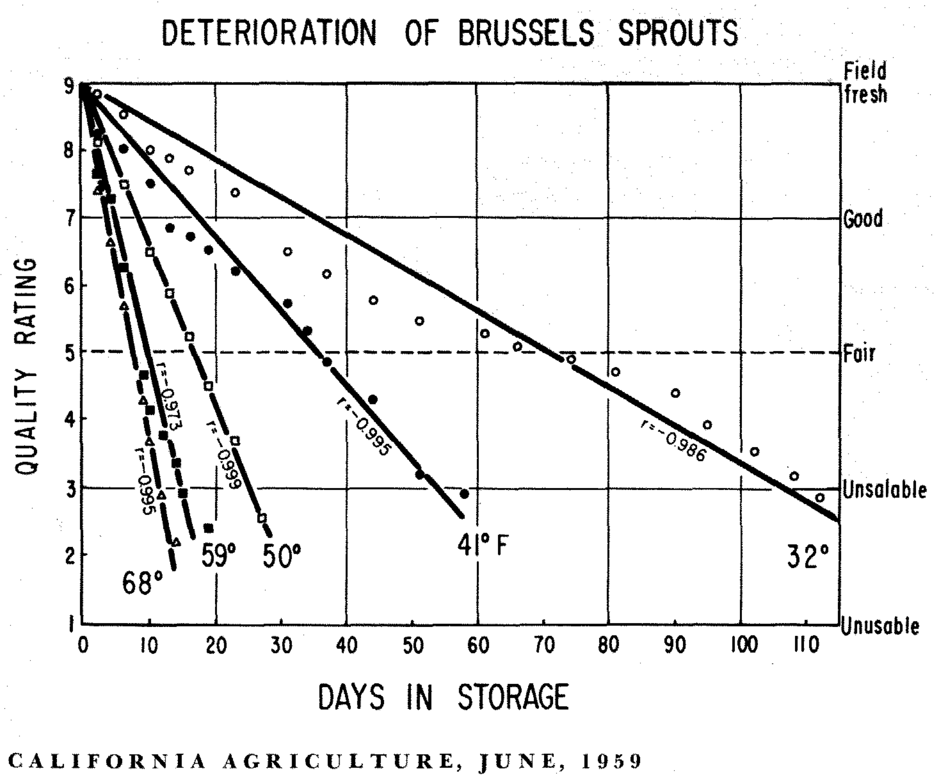
A high correlation was obtained between quality and time in storage at each of the temperatures studied. Sprouts deteriorated to a rating of 5—fair—in eight days at 68°F, but at 32°F the sprouts did not reach the same rating until after 72 days in storage.

At the higher temperatures—59°F and 68°F—loss of quality was characterized by a rapid disappearance of chlorophyll from the outer leaves. Sprouts that retained a green color became dull and flaccid in appearance. Cut stems became discolored in a few days, and adventitious roots developed near the outer margin of the cut surface in from one to two weeks.

At an intermediate temperature—50°F —the sprouts yellowed more slowly, but the cut stems darkened almost as rapidly as at the higher temperatures and roots did not develop before the sample was discarded.

At lower temperatures—32°F and 41°F—the sprouts retained their green and bright appearance for relatively long periods. Discoloration of the cut stems was gradual, and did not become a serious defect until near the end of the storage period. After about one month in storage, the sprouts developed small, dark lesions on the basal portion of the outer leaves. These gradually covered the entire surface of the sprouts. The lesions were gradually invaded by decay organisms which hastened deterioration.

Effect of storage time and temperature on quality deterioration of Brussels sprouts.



Respiration Rate

The rates of carbon dioxide production at five constant temperatures are shown in the graph on the next page. Initial rate at 32°F was about 38 milli-

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Description of Numerical Quality Ratings Used to Evaluate Deterioration of Brussels Sprouts

Numerical rating[a]	Descriptive rating	Appearance
9	Field fresh	Excellent. Bright green appearance, free from defects.
7	Good	Minor defects present but not objectionable. Green color slightly bleached and dull; stem end discoloration. Good retail sales appeal.
5	Fair	Defects bordering on objectionable. Outer leaves showing slight yellowing. Could be returned to acceptable condition with slight trimming.
3	Unsalable	Objectionable defects correctable by trimming. No more than slight decay.
1	Unusable	Slime and other defects serious; would not be eaten.

[a] Intermediate scores used when appropriate.

BRUSSELS SPROUTS

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grams of carbon dioxide per kilogram per hour, and at 68°F was 190 milligrams of carbon dioxide per kilogram per hour, a fivefold increase over the temperature range studied. At higher temperatures, rates dropped off rapidly during the first six days in storage, and increased again toward the end of the storage period, a phenomenon associated with the appearance of decay organisms. At lower temperatures the rate of respiration declined gradually for the first 10 days, and leveled off for the remainder of the holding period. The number of days before half of the sprouts in a sample reached a quality rating of 3—unsalable—is indicated by the termination of each curve in the graph.

Time and Temperature

Over the temperature range studied, decreases in temperature resulted in decreases in deterioration rate. Most rapid loss of green in the outer leaves occurs at 50°F or above and is associated with decreasing quality of Brussels sprouts. In the present study, a yellowing of sprouts was the major symptom of deterioration at high temperatures. At lower temperatures the sprouts retained green color, and deterioration was expressed through gradual changes. At 32°F, and to a lesser extent at 41°F, the slight deviation of the quality ratings from a linear function can be explained as three phases of symptom expression rather than as the single phase shown at higher temperatures. Thus, during the first 30 days in storage at 32°F, deterioration was expressed by a loss of bright green color, with the sprouts deteriorating to a rating of between good and fair. During this period from 50 days to about 70 days appearance changed very little, and finally, deterioration was associated with black specking and subsequent decay.

