Quality and Consumer Acceptance of *hydrocooled* Strawberries

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SUMMARY

Strawberries for Processing

DURING the 1957 strawberry season a pilot study was conducted to determine the effect of selected precooling and shipping treatments on strawberries to be processed and frozen.

- Hydrocooling did not significantly affect spoilage, processing loss, or percent turn-out. However, when the treatments were grouped between dry and wet, the difference in average processing loss of 12% for dry and 16% for wet treatments was found to be highly significant. The weight changes under the nine treatments were significantly different at the 0.01 level. However, additional tests showed that not all the mean differences were significant.

Strawberries for Fresh Market

- During the 1958 season, field and transportation experiments were conducted to determine the effects of hydrocooling on fresh-market strawberries, using an experimental hydrocooler.
- Hydrocooling significantly reduced weight loss in transit. Nonhydrocooled strawberries lost 1.6% in weight during transit.
- Hydrocooling did not affect soluble solids, pH, or mold count on strawberries.
- The taste panel's evaluation showed that the odor, flavor, texture, brightness, and color of the hydrocooled strawberries were not different from those of the nonhydrocooled berries at the 0.05 level.

Consumer Evaluation of Hydrocooled and Nonhydrocooled Strawberries

- About 77% of the evaluations for hydrocooled strawberries on the refrigerated tables at three retail grocery stores were "excellent" and "good" compared to 61% for the nonhydrocooled strawberries. Similar ratings for the berries on the unrefrigerated table of one store were 68% "excellent" and "good" for the hydrocooled berries and 52% for the nonhydrocooled.
- At the three stores, the pooled ratings on odor, texture, brightness, and color for hydrocooled strawberries were significantly higher than for nonhydrocooled strawberries in the "excellent" and "good" categories. This indicates that quality was maintained better in hydrocooled strawberries. Hydrocooling appeared to wash the color from bruised strawberries, producing areas light in color.

• Both hydrocooled and nonhydrocooled strawberries displayed on the refrigerated tables received about the same percent of "good" ratings in the stores and homes. However, both hydrocooled and nonhydrocooled strawberries received significantly more "excellent" ratings in the homes and "fair" ratings in the stores.

• The hydrocooled strawberries on the unrefrigerated table received significantly more "excellent" ratings in the homes and "poor" ratings in the store. The nonhydrocooled strawberries on the unrefrigerated table received significantly more "fair" ratings in the store than in the homes.

• The difference between the store and home ratings of the berries might be attributed to the fact that in their homes the consumers had more time to examine the berries and they had also eaten some of them.

Consumer Buying Preferences

• Favorable evaluations of both hydrocooled and nonhydrocooled berries were made about twice as often as were unfavorable ones, and the numbers of each for the two treatments were very similar.

• The consumers reported eight methods of using the test strawberries. More than half of the consumers served them with shortcake for dessert. About 74% of the consumers expressed a definite preference for medium-size strawberries (⅝-1 in.).

• Of the 141 consumers who bought hydrocooled strawberries from the refrigerated tables, 86% reported no decay from 1 through 4 days and 14% reported some decay ranging from 1% to 4%. On the nonhydrocooled berries only 73% of 96 consumers reported no decay from 1 through 3 days; 27% reported decay ranging from 1% to over 5% from 1 through 3 days.

• Of the consumers who bought hydrocooled strawberries from the unrefrigerated table, 92% of the 181 consumers reported no decay from 1 to 3 days. About 84% of the 115 consumers who purchased nonhydrocooled berries reported that they found no decay from 1 through 3 days; 16% of the consumers reported decay ranging from 1% to over 5% from 1 through 3 days. The range of decay for the nonhydrocooled berries was 1% to over 5%, whereas the range of decay for hydrocooled berries was only 1% to 3%.

ACKNOWLEDGMENTS

Appreciation is expressed to all who have assisted in this study: to the farmers who furnished strawberries for the hydrocooling tests; to those who provided a location for storing the hydrocooler; to the managers of the four retail grocery stores for their cooperation in giving authorization for consumer acceptance tests; and to the taste panel that participated in the consumer tests.

Appreciation is also expressed to staff members of the University of Tennessee and to members of the Technical Committee of the Southern Regional Project SM-8 for suggestions in preparing this report.

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Quality and Consumer Acceptance of Hydrocooled Strawberries[1]

by

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INTRODUCTION

The Problem and Importance of the Study

TENNESSEE ranked fifth in production (26.6 million pounds) and sixth in value ($3,908,000) of the nation's strawberries in 1961. Strawberry production in the United States for 1961 was 512.6 million pounds—about 10% more than in 1960, and the farm value was $89,248,000.[2]

Strawberries are one of the more perishable fruits and require extremely careful handling during harvesting, grading, packing, and shipping to avoid delivery of unsatisfactory quality at consumer markets. Strawberries of a dependable grade and pack inspire in the trade a confidence which might be reflected in greater demand and higher price for the product. The most efficient marketing facilities, however, cannot overcome the effect of picking underripe and overripe strawberries, nor poor handling methods during and following harvest.

Because of the distances which Tennessee fresh-market strawberries are usually shipped, marketing them satisfactorily requires particular attention to handling and shipping practices. The importance of precooling and refrigeration in transit is also generally recognized.

Interest in studying methods for maintaining the fresh quality of produce from the producer to the consumer has increased in re-

[1]This is one phase of the Tennessee project contributing to Regional Project SM-8, "Evaluation of Alternative Vegetable Marketing Organizations and Handling Methods."

[2]*Vegetables—Fresh Market*, 1961 Annual Summary, USDA.

cent years. Much of the early interest was focused on type and size of package and method of display. Now more emphasis is being placed on consumer satisfaction with respect to the inherent qualities of the product itself.

The Process of Hydrocooling

Because Tennessee strawberries are generally subjected to high temperatures throughout harvesting, grading, and transportation to the first buyer, hydrocooling was tried in this study. Ice water, which may or may not contain a fungicide, with a temperature ranging from 32 to 36 degrees F., is pumped from beneath the machine to the top where it runs through screens or flood pans. The screens retard the water flow and provide an even distribution of water over the berries in open crates as they are hydrocooled. This cooling method reduces the temperature of the fruit by 30 to 40 degrees within 8 to 15 minutes, depending upon the initial temperature of the berries.

Under usual transit and storage conditions, the life of strawberries as a marketable commodity varies from a few days to about a week. After that there is great likelihood of berry decay, wilting and deterioration in color. The decay may begin even before harvest. Although a large number of fungi and bacteria have been isolated from rotten berries, the ones primarily responsible for constant and extensive losses are *Botrytis cinerea* causing "grey mold" rot and *Rhizopus nigricans* causing "leak." The first is more likely to cause extensive damage in the field, while the *Rhizopus* rot is more often a market-disease problem.

Three other rots, "*Rhizoctonia* brown rot," "leather rot," and "tan brown rot" (Pezizella rot), have been described as common in some areas, but in general are of minor importance.[3]

Objectives of the Study

The specific objectives of the hydrocooling study were:

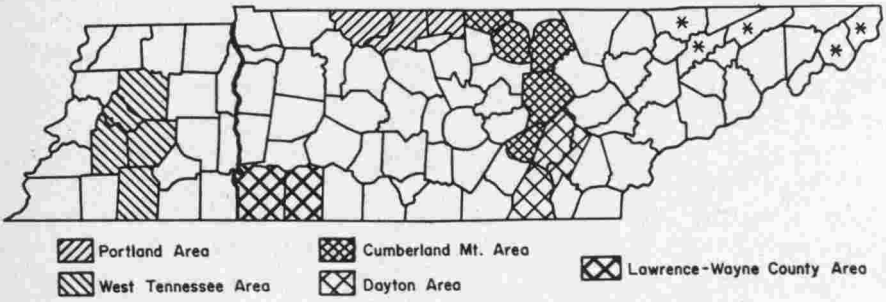
1) To investigate the effects of hydrocooling on shrinkage. pH, soluble solids, and bacteriological mold count.
2) To obtain a taste panel's evaluation on odor, flavor, textures, brightness, and color of the hydrocooled and nonhydrocooled berries.
3) To obtain a consumer evaluation of the hydrocooled and nonhydrocooled berries in retail grocery stores.

