VACUUM COOLING OF FLORIDA VEGETABLES

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The first Florida shipments of vacuum cooled lettuce were made from Oneco during the 1955-56 season. Although the vacuum cooling of lettuce has developed rapidly in California and Arizona since the first commercial shipments in 1948, the method has not been widely adapted in other areas. Florida growers and shippers have shown considerable interest in vacuum cooling. The reported advantages are the maintenance of better quality by more rapid precooling and the reduction in packing and shipping costs through cheaper containers and the elimination of package and top ice. Lettuce has not been grown in sufficient volume in concentrated areas in Florida to justify the cost of establishing a permanently located vacuum cooler. The unit at Oneco was semi-portable and when the lettuce season ended in Manatee County it was moved to lettuce production areas in other states. The results presented here were obtained from preliminary vacuum cooling studies with several vegetables to determine primarily the effects of the vacuum treatment on quality.

Vacuum cooling has been studied by several investigators. Friedman (3) found that almost any fruit or vegetable can be vacuum cooled to some extent, but there was a rapid temperature decrease only in vegetables with a large ratio of surface area to volume. Vacuum cooling was found effective for prepackaged spinach, coleslaw, and salad mix after the bags were packed in master containers (2).

VACUUM COOLING PROCESS

The process by which the rapid chilling occurs is based on evaporative cooling. At normal atmospheric pressure of approximately 30 inches, water boils at 212° F. If the pressure over water is reduced to 0.18 inches (vacuum of 29.82 inches) the water boils at 32° F. The water which "boils" or evaporates from the vegetables cools them to a temperature corresponding to the temperature of the water. To secure the reduced pressure, vegetables are placed in a chamber and the required vacuum is obtained by a pump or a steam jet. The cooling of the vegetable is measured with a recording thermometer and the vacuum is released when the desired temperature is reached. Since vacuum cooling depends upon evaporation of water, one might think that considerable weight loss occurs. However, wilting is not severe and Friedman and Radspinner (4) reported weight losses of only 1 to 4.7 percent.

The lettuce vacuum cooled in fiberboard cartons at Oneco was either packed dry in the field or washed and packed in the packinghouse. The vacuum tube (22 ft. long x 7½ ft. in diameter) was loaded with 240 cartons each containing 1½ or 2 dozen heads of lettuce. The vacuum pump, powered by a diesel engine, pulled the air from the tube containing the lettuce through a second tube of equal size containing blocks of ice. The tube of ice condensed the evaporated moisture before it reached the vacuum pump.

Studies were made in a laboratory model vacuum cooler at Belle Glade in May and June 1956. The vacuum chamber, with a capacity of about 4 cartons, was evacuated by an electric powered pump. The evaporated moisture was condensed by mechanical refrigeration.

VACUUM COOLING OF LETTUCE

Data were obtained on the weight loss, cooling rate, and quality of wet and dry lettuce. Wetting the lettuce before vacuum cooling did not affect the cooling rate. Little difference in weight loss was found among 50 cartons of wet and dry lettuce from five different lots as shown in Table 1. When the individual heads were weighed in one test, those with added water lost only 1.9 percent compared with 2.3 percent weight loss of the dry heads.

Vacuum cooling had no apparent detrimental effects upon the quality of the lettuce.

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Table 1. - Average Temperatures and Weight Losses of Wet and Dry Lettuce Vacuum Cooled in Commercial Unit at Oneco, Florida

Dry or Wet	Units Tested		Time in Vacuum	Vegetable Temp.		Weight Loss
	Number	Type	Min.	Before °F	After °F	%
		Lettuce				
Wet	10	Fiberboard Cartons	45	65	36	2.6
Wet	10	" "	36	71	38	3.5
Wet	10	" "	40	76	38	3.1
Dry	10	" "	36	75	38	3.1
Dry	10	" "	57	74	42	3.2
Wet	32	Single Heads	45	65	36	1.9
Dry	30	Single Heads	45	65	36	2.3

When held in storage at 37°-40° for 8 days the quality was still good. The dry lettuce showed moderate wilting after 8 days and a weight loss of 4.1 percent compared with slight wilting and a loss of 1.4 percent for the wet lettuce. After 16 days storage the outer leaves of both wet and dry lettuce were considerably wilted. Another lot hydrocooled and top-iced for 16 days was very crisp. However, the top-iced heads developed more reddish discoloration than the vacuum cooled heads.