Regression Coefficients (b values) for Quality Loss of Brussels Sprouts as a Function of Time. Tests 1 and 2 were started in December 1957 and in January 1958.

Temperature °F	Regression coefficient (b)	
	Test 1	Test 2
32	−0.0560	−0.0535
41	−0.1113	−0.1169
50	−0.2362	−0.2281
59	−0.3982	−0.4071
68	−0.5147	−0.5215

Estimated Deterioration of Brussels Sprouts Under Desirable and Undesirable Handling, Transporting and Marketing Conditions for a Hypothetical Transcontinental Shipment. Deterioration Expressed in Terms of the Time Required for an Equivalent Amount of Deterioration to Occur at 32°F.

Handling period and assumed conditions	Deterioration equivalent expressed as days at 32°F	
	Desirable*	Undesirable
Before cooling:		
Desirable		
4 hrs. at 50°F	0.7	
Undesirable		
10 hrs. at 59°F plus 18 hrs. at 41°F**		4.6
Rail transit:		
Desirable		
6 days at 32°F	6.0	
Undesirable		
13 days at 50°F		57.2
Marketing:		
Desirable		
1 day at 41°F	2.0	
Undesirable		
4 days at 50°F		17.6
Total equivalent days	8.7	79.4
Estimated quality (salability)	Good+	Fair−

* Desirable—assumed minimum time at desirable temperatures. Undesirable—assumed conditions of undesirable time and temperatures.

** Equivalent to an overnight holding period.

The data showing the relationship between time and temperature on quality deterioration are in general agreement with previous findings. The high correlation shown in the graph on page 11 demonstrates the usefulness of the visual rating scale used in this study to describe quality deterioration of Brussels sprouts. Since total storage life depends on average rate of deterioration, the rate at each temperature studied was related to the total storage life at 32°F. Thus, at 41°F the sprouts deteriorated 2.0 times as fast as those held at 32°F, while at 50°, 59°, and 68°F, the relative rates of deterioration were 4.4, 7.3, and 10.0 times as fast as at 32°F. This information was used to illustrate the slower rate of deterioration under desirable handling, transporting and marketing conditions.

Temperature markedly influenced the rate of respiration of Brussels sprouts; respiratory activity decreased as temperature decreased. Carbon dioxide production was greatest at temperatures which most favored rapid quality loss. This response is characteristic of many cool season crops. Initial respiratory activity declined rapidly at higher temperatures, and gradually at lower temperatures, followed by a leveling off.

The respiration rates and quality deterioration data emphasize the value of low temperature in extending the storage life of Brussels sprouts.

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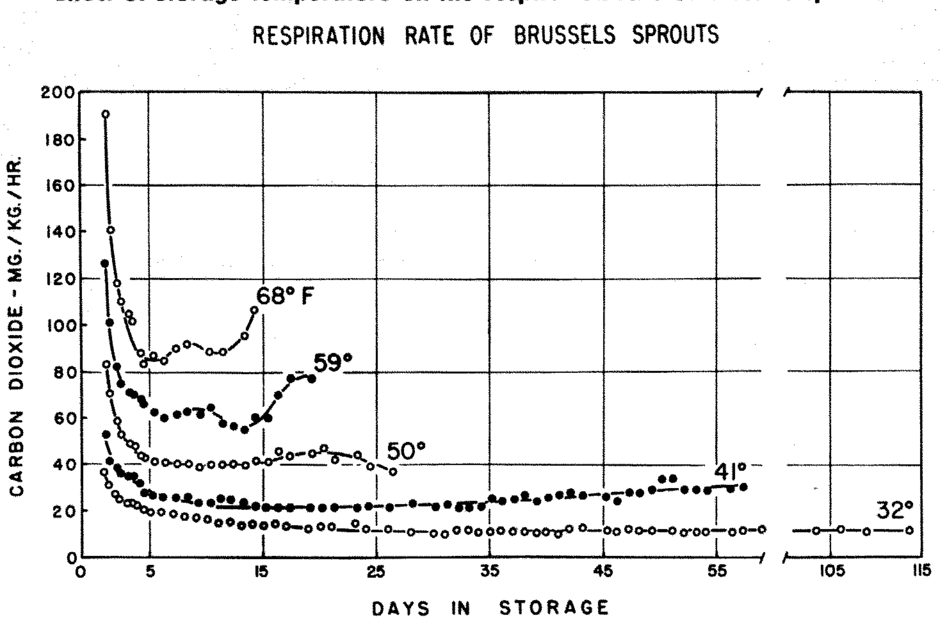
Effect of storage temperature on the respiration rate of Brussels sprouts.



POTATOES

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agreement between the amount of exchangeable potassium in the soil and the amount of potassium absorbed by the plants grown on these soils. According to the graph on page 8, where potassium in the plant samples fell below 4%, exchangeable soil potassium generally was less than 100 ppm. Conversely, where potassium in the plant was above 8% at 110 days, exchangeable soil potassium was observed to be in the sufficiency range or above 150 ppm.

In these investigations it was noted that soil reaction has been considerably reduced over the years through continuous use of acidifying fertilizers such as ammonium sulfate and through the addition of sulfur for potato scab control. In three of the eight soils, for example, the pH—relative alkalinity-acidity—had