[3]Anderson, H. W., *Diseases of Fruit Crops*, McGraw-Hill Book Company, Inc., New York—Toronto—London, 1956.

4) To determine consumer characteristics and consumer buying preferences for hydrocooled and nonhydrocooled berries.

PROCEDURE

Figure 1 shows the principal strawberry production areas in Tennessee: Cumberland Mountain, Dayton, Portland, Lawrence-Wayne counties, and West Tennessee. The strawberries obtained



*There is some commercial production in these counties.

Figure 1. Major strawberry-producing areas in Tennessee.

for the experimental work during the 1957 and 1958 seasons were from the Dayton area. During the 1957 and 1958 seasons, precooled and dry (or control) strawberries were transported from the field by several methods.

1957 Season

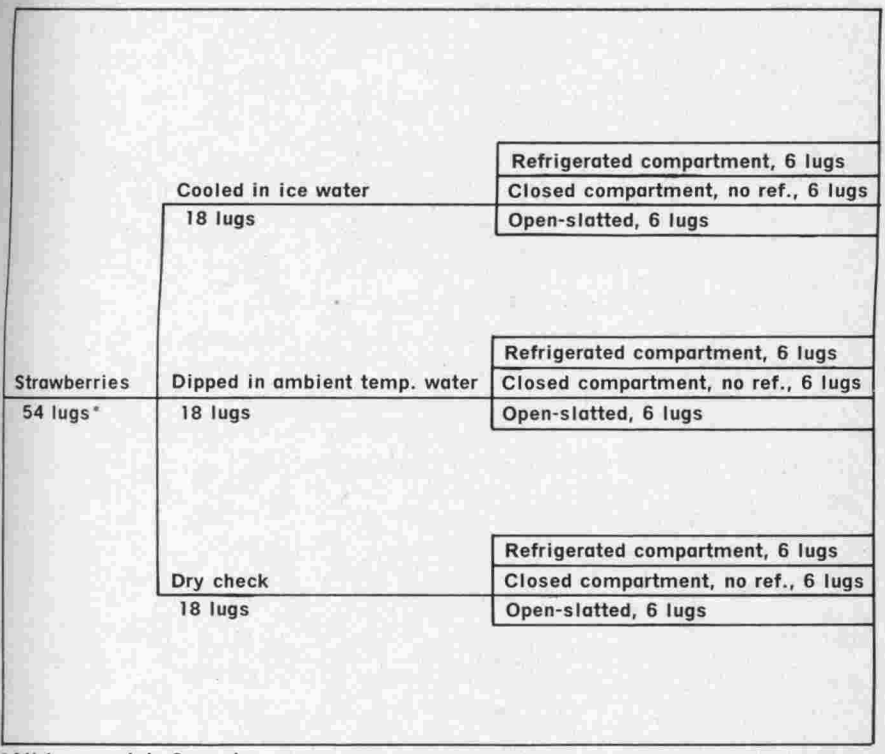
During the period from May 6 to June 4, 1957, 15 lots of strawberries were used to determine the effect of selected precooling and shipping treatments on strawberries to be machine capped, processed, and frozen. Two types of precooling used were 1) submerging in ice water, and 2) submerging in ambient temperature water. A third (check) treatment was dry, uncooled strawberries. Each treatment consisted of 18 eight-quart lugs of uncapped strawberries, making a total of 54 lugs per test.

Three methods of truck shipment tested were: 1) closed compartments with and 2) without refrigeration, and 3) an open-slatted truck—the usual method in Tennessee for transporting strawberries for processing.

Precooling was done under shade at the edge of the strawberry field immediately after harvest, so as to derive maximum effect from the cooling. Eighteen 8-quart lugs of berries were submerged and agitated in ice water at 35 degrees F. until they were cooled to 40 degrees F. This required about 8 minutes, depending some-

what upon their initial temperature and size. The treatment in ambient temperature water was submergence for a few minutes to determine its effect on strawberry "processability."

Figure 2 depicts the procedure used in dividing each lot into



*All lugs contain 8 quarts

Figure 2. Diagrammatic representation of strawberry treatments, 1957.

sublots for the transit tests. Instruments were used for recording continuously the temperature and humidity outside (open-slatted truck), and inside the refrigerated compartment and the closed unrefrigerated compartment in which the various sublots were transported.

The following data were recorded for each lot: weight before any field treatment, weight of a representative lug from each sublot upon arrival at the processing plant 70 miles from point of origin, weight of rejected berries in each sublot picked out in processing, and weight of processed berries. Also included as a variable in the test was the effect of storage for periods of 1, 2, and 3 days under identical refrigerated storage before processing.

All strawberries from all treatments were machine-capped in the processing plant immediately before belt inspection, slicing, sugaring, and freezing. The information on spoilage was collected each day as the strawberries in each sublot were processed. Each treatment or sublot was processed separately. Women inspectors stationed along the inspection belt which carried the capped berries from the capping machine to the slicer were required to place all spoiled (rotten or deformed) strawberries in a container. These berries were weighed and this weight was related to the field weight, which was the last stable weight before being modified by the cooling processes or various transit treatments.

1958 Season

During the 1958 strawberry season, field and transportation experiments were conducted to determine the effects of hydrocooling on fresh-market strawberries. This was done by using an experimental hydrocooler[4] which would accommodate 2 crates at a time. Ten to 20 crates of No. 1 strawberries were purchased at a time from a grower near Dayton, Tennessee, transported in open-slatted trucks to the hydrocooler which was located 24 miles from the field, and divided into two equal lots. During the season 190 crates were used in the experiments. One lot, still in the crates, was placed 2 crates at a time in the hydrocooler until the internal temperature of the berries reached 40 degrees F. To reduce the fruit to this temperature required 8 to 12 minutes, depending somewhat on the retained field heat.

These crates were then placed on a truck in a closed refrigerated unit in which the temperature varied from 32 to 38 degrees F. The control, or nontreated berries, were placed outside the refrigerated unit on the same open-slatted truck, and as soon as the hydrocooling process was completed, they were all transported to Knoxville. From the hydrocooler site to the University Food Technology Department was about 70 miles and required 2 hours driving time. Here, all strawberries were moved into the storage locker to await movement to the retail market outlets on the following day.

All strawberries were stored under refrigeration for approximately 16 hours before being weighed for shrinkage prior to processing. The overnight storage time was equivalent to the time required for transporting strawberries to Cincinnati. The factors which were considered were weight changes in hydrocooled and

[4]Furnished by the Food Machinery Corporation.

Figure 3. Members of taste panel, Food Technology Dept., Knoxville, Tenn., 1958.

nonhydrocooled strawberries, chemical changes—such as pH and soluble solids—occurring overnight, mold development, and consumer evaluation.

Consumer evaluation was determined by a taste panel of ten at the University of Tennessee at Knoxville and by 508 customers in four retail stores in the same city. The grading chart used by the taste panel as a basis for the evaluation is shown in Appendix Table 1. Figure 3 shows some of the panel members writing an evaluation of the berries they have sampled. The taste panel and the consumers were asked to evaluate the quality attributes of odor, texture, cleanness, brightness, and color of hydrocooled and nonhydrocooled berries.