Vegetables in Various Containers

During March 1956, small quantities of vegetables were cooled in the commercial vacuum unit along with the loads of lettuce. Prepackaged broccoli, spinach, radishes, salad mix, and coleslaw cooled at different rates. The temperature of the broccoli decreased only 15° in the same period that the spinach and salad mix cooled 30-33° (Table 2). In the commercial vacuum unit celery cooled from 61° to 45° at the slowest rate for the vegetables in bulk containers.

In the laboratory vacuum unit two tests of similar cartons of celery cooled from 80° to 38° in 30 minutes and from 80° to 44° in 20 minutes. Friedman and Radspinner (4) found that the initial temperature of celery had a marked effect on the final temperature, while the initial temperature of lettuce had little effect on its final temperature. They attributed the difference to the smaller surface area-volume ratio of celery. In the celery cooled to 38° at the base of the stalks, considerable freezing injury of the leaves occurred.

Although the vegetables were vacuum cooled in film bags, fiberboard cartons, small baskets and wirebound crates, the containers were not all compared in the same tests. Fiberboard cartons and wirebound crates of sweet corn were vacuum cooled at the same time in one test (Test No. 3, Table 3), and there was little difference in rate of cooling and no difference in appearance of the corn. In another test bunched radishes in wooden baskets were vacuum cooled with topped prepackaged radishes (Table 2). Some of the tops on the bunched radishes were severely wilted, but there was no change in appearance of the prepackaged lot. The weight loss of the bunched radishes averaged 7 percent compared with 4 percent for the prepackaged ones.

Prewetting of Sweet Corn

Since succulence or moisture content is one of the important quality factors of sweet corn, attempts were made to reduce the moisture loss during cooling by previously wetting the ears in water. The results in Test 5, Table 3, showed that in one test in the laboratory cooler the weight loss was reduced one-half by wetting. In Test 6 the dry ears lost 6.1 percent compared with no loss for the wet ears. Ears from the same lot gained 13.7 percent in weight during hydro-

cooling. Dewey (1) also reduced the weight loss of sweet corn by adding water immediately prior to the vacuum treatment. He reduced the weight loss from 3.2 percent for dry broccoli to almost none for wet broccoli.

Effect of Vacuum Cooling on Quality

Quality evaluations of the dry and wet vacuum cooled and hydrocooled sweet corn were made at harvest and after 2, 6, and 7 days' storage at 35° and 90-95 percent relative humidity. The vacuum cooled ears were packed in fiberboard cartons and the hydrocooled ears in wirebound crates. The succulence as measured by the shear press, was lower after vacuum cooling dry than at harvest, and remained lower than the other treatments at all storage periods (Table 4). The kernels vacuum cooled wet were still more succulent after 7 days' cold storage than at harvest, although the husks had wilted very slightly. The hydrocooled ears maintained the most succulence and the freshest husks. The husks in all treatments remained green. Slight denting of kernels was found only in the dry vacuum lot after 6 and 7 days' storage.

Small quantities of vacuum cooled and hydrocooled vegetables were stored at 37°-40° and at 65°-70° for comparisons of quality. After 6 days at 65°-70° the celery leaves and stems of both vacuum and hydrocooled lots were considerably yellowed. After 11 days at 37°-40° the quality of the celery from both lots was good, only a few leaves were slightly yellowed, the stalks were crisp and the weight loss averaged 2 ounces per stalk in both lots.