Three of the retail grocery stores displayed the strawberries on refrigerated tables. Figure 4 shows a consumer being interviewed at the fourth store where strawberries were displayed on an unrefrigerated table. Following the store interviews, the consumers were called by telephone to obtain answers on quality and other relevant information about the strawberries.

RESULTS

Strawberries for Processing

Table 1 shows the temperature of the various sublots which was taken with a puncture thermometer to determine the effectiveness of the various treatments in cooling the berries. The average temperature of strawberries from the ice water-dipped treatments was lower than those for the water dipped and the dry treatments, which were almost identical.

Table 1. Temperature of Strawberries Upon Arrival at Food Technology Department, 1957.

Date	Treatments*								
	IR	IC	IO	WR	WC	WO	DR	DC	DO
	Degrees F.								
May 6	38.0	47.0	47.0	46.5	57.0	48.0	48.0	58.0	53.5
9	41.2	44.7	50.0	42.5	52.0	56.3	34.7	56.7	52.3
10	34.2	54.7	52.0	41.7	60.8	59.3	42.2	61.3	53.0
13	40.0	51.0	58.0	43.0	56.0	59.5	36.5	58.0	61.5
15	40.5	53.5	61.0	48.0	58.5	57.0	44.5	59.0	62.5
16	39.5	58.0	63.5	57.5	65.5	64.0	54.0	62.0	65.5
20	40.5	53.5	55.0	41.5	61.5	60.5	45.5	58.5	62.0
21	40.5	55.0	58.0	41.5	53.5	60.0	49.5	62.5	61.0
23	43.5	57.5	65.5	39.0	64.0	67.5	38.5	65.0	62.0
27	37.0	54.0	59.0	40.5	56.0	58.5	45.0	55.5	57.5
28	36.0	52.5	55.0	40.0	58.5	59.0	39.5	59.5	59.2
30	38.5	51.0	61.5	46.0	61.0	62.0	54.0	66.0	66.0
31	50.0	53.0	62.0	48.0	65.5	61.5	50.0	63.5	63.0
June 3	53.0	57.0	64.0	51.5	61.0	66.5	—	—	—
4	—	—	—	48.0	58.5	65.5	50.5	62.5	63.5
Average	40.9	53.0	58.0	45.0	59.3	60.3	45.2	60.6	60.2

*Code to treatments
IR—Ice water dipped, refrigerated in transit.
IC—Ice water dipped, transported in closed compartment.
IO—Ice water dipped, transported in open-slatted truck.
WR—Water dipped, refrigerated in transit.
WC—Water dipped, transported in closed compartment.
WO—Water dipped, transported in open-slatted truck.
DR—Dry, not dipped, refrigerated in transit.
DC—Dry, not dipped, transported in closed compartment.
DO—Dry, not dipped, transported in open-slatted truck.

Table 2. Weight Change in Strawberries Under Nine Treatments, Food Technology Plant, Knoxville, Tennessee, 1957.

Date	Treatments*								
	IR	IC	IO	WR	WC	WO	DR	DC	DO
	Percent of net weight								
May 6	4.2	5.2	3.1	2.3	3.7	1.0	— .4	— .1	— .9
13	3.3	3.2	1.5	.8	1.3	—2.1	—2.1	—2.5	—2.7
15	3.0	2.8	3.8	.5	.0	—1.8	—4.2	— .2	—3.5
16	2.0	2.6	—1.3	1.8	.3	—3.3	—3.1	—3.0	—4.9
20	2.4	1.1	.1	4.7	2.1	—1.7	—1.8	—1.3	—4.3
21	4.2	2.8	—1.3	1.3	1.0	2.6	—1.9	—1.3	—8.9
23	1.4	3.4	2.7	1.9	1.4	— .6	—3.0	—1.3	—4.4
27	2.5	2.2	— .9	1.1	2.4	—1.3	—2.4	—2.5	—3.9
28	1.7	3.0	—1.4	1.9	2.0	— .6	—1.9	—3.0	—2.9
30	4.0	3.7	.6	1.8	3.4	.8	—1.4	— .9	—4.1
31	4.3	5.0	1.9	1.4	1.6	— .6	—1.7	—1.0	—3.2
Average	3.0	3.2	.8	1.8	1.7	— .7	—2.2	—1.6	—4.0

*See Table 1, above, for code which also applies to this table.

Figure 4. Consumer interview at retail grocery store, Knoxville, Tenn., May, 1958.

Shrinkage

The percent weight gain or loss under the 9 treatments is shown in Table 2. The F test showed the treatments were significantly different at the 0.01 level (Appendix Table 2). However, an additional test showed that not all of the mean differences were significant. A triangular table of differences among all means is shown in Appendix Table 3. The treatment means ranked from lowest to highest are shown on the first line in the table. The row-column intersection indicates the amount by which the two treatment means differ. For example, treatment DO (—3.98) and treatment DR (—2.17) differ by 1.81. This number is found in the column headed DR and the row labeled DO. All terms on the main diagonal represent the differences between adjacent treatments; all terms just above the main diagonal represent differences between treatment means which are reported by a single treatment. Any term on the main diagonal which exceeds 1.18 is significant at the 0.05 level.

Spoilage

Spoilage included all rotten or deformed strawberries. Table 3

shows the spoilage by treatments. The treatments were not significantly different (Appendix Table 4).

Table 3. Spoilage of Strawberries Under Nine Treatments, Food Technology Department, 1957.

Date	Treatments*								
	IR	IC	IO	WR	WC	WO	DR	DC	DO
	Percent of net weight								
May 6	3.4	5.0	5.7	3.5	6.9	7.0	4.8	7.4	6.9
9	16.9	4.8	8.4	6.6	7.0	5.8	4.5	3.8	10.8
10	7.2	7.6	7.9	9.1	7.4	5.6	8.3	5.0	6.1
13	12.5	14.6	6.7	8.9	9.0	5.1	11.9	7.3	11.8
15	15.2	14.1	14.8	11.0	15.1	13.9	13.3	16.3	13.6
16	15.1	18.7	18.8	19.5	19.8	18.3	16.3	17.6	15.2
20	13.1	14.6	11.4	16.8	11.0	16.3	12.7	12.8	16.6
21	9.9	7.9	7.0	11.2	11.2	13.8	14.3	16.6	9.6
23	14.9	17.2	16.1	11.7	12.4	10.3	10.5	19.9	16.8
27	12.6	12.1	8.9	8.5	12.9	13.7	6.8	5.4	4.6
28	11.7	9.5	14.3	17.2	17.5	15.6	13.1	14.6	14.5
30	16.5	13.0	17.6	17.4	17.1	11.0	10.5	17.2	11.9
31	12.6	10.6	11.9	18.8	17.9	14.9	9.8	14.9	15.7
Average	12.4	11.5	11.5	12.3	12.7	11.6	10.5	12.2	11.9

*See Table 1, page 11, for code which also applies to this table.

Processing Loss

Processing loss, which did not include spoilage, was the weight of caps and of soft, mashed, and damaged berries that passed be-

Table 4. Processing Loss of Strawberries Under Nine Treatments, Food Technology Department, 1957.

Date	Treatments*								
	IR	IC	IO	WR	WC	WO	DR	DC	DO
	Percent of net weight								
May 6	7.9	11.2	8.3	7.7	9.9	12.5	6.7	5.7	6.4
9	12.1	12.4	7.9	11.2	8.3	10.0	5.7	7.1	8.9
10	3.9	7.2	4.2	6.8	3.9	5.7	3.6	4.3	2.9
13	26.2	20.7	17.3	20.0	19.3	17.8	13.3	21.0	14.4
15	27.8	26.5	25.0	27.4	29.2	24.7	21.8	25.0	22.9
16	19.0	23.5	24.3	21.1	25.8	20.3	21.7	20.8	17.8
20	11.3	11.2	10.9	15.7	12.1	9.3	10.4	11.3	10.1
21	11.4	12.3	9.9	17.4	10.3	12.5	10.7	16.9	13.0
23	12.3	16.1	16.1	13.6	12.5	10.2	12.6	5.4	6.6
27	20.2	19.5	12.0	17.7	20.5	14.9	7.1	13.8	11.4
28	17.9	18.1	18.7	24.3	21.1	18.4	17.8	17.4	15.1
30	17.8	22.3	16.3	19.5	16.4	13.7	7.4	14.3	9.5
31	22.6	23.1	21.8	24.0	25.8	21.5	19.9	20.6	17.1
Average	16.2	17.2	14.8	17.4	16.5	14.7	12.2	14.1	12.0

*See Table 1, page 11, for code which also applies to this table.

tween the rollers of the capping machine. Table 4 shows the processing loss by treatments. The differences between the treatments were not significant (Appendix Table 5). However, when the treatments were grouped between dry and wet, the difference in average processing loss of 12% for dry and 16% for wet treatments was found to be highly significant at the 0.01 level (Appendix Table 6).

Percent Turn-out

The percentage of usable strawberries realized from those purchased will be referred to hereafter as "percent turn-out." It was calculated by dividing the weight of the usable berries obtained at the end of the inspection belt by the field weight of the freshly harvested fruit. The strawberries had been washed, machine-capped and inspected before the final weighing. There was no significant difference between the treatments on the basis of percent turn-out. Even when grouped according to wet or dry treatments, there was no significant difference (the mean turn-out for wet and dry strawberries was 71.5% and 72.5%, respectively, for the entire processing season).

Strawberries for Fresh Market

Shrinkage

The hydrocooling process significantly reduced the weight loss in transit (Appendix Table 7). The 2% gain in weight by hydrocooled berries, or 0.7% of a pound per crate, was evidently due to both the thin film of water which surrounded each strawberry and the reduced fruit temperature. Nonhydrocooled berries lost about 1.6%, or 0.5 of a pound per crate, in weight during transit.

The data in 1958 agreed with the data for the previous season in that precooling strawberries significantly reduced weight loss in transit. There was no indication of significant differences in changes of weight between the treatments during overnight storage.

pH

Samples of hydrocooled and nonhydrocooled strawberries, consisting of 1 quart each, were selected from each truckload of berries at the Food Technology Department for pH determinations (Table 5). There were no significant differences in pH (Appendix Table 8).

Table 5. The pH and Soluble Solids Content in Hydrocooled and Nonhydrocooled Strawberries Food Technology Department, 1958.

Date	pH		Soluble solids	
	Hydrocooled	Nonhydrocooled	Hydrocooled	Nonhydrocooled
			Percent	
May 16	3.5	3.2	7.2	7.2
19	3.3	3.4	5.4	5.7
20	3.3	3.4	4.8	6.0
22	3.2	3.3	5.4	5.6
23	3.2	3.2	4.4	5.0
26	3.1	3.2	5.0	5.0
28	3.5	3.4	6.0	5.5
29	3.3	3.3	5.5	6.5
30	3.4	3.3	5.6	6.5
June 3	3.6	3.4	7.0	7.5
4	3.3	3.3	5.5	6.0
Average	3.3	3.3	5.6	6.0

Soluble Solids[5]

An analysis of soluble solid content was run on the same samples of hydrocooled and nonhydrocooled strawberries (Table 5). The ranges of soluble solid content for the treatments were about the same, 4.4% to 7.2% and 5.0% to 7.5% for hydrocooled and nonhydrocooled berries, respectively. No significant differences were found in soluble solids (Appendix Table 9).

[5]Conducted by Ivon E. McCarty, Department of Food Technology, University of Tennessee.

Table 6. Mold Count for Hydrocooled and Nonhydrocooled Strawberries, 1958.

Date	Hydrocooled	Nonhydrocooled
	Percent moldy	
May 16	32	20
19	20	16
20	12	24
22	32	48
23	28	20
26	32	36
27	56	80
28	12	44
29	4	60
30	36	36
June 3	12	16
4	44	52
Average	26.7	37.7

Mold Count[6]

Tests were made on the same berry samples to determine the effect of hydrocooling on the mold count (Table 6). Hydrocooling did not affect the mold count on strawberries significantly (Appendix Table 10).

TASTE PANEL EVALUATION[7]

Each characteristic of the strawberries—odor, flavor, texture, brightness and color—was ranked according to the grade given by the taste panel, which was composed of 10 University employees. The characteristics of the hydrocooled strawberries were not significantly different from the nonhydrocooled (Appendix Tables 11-15).

CONSUMER EVALUATION OF HYDROCOOLED AND NONHYDROCOOLED STRAWBERRIES IN RETAIL STORES AND IN THEIR HOMES

Data on consumers' evaluation of strawberries at the time of purchase are shown in Table 7. About 77% of the evaluations for hydrocooled strawberries on the refrigerated tables were "excellent" and "good" compared to 61% for the nonhydrocooled strawberries. Similar ratings for the berries on the unrefrigerated table of one store were 68% of "excellent" and "good" for the hydrocooled berries and 52% for the nonhydrocooled (see Table 8 for details).

Hydrocooling appeared to wash the color from bruised strawberries, producing areas light in color. This was especially noted on capped berries. Strawberries to be hydrocooled should not be bruised.

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[6]Conducted under the supervision of J. O. Mundt, Food Technology Department, University of Tennessee.

[7]Conducted under the supervision of Bernadine Meyer, Home Economics Research, University of Tennessee.

Table 7. Summary of Consumers' Evaluation of Hydrocooled and Nonhydrocooled Strawberries, Four Retail Grocery Stores, Knoxville, Tennessee, 1958.

	Type of display							
	Refrigerated table*				Unrefrigerated table**			
Ratings	Hydrocooled		Nonhydrocooled		Hydrocooled		Nonhydrocooled	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Excellent	130	17.2	85	11.2	16	9.4	8	4.7
Good	450	59.4	377	49.8	100	58.4	80	46.8
Fair	162	21.4	259	34.2	46	26.9	66	38.6
Poor	15	2.0	36	4.8	9	5.3	17	9.9
Total	757	100.0	757	100.0	171	100.0	171	100.0

*Three stores
**One store

At the three retail grocery stores where the strawberries were displayed on refrigerated tables, the evaluations on brightness and color of hydrocooled strawberries in the "excellent" category were significantly higher than for the nonhydrocooled strawberries. The color evaluations were higher in the "good" category for the hydrocooled strawberries. Evaluations on brightness and color in the "fair" and "poor" categories were significantly higher for the nonhydrocooled strawberries.

The pooled ratings on odor, texture, brightness, and color for hydrocooled strawberries were significantly higher than for nonhydrocooled strawberries in the "excellent" and "good" categories, but were significantly lower for the "fair" and "poor" categories (Appendix Table 16). The difference in ratings between hydro-

Table 8. Consumers' Evaluation of Hydrocooled and Nonhydrocooled Strawberries, Four Retail Grocery Stores, Knoxville, Tennessee, 1958.