The vacuum cooled packages of salad mix developed decay in cold storage faster than the hydrocooled packages. The quality of the vacuum cooled and hydrocooled escarole

Table 2. - Average Temperatures and Weight Losses of Vegetables in Various Containers Vacuum Cooled in Commercial Unit at Oneco, Florida

Vegetable	Container	Number of Units Tested	Vegetable Temperature			Initial Weight	Weight Loss
			Before	After	Decrease		
			°F	°F	°F	oz/unit	%
Broccoli	Cellophane Bag	12 Bags	64	49	15	11.5	1.8
Coleslaw	Cellophane Bag	12 Bags	74	49	25	10.5	4.8
Salad Mix	Cellophane Bag	12 Bags	79	46	33	8.9	3.8
Spinach	Cellophane Bag	12 Bags	78	48	30	11.9	2.9
"	" "	" "	78	48	30	11.3	2.6
Radishes	Polyethylene Bag	15 Bags	70	41	29	9.1	5.5
"	" "	15 "	--	--	--	9.1	2.6
Radishes	Wooden Basket	15 Bunches	62	44	18	7.3	7.3
"	" "	15 "	--	--	--	7.7	6.9
Cauliflower	Fiberboard Carton	8 Heads	77	50	27	50.0	4.0
Endive	Wooden Basket	7 Heads	75	53	22	14.6	3.0
Escarole	Wooden Basket	4 Heads	71	53	18	33.2	3.4
Sweet Corn	Fiberboard Carton	59 Ears	64	44	20	9.7	1.8
" "	" "	4 "	64	41	23	10.2	1.2
Celery	Fiberboard Carton	12 Stalks	61	45	16	35.5	2.3
"	" "	12 "	61	45	16	34.1	2.3
* "	" "	12 "	80	38	42	----	---
* "	" "	12 "	80	44	36	-----	---

*Cooled in laboratory unit at Belle Glade, Florida

Table 3. - Average Temperatures and Weight Losses of Wet and Dry Sweet Corn Vacuum Cooled in Laboratory Unit at Belle Glade, Florida.

Test No.	Dry or Wet	Units Tested No.	Containers or Ears	Time in Vacuum Min.	Corn Temperature (Cob) Before °F	After °F	Decrease °F	Weight Loss %
1	Dry	2	Fiberboard Cartons	18	78	38	40	—
2	Dry	2	" "	30	84	38	46	--
3	Dry	1	Wirebound Crate	25	83	40	43	—
3	Dry	1	Fiberboard Carton	25	84	36	48	--
4	Wet	1	Wirebound Crate	40	82	33	49	--
4	Dry	1	" "	40	84	32	52	--
5	Wet	60	Ears	40	81	35	46	2.7
5	Dry	60	Ears	40	90	34	56	5.5
6	Wet	36	Ears	40	84	38	46	0
6	Dry	36	Ears	40	86	38	48	6.1

and endive was about the same after 11 days cold storage.

Summary

The first Florida shipments of vacuum cooled lettuce originated from the semi-portable installation at Oneco. A number of vegetables were vacuum cooled in the Spring of 1956 with the commercial lettuce cooling equipment and a laboratory model at Belle Glade. The vegetables with a large ratio of surface area to volume cooled most rapidly, but sweet corn and celery also cooled satisfactorily.

The bulk and prepackaged vegetable containers tested did not affect the cooling process. The vacuum method did not result in objectionable wilting except for radish tops. Weight loss of sweet corn was reduced by wetting before vacuum cooling. Vacuum cooled vegetables retained their freshness well during storage.

LITERATURE CITED

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Table 4. - Changes in Quality of Florida Sweet Corn After Dry and Wet Vacuum Cooling and Hydrocooling.

Method of Precooling	At Harvest	2 Days Cold Storage*			6 Days Cold Storage*			7 Days Cold Storage*		
	Succulence ml. Juice	Succulence ml. Juice	Husks Condition	Kernels Denting	Succulence ml. Juice	Husks Condition	Kernels Denting	Succulence ml. Juice	Husks Condition	Kernels Denting
Dry Vacuum Cooled	11.4	11.2	Slight Wilting	None	11.2	Slight Wilting	Slight on 25% ears	10.2	Slight Wilting	Slight on 50% ears
Wet Vacuum Cooled	11.4	15.7	Fresh	None	14.0	Not Crisp	None	13.0	Very Slight	None
Hydrocooled	11.4	18.6	Fresh & Wet	None	18.4	Fresh	None	—	-----	—

* Cold storage temperature 35° F. and relative humidity 90-95 percent.