Type of display and rating	Quality attributes									
	Odor		Texture		Brightness		Color		Total	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Refrigerated tables										
Hydrocooled										
Excellent	22	20.6	23	19.8	42	15.7	43	16.1	130	17.2
Good	70	65.4	74	63.8	154	57.7	152	56.9	450	59.4
Fair	14	13.1	18	15.5	65	24.3	65	24.4	162	21.4
Poor	1	.9	1	.9	6	2.3	7	2.6	15	2.0
Total	107	100.0	116	100.0	267	100.0	267	100.0	757	100.0
Nonhydrocooled										
Excellent	19	17.8	19	16.4	22	8.2	25	9.4	85	11.2
Good	66	61.7	69	59.5	122	45.7	120	44.9	377	49.8
Fair	21	19.6	27	23.3	106	39.7	105	39.3	259	34.2
Poor	1	.9	1	.8	17	6.4	17	6.4	36	4.8
Total	107	100.0	116	100.0	267	100.0	267	100.0	757	100.0
Unrefrigerated tables										
Hydrocooled										
Excellent	1	9.1	1	7.1	7	9.6	7	9.6	16	9.4
Good	6	54.5	10	71.5	42	57.5	42	57.5	100	58.4
Fair	2	18.2	2	14.3	21	28.8	21	28.8	46	26.9
Poor	2	18.2	1	7.1	3	4.1	3	4.1	9	5.3
Total	11	100.0	14	100.0	73	100.0	73	100.0	171	100.0
Nonhydrocooled										
Excellent	1	9.1	1	7.1	3	4.1	3	4.1	8	4.7
Good	5	45.4	7	50.0	34	46.6	34	46.6	80	46.8
Fair	3	27.3	4	28.6	29	39.7	30	41.1	66	38.6
Poor	2	18.2	2	14.3	7	9.6	6	8.2	17	9.9
Total	11	100.0	14	100.0	73	100.0	73	100.0	171	100.0

Table 9. Summary of the Consumers' Evaluation in the Store and in the Home of Hydrocooled and Nonhydrocooled Strawberries by Type of Display, Knoxville, Tennessee, 1958.

Type of display	Evaluations																			
	Excellent				Good				Fair				Poor				Total			
	Store		Home		Store		Home		Store		Home		Store		Home		Store		Home	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Refrigerated table																				
Hydrocooled	149	21.3	216	30.9	411	58.7	407	58.1	130	18.6	61	8.7	10	1.4	16	2.3	700	100.0	700	100.0
Nonhydrocooled	51	12.9	120	30.4	223	56.5	222	56.2	112	28.3	45	11.4	9	2.3	8	2.0	395	100.0	395	100.0
Total	200	18.3	336	30.7	634	57.9	629	57.9	242	22.1	106	9.7	19	1.7	24	2.2	1095	100.0	1095	100.0
Nonrefrigerated table																				
Hydrocooled	14	7.0	51	25.5	137	68.5	124	62.0	39	19.5	24	12.0	10	5.0	1	.5	200	100.0	200	100.0
Nonhydrocooled	15	7.4	24	11.8	116	56.9	142	69.6	68	33.3	32	15.7	5	2.4	6	2.9	204	100.0	204	100.0
Total	29	7.2	75	18.6	253	62.6	266	65.8	107	26.5	56	13.9	15	3.7	7	1.7	404	100.0	404	100.0

cooled and nonhydrocooled strawberries in the "excellent" and "good" and the "fair" and "poor" categories is attributed to this fact: that the total "fair" and "poor" ratings of the hydrocooled strawberries consisted of only 23% of the consumers compared with 39% for the nonhydrocooled. This indicates quality was maintained better in hydrocooled strawberries (see Table 8).

Refrigeration in any form appears to retard the rate of maturation of the strawberries and should prolong shelf life unless fungal growth were promoted by wetting.

Table 9 shows a summary of the pooled evaluations on odor, texture, brightness, and color in homes and in stores—the three

Table 10. Consumers' Evaluation of Hydrocooled and Nonhydrocooled Strawberries at Four Retail Grocery Stores by Type of Display, Knoxville, Tennessee, 1958.

Type of display and rating	Quality factors									
	Odor		Texture		Brightness		Color		Total	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Refrigerated tables					Store					
Hydrocooled										
Excellent	22	29.0	31	19.5	48	20.8	48	20.5	149	21.3
Good	45	59.2	99	62.3	135	58.4	132	56.4	411	58.7
Fair	8	10.5	28	17.6	45	19.5	49	21.0	130	18.6
Poor	1	1.3	1	.6	3	1.3	5	2.1	10	1.4
Total	76	100.0	159	100.0	231	100.0	234	100.0	700	100.0
Nonhydrocooled										
Excellent	6	13.3	15	15.2	14	11.3	16	12.6	51	12.9
Good	31	68.9	56	56.6	68	54.8	68	53.5	223	56.4
Fair	7	15.6	25	25.2	38	30.7	42	33.1	112	28.4
Poor	1	2.2	3	3.0	4	3.2	1	.8	9	2.3
Total	45	100.0	99	100.0	124	100.0	127	100.0	395	100.0
Unrefrigerated table										
Hydrocooled										
Excellent	1	10.0	—	—	6	7.4	7	8.6	14	7.0
Good	7	70.0	20	71.4	56	69.1	54	66.7	137	68.5
Fair	—	—	7	25.0	16	19.8	16	19.8	39	19.5
Poor	2	20.0	1	3.6	3	3.7	4	4.9	10	5.0
Total	10	100.0	28	100.0	81	100.0	81	100.0	200	100.0
Nonhydrocooled										
Excellent	—	—	3	10.4	6	7.2	6	7.0	15	7.4
Good	2	40.0	15	51.7	49	58.3	50	58.1	116	56.9
Fair	—	—	11	37.9	28	33.3	29	33.7	68	33.3
Poor	3	60.0	—	—	1	1.2	1	1.2	5	2.4
Total	5	100.0	29	100.0	84	100.0	86	100.0	204	100.0

stores displaying strawberries on refrigerated tables and the one store displaying on an unrefrigerated table (see Tables 10 and 11 for details). Both hydrocooled and nonhydrocooled strawberries displayed on the refrigerated tables received about the same percent of "good" ratings in the stores and in the homes. However, they received significantly more "excellent" ratings in the homes and "fair" ratings in the stores (Appendix Tables 17 and 18). The difference in rating given to the berries rated "excellent" and "fair" might be attributed to the fact that the consumers had more time to examine the berries and they had also eaten some of them.

The hydrocooled strawberries on the unrefrigerated table re-

Table 11. Consumers' Evaluation of Hydrocooled and Nonhydrocooled Strawberries in the Consumers' Homes, Knoxville, Tennessee, 1958.

Type of display and rating	Quality factors									
	Odor		Texture		Brightness		Color		Total	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Refrigerated tables					Home					
Hydrocooled										
Excellent	26	34.2	50	31.4	69	29.9	71	30.3	216	30.9
Good	39	51.3	90	56.6	140	60.6	138	59.0	407	58.1
Fair	9	11.9	16	10.1	16	6.9	20	8.6	61	8.7
Poor	2	2.6	3	1.9	6	2.6	5	2.1	16	2.3
Total	76	100.0	159	100.0	231	100.0	234	100.0	700	100.0
Nonhydrocooled										
Excellent	12	26.7	28	28.3	40	32.3	40	31.5	120	30.4
Good	29	64.4	57	57.6	70	56.4	66	52.0	222	56.2
Fair	4	8.9	10	10.1	12	9.7	19	14.9	45	11.4
Poor	—	—	4	4.0	2	1.6	2	1.6	8	2.0
Total	45	100.0	99	100.0	124	100.0	127	100.0	395	100.0
Unrefrigerated table										
Hydrocooled										
Excellent	3	30.0	10	35.7	18	22.2	20	24.7	51	25.5
Good	6	60.0	16	57.2	54	66.7	48	59.3	124	62.0
Fair	—	—	2	7.1	9	11.1	13	16.0	24	12.0
Poor	1	10.0	—	—	—	—	—	—	1	.5
Total	10	100.0	28	100.0	81	100.0	81	100.0	200	100.0
Nonhydrocooled										
Excellent	—	—	1	3.5	12	14.3	11	12.8	24	11.8
Good	4	80.0	23	79.3	58	69.0	57	66.3	142	69.6
Fair	1	20.0	5	17.2	11	13.1	15	17.4	32	15.7
Poor	—	—	—	—	3	3.6	3	3.5	6	2.9
Total	5	100.0	29	100.0	84	100.0	86	100.0	204	100.0

ceived significantly more "excellent" ratings in the homes and "poor" ratings in the store. The nonhydrocooled strawberries on the unrefrigerated table received significantly more "fair" ratings in the store than in the homes.

CONSUMER CHARACTERISTICS AND BUYING PREFERENCES

Who did the buying? Wives made 86% of the purchases, husbands 12%, and sons and daughters 2%.

Level of education. College-trained persons made up 49% of the 508 consumers interviewed in the four retail stores where these experiments were conducted. Consumers with high school training comprised 42% and those who had only elementary education comprised 9%.

Satisfaction with size of fresh-market container. The containers in which the fresh-market strawberries were sold held 1 quart. It seemed possible that this would be more strawberries than a small household would want to buy at one time. The consumers were, therefore, asked "Is this container the right size?" Table 12 indicates that the container was satisfactory for 96% of the consumers.

Table 12. Replies to the Question, "Is this fresh-market container the right size?" 508 Consumers, Knoxville, Tennessee, 1958.

Size Preference	Number	Percent
Size satisfactory	485	95.5
Smaller	16	3.1
Larger	7	1.4
Total	508	100.0

Specific comments about container. Consumers were asked to give suggestions about the container that would be helpful in designing a better one. Most respondents expressed approval of the quart container made of plywood (Table 13).

Table 13. Replies to the Question, "Was there anything you didn't like about the quart container?" 508 Consumers, Four Retail Grocery Stores, Knoxville, Tennessee, 1958.

Responses	Number	Percent
It was all right	381	75.0
Prefer plastic cups	78	15.3
Container was wet	44	8.7
Container had been used	3	0.6
Container needed more air	2	0.4
Total	508	100.0

However, about 15% of the consumers indicated a preference for plastic cups. Used or wet containers and inadequate ventilation were reported by about 10% of the consumers.

Comments about strawberries. Table 14 shows the responses of buyers of hydrocooled berries and those who bought nonhydrocooled berries. The responses were about the same for both hydrocooled and nonhydrocooled strawberries. Since about 45% of the

Table 14. Comments About Fresh-Market Hydrocooled and Nonhydrocooled Strawberries, 508 Consumers, Four Retail Grocery Stores, Knoxville, Tennessee, 1958.

Responses on evaluation	322 consumers evaluating hydrocooled berries[1]		215 consumers evaluating nonhydrocooled berries[1]	
	No.[2]	Percent	No.[2]	Percent
Favorable				
Good	248	77.0	163	75.8
All right	24	7.5	8	3.7
Delicious	9	2.8	9	4.2
Acceptable	5	1.5	8	3.7
Total	286	88.8	188	87.4
Unfavorable				
Immature	84	26.1	45	20.9
Too small	14	4.3	7	3.3
Tough	12	3.7	18	8.4
Below average	12	3.7	3	1.4
Poor	11	3.4	10	4.7
Spoiled	8	2.5	4	1.9
No flavor	3	0.9	—	—
Not uniform	2	0.6	—	—
Total	146	45.2	87	40.6

[1]Twenty-nine consumers purchased both hydrocooled and nonhydrocooled berries.
[2]Some consumers expressed more than one comment.

consumers complained about poor quality, it would appear highly desirable to use quality-control-grading procedures to improve the grade of fresh-market strawberries.

Ways of serving. The specific ways the consumers who were interviewed served the test strawberries are shown in Table 15. More than half of the consumers served the strawberries with shortcake for dessert.

Frequency of purchase. The number of times consumers bought fresh strawberries is an indication of consumer demand for strawberries. The relationship between income and the number of times fresh strawberries were purchased during the previous 12 months is shown on Table 16. Eighty-one percent of the lower-income group either made no purchases or made only 1 to 3 purchases of

Table 15. Specific Method of Serving Strawberries Reported by 508 Consumers, Knoxville, Tennessee, 1958.

Method of serving	Number reporting	Percent
With shortcake	269	52.9
With sugar only	74	14.6
With sugar and cream	51	10.0
In pie	29	5.7
With cream only	29	5.7
Plain	24	4.7
With cereal	16	3.2
In ice cream	16	3.2
Total	508	100.0

fresh berries in that time compared to 76% of the higher-income group. On the other hand, 10% of the higher-income group bought fresh strawberries 11 or more times, whereas only 4% of the lower-income group bought fresh strawberries 11 or more times.

Table 16. Frequency of Purchase of Fresh Strawberries During the Previous 12 Months, by Income Groups, 508 Consumers, Knoxville, Tennessee, 1958.

Times purchased	Income group					
	0 — $5,000		$5,001 or more		Total	
	No.	Pct.	No.	Pct.	No.	Pct.
None	105	33.2	49	25.5	154	30.3
1	61	19.3	39	20.3	100	19.7
2	59	18.7	33	17.2	92	18.1
3	30	9.5	10	5.2	40	7.9
4	6	1.9	8	4.2	14	2.8
5	9	2.9	9	4.7	18	3.5
6	15	4.7	11	5.7	26	5.1
7	1	0.3	—	—	1	0.2
8	5	1.6	5	2.6	10	2.0
9	—	—	1	0.5	1	0.2
10	14	4.4	8	4.2	22	4.3
11 or more	11	3.5	19	9.9	30	5.9
Total	316	100.0	192	100.0	508	100.0

Table 17. Replies to the Question, "What size strawberries do you prefer?" 484 Consumers Reporting, Knoxville, Tennessee, 1958.

Size preference	Consumers	
	Number	Percent
Small (0—5/8 in.)	23	4.7
Medium (5/8—1 in.)	360	74.4
Large (over 1 in.)	101	20.9
Total	484	100.0

Size preference. The consumers were asked, "What size strawberries do you prefer?" Table 17 presents the preferences as reported. Very few of the consumers said they wanted the small size, but most wanted the medium size.

Home storage. It was believed that the methods consumers employed in storing strawberries undoubtedly would affect the life of the berries. Consumers were asked, "How did you store these strawberries before you used them?" Table 18 gives the replies to this question.

Table 18. Replies to the Question, "How did you store these strawberries before you used them?" 464 Consumers, Knoxville, Tennessee, 1958[1].

Storage method	Hydrocooled		Nonhydrocooled	
	Number	Percent	Number	Percent
Freezing compartment	6	2.1	1	0.5
Refrigerator	272	93.8	186	94.9
Outside refrigerator	12	4.1	9	4.6
Total	290	100.0	196	100.0

[1]Twenty-two of the consumers bought both hydrocooled and nonhydrocooled strawberries.

Almost all of the purchasers of both hydrocooled and nonhydrocooled berries stored them in a refrigerator until they were ready to use them. Furthermore, there was only 1% difference in the percentage of consumers who stored hydrocooled strawberries in a refrigerator, compared with those who stored nonhydrocooled strawberries there. Most consumers who stored the strawberries outside the refrigerator served them the same day.

RELATIONSHIP OF TIME BETWEEN PURCHASE, SERVING, AND DECAY

Table 19 discloses information from consumers buying strawberries at three retail grocery stores in which strawberries had been stored on refrigerated tables.

Of the 141 consumers who purchased hydrocooled strawberries from refrigerated tables, 85.8% reported no decay from 1 through 4 days and 14.2% reported some decay—ranging in amount from 1 to 4% from 1 through 2 days. On the nonhydrocooled berries, 72.9% of the 96 consumers reported no decay from 1 through 3 days and 27.1% reported some decay ranging from 1 to over 5% from 1 through 3 days.

Table 19. Amount of Decay Before Purchase from Refrigerated Table in Three Retail Grocery Stores, 237 Consumers, Knoxville, Tennessee, 1958.

Time from purchase to serving	Percent of decay													
	Hydrocooled							Nonhydrocooled						
	0	1	2	3	4	5	Over-5	0	1	2	3	4	5	Over-5
	Number of consumers													
Same day	38	0	0	0	0	0	0	29	0	0	0	0	0	0
One day	52	6	7	0	0	0	0	27	1	13	0	0	1	1
Two days	24	0	3	1	3	0	0	13	3	3	0	1	0	0
Three days	6	0	0	0	0	0	0	1	0	3	0	0	0	0
Four days	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	121	6	10	1	3	0	0	70	4	19	0	1	1	1
Percent of total	85.8	4.3	7.1	0.7	2.1	0	0	72.9	4.2	19.9	0.0	1.0	1.0	1.0

Table 20 shows information comparable to that given in the preceding table for consumers who bought strawberries at the retail grocery store where the strawberries were stored on a display table without refrigeration. About 92% of the 181 consumers buying hydrocooled berries reported no decay, and 7.7% of them reported decay ranging from 1 to 3%. Of the consumers purchasing

Table 20. Amount of Decay in Strawberries Displayed on Unrefrigerated Tables Before Purchase, 296 Consumers, Knoxville, Tennessee, 1958[1].

Time from purchase to serving	Percent of decay													
	Hydrocooled							Nonhydrocooled						
	0	1	2	3	4	5	Over-5	0	1	2	3	4	5	Over-5
	Number of consumers													
Same day	66	0	0	0	0	0	0	40	0	0	0	0	0	0
One day	45	4	3	0	0	0	0	25	1	6	0	0	2	1
Two days	48	0	2	2	0	0	0	18	3	3	0	0	0	0
Three days	8	1	2	0	0	0	0	14	0	2	0	0	0	0
Total	167	5	7	2	0	0	0	97	4	11	0	0	2	1
Percent of total	92.3	2.7	3.9	1.1	0	0	0	84.3	3.5	9.6	0	0	1.7	0.9

[1]Twenty-nine of the consumers reporting bought both hydrocooled and nonhydrocooled strawberries.

nonhydrocooled strawberries, 84.3% reported no decay, and 15.7% reported decay ranging from 1 to over 5%. This indicates that quality was maintained better by hydrocooling. The range of decay for the nonhydrocooled berries was 1 to over 5%, whereas the range of decay for hydrocooled berries was only 1 to 3%.

THE COSTS OF HYDROCOOLING

Costs of hydrocooling can be divided into two major categories: variable and fixed. When a grower buys a hydrocooler, he is unable to reduce his fixed costs unless he sells the machine or a partial interest in it. Consequently variable costs determine the profitability of a machine already owned.

Variable Costs

The variable cost items are ice, water, labor, and electricity. Ice and labor are the major variable costs. The consumption of ice will depend on the number of crates of berries to be cooled and the required drop in temperature. A certain amount of ice is necessary—based on air temperature and amount of water used—to reduce the temperature of the water used in hydrocooling to 40 degrees F. before the process can begin; then to cool a 16-quart crate of berries an estimated 0.15 pounds of ice is required for each degree of reduction in temperature. Actual ice consumption might be somewhat higher than the theoretical estimate. The variables that would influence the use of more ice would be heat from the atmosphere, ice meltage before it is used on hot days, and the number of crates cooled. A machine running at full capacity would use proportionately less ice; breaks in operation would require more ice.

Usually three men are required to operate a commercial hydrocooler. One man lifts containers into the machine, one takes them out of the other side, and one adds ice as needed. An average day of operation might be about 5.7 hours, or 17.1 man-hours of total labor. Assuming a wage of $1 per hour, the labor cost would be $17.10 per day. The cost of electricity and water is relatively small for the operation of the machine.

Fixed Costs

The investment in equipment will vary according to the size of the machine. A single-unit (24-foot) machine and allied equipment to operate it cost about $5,150 installed, as of 1962. Double and triple units cost 2 and 3 times that amount. A smaller 12-foot machine could be bought for about $2,990.

The major fixed costs consist of depreciation, interest on investment, insurance, and taxes. Table 21 shows the estimated annual fixed costs for hydrocooling.

Exact information is not available on the expected years of life and annual repairs. Ten years appears to be a reasonable estimate of life. An estimate of 1% for repairs and 10% for depreciation are used in this report.

Table 21. Estimated Annual Fixed Costs for Hydrocooling[1].

Item	Annual cost 24' unit	12' unit
	Dollars	
Depreciation and repairs (11% of the original cost)	566	329
Interest on investment (5% of 1/2 the original cost)	129	75
Insurance ($1.56 per hundred)	80	47
Taxes ($1.20 per hundred for one-third of the depreciated machinery value)	10	6
Total	785	457

[1]Based on a cost of $5,150 for the 24-foot unit and $2,990 for the 12-foot unit. If an ice house and pack house additions are needed, fixed costs are higher than these figures.

APPENDIX

Appendix Table 1

Grading Chart for Strawberries

Date _____ Name _____

Directions: Write in value which represents your opinion.
Taste samples in order presented.

Values: 4 — Excellent
3 — Good
2 — Fair
1 — Poor

Sample	
Odor	
Flavor	
Texture (pithy, tough, mushy, rubbery)	
Brightness	
Color	
What did you like about the color?	

Appendix Table 2

Analysis of Variance on Weight Changes in Strawberries Under Nine Treatments, 1957.

Source of variation	Degrees of freedom	Mean square	F
Total	98		
Between treatments	8	66.95	34.33**
Within treatments	90	1.95	

**Significant at the 0.01 level.

Appendix Table 3

Difference Between Means for Nine Treatments on Weight Change of Strawberries, Food Technology Plant, Knoxville, Tennessee, 1958.

Mean	Treat-ment	DR	DC	WO	IO	WC	WR	IR	IC
—3.98	DO	1.81*	2.44*	3.29*	4.78*	5.72*	5.74*	6.98*	7.16*
—2.17	DR		0.63	1.48*	2.97*	3.91*	3.93*	5.17*	5.35*
—1.54	DC			.85	2.34*	3.28*	3.30*	4.54*	4.72*
—0.69	WO				1.49*	2.43*	2.45*	3.69*	3.87*
.80	IO					.94	.96	2.20*	2.38*
1.74	WC						.02	1.26*	1.44*
1.76	WR							1.24*	1.42*
3.00	IR								.18

*Significant at the 0.05 level.

Appendix Table 4

Analysis of Variance on Spoilage of Strawberries Under Nine Treatments, 1957.

Source of variation	Degrees of freedom	Mean square	F
Total	116		
Between treatments	8	5.65	0.28
Within treatments	108	20.11	

Appendix Table 5

Analysis of Variance on Processing Loss Under Nine Treatments, 1957.

Source of variation	Degrees of freedom	Mean square	F
Total	116		
Between treatments	8	52.45	1.25
Within treatments	108	41.80	

Appendix Table 6

Comparison of the Means in Processing Loss of Strawberries Under Dry and Wet Treatments, 1957.

	Treatment		Difference	Squared deviation
	Dry	Wet		
Total	5.1710	14.0205		
Mean	0.1231	0.1612	—0.0381	0.5072

$S^2 = 0.0040$ $S\overline{x}_1 - \overline{x}_2 = 0.0119$ $t = 320^{**}, 127$ df

**Significant at the 0.01 level.

Appendix Table 7

Comparison of the Means in the Average Weight Change of Strawberries in Transit, Dayton to Knoxville, Tennessee, 1958.

	Average weight change of strawberries per crate		Difference	Squared deviation
	Hydrocooled	Nonhydrocooled		
Total	120.23	—91.73		
Mean	2.11	— 1.61	3.72	187.1542

$SD^2 = 3.3420$ $SD = 1.8281$ $S\overline{d}^2 = 0.0586$ $S\overline{d} = 0.2421$ $t = 15.37^{**}$, 56 df

**Significant at the 0.01 level.

Appendix Table 8

Comparison of the Means in the pH Test of Hydrocooled and Nonhydrocooled Strawberries, 1958.

	pH		Difference	Squared deviation
	Hydrocooled	Nonhydrocooled		
Total	40.09	39.90		
Mean	3.35	3.33	0.02	0.1472

$SD^2 = 0.134$ $SD = 0.1158$ $S\bar{d}^2 = 0.0011$ $S\bar{d} = 0.0332$ $t = 0.48$, 11 df

Appendix Table 9

Comparison of the Means in the Soluble Solids Test of Hydrocooled and Nonhydrocooled Strawberries, 1958.

	Soluble solids		Difference	Squared deviation
	Hydrocooled	Nonhydrocooled		
Total	67.7	71.5		
Mean	5.64	5.96	—0.32	4.0967

$SD^2 = 0.3724$ $SD = 0.6102$ $S\bar{d}^2 = 0.310$ $S\bar{d} = 0.1761$ $t = -1.80$, 11 df

Appendix Table 10

Comparison of the Means in the Mold Count Test of Hydrocooled and Nonhydrocooled Strawberries, 1958.

	Mold Count (Percent)		Difference	Squared deviation
	Hydrocooled	Nonhydrocooled		
Total	320	452		
Mean	26.67	37.67	—11	4004

$SD^2 = 364$ $SD = 19.08$ $S\bar{d}^2 = 30.33$ $S\bar{d} = 5.5$ $t = -2.00$, 11 df

Appendix Table 11

Analysis of Variance on Taste Panel's Evaluation of Odor, Food Technology Department, 1958.

Source of variability	Variability	df	Mean square	F
Among tasters	9.7470	9	1.0830	5.31*
Among tests	7.3270	9	0.8141	1.98
Between treatments	0.0436	1	0.0436	0.21
TA-TE 1	33.3316	81	0.4115	2.02**
TA-TR 1	1.7719	9	0.1969	0.97
TE-TR 1	1.1318	9	0.1258	0.62
Residual	16.5181	81	0.2040	
Total	69.8710	199		

*Significant at the 0.05 level.
**Significant at the 0.01 level.

Appendix Table 12

Analysis of Variance on Taste Panel's Evaluation of Flavor, Food Technology Department, 1958.

Source of variability	Variability	df	Mean square	F
Among tasters	8.5573	9	0.9508	4.40*
Among tests	10.3997	9	1.1555	5.35*
Between treatments	0.1176	1	0.1176	0.54
TA-TE I	24.9076	81	0.3075	1.42
TA-TR I	1.7380	9	0.1931	0.89
TE-TR I	2.2879	9	0.2542	1.18
Residual	17.4849	81	0.2159	
Total	65.4930	199		

*Significant at the 0.05 level.

Appendix Table 13

Analysis of Variance on Taste Panel's Evaluation of Texture, Food Technology Department, 1958.

Source of variability	Variability	df	Mean square	F
Among tasters	9.1254	9	1.0139	6.73*
Among tests	16.3403	9	1.8156	4.91
Between treatments	0.0450	1	0.0450	0.30
TA-TE I	29.9571	81	0.3698	2.45*
TA-TR I	0.8876	9	0.0986	0.65
TE-TR I	2.4378	9	0.2709	1.80
Residual	12.2060	81	0.1507	
Total	70.9992	199		

*Significant at the 0.05 level.

Appendix Table 14

Analysis of Variance on Taste Panel's Evaluation of Brightness, Food Technology Department, 1958.

Source of variability	Variability	df	Mean square	F
Among tasters	6.1331	9	0.6815	5.76*
Among tests	22.0687	9	2.4521	8.72*
Between treatments	0.0776	1	0.0776	0.66
TA-TE I	22.7816	81	0.2813	2.38*
TA-TR I	1.6382	9	0.1820	1.54
TE-TR I	1.9596	9	0.2177	1.84
Residual	9.5823	81	0.1183	
Total	64.2411	199		

*Significant at the 0.05 level.

Appendix Table 15

Analysis of Variance on Taste Panel's Evaluation of Color, Food Technology Department, 1958.

Source of variability	Variability	df	Mean square	F
Among tasters	4.3422	9	0.4825	3.49*
Among tests	19.2971	9	2.1441	8.21*
Between treatments	0.2843	1	0.2843	2.06
TA-TE 1	21.1377	81	0.2610	1.95
TA-TR 1	1.1524	9	0.1280	0.93
TE-TR 1	—0.9160	9	—0.1018	—0.74
Residual	11.1845	81	0.1381	
Total	56.4822	199		

*Significant at the 0.05 level.

Appendix Table 16

Summary of Chi-Square Tests of the Consumers' Evaluation of Hydrocooled and Nonhydrocooled Strawberries at Time of Purchase, Three Retail Grocery Stores, Knoxville, Tennessee, 1958.

	Quality ratings			
Quality attributes	Excellent	Good	Fair	Poor
	Significant at probability level			
Odor				
Texture				
Brightness	0.05		0.01	0.05
Color	0.05	0.05	0.01	0.05
Pooled rating on quality attributes	0.05	0.05	0.01	0.01

Appendix Table 17

Summary of Chi-Square Tests for the Consumers' Evaluation of Hydrocooled and Nonhydrocooled Strawberries on Refrigerated Tables in the Store and in Their Homes, Three Retail Grocery Stores, Knoxville, Tennessee, 1958.

	Hydrocooled				Nonhydrocooled			
	Quality ratings							
Quality attributes	Excellent	Good	Fair	Poor	Excellent	Good	Fair	Poor
	Significant at probability level							
Odor								
Texture	0.05				0.05		0.05	
Brightness	0.05		0.01		0.01		0.01	
Color	0.05		0.01		0.01		0.01	
Pooled	0.01		0.01		0.01		0.01	

Appendix Table 18

Summary of Chi-Square Tests for the Consumers' Evaluation of Hydrocooled and Nonhydrocooled Strawberries on an Unrefrigerated Table in one Retail Grocery Store and in Their Homes, Knoxville, Tennessee, 1958.

	Hydrocooled				Nonhydrocooled			
	Quality ratings							
Quality attributes	Excellent	Good	Fair	Poor	Excellent	Good	Fair	Poor
	Significant at probability level							
Odor								
Texture	0.01	0.05						
Brightness	0.05						0.01	
Color	0.05						0.05	
Pooled	0.01			0.01			0.01	

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