

Marketing
FRESH SWEET CORN
in the Midwest



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Foreword

FRESH SWEET CORN is a major vegetable crop in the North Central States. Because of its extremely perishable nature it is a crop that offers a chance for wide improvements in product quality through improved handling and marketing methods. These improvements are to the advantage of growers seeking an expanded market and also to consumers, many of whom would not otherwise experience the pleasure of eating fresh, high-quality sweet corn.

It was to this end that studies by workers at the Minnesota Agricultural Experiment Station and the Indiana Agricultural Experiment Station at Purdue University were initiated under the North Central Regional Fruit and Vegetable Technical Committee. In these studies Minnesota concentrated on the effects of cooling, handling methods, and packaging films on sweet-corn quality, the costs of handling by these methods, and the quality of sweet corn as now marketed; Purdue studied the effect of methods of packaging and merchandising of properly cooled sweet corn on sales and consumer acceptance. This report includes the results of the studies at both these institutions, along with conclusions based on these and other studies.

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Marketing

FRESH SWEET CORN

in the Midwest

THE MARKET and culinary quality of vegetables has become of major importance to producers, principally because of competitive factors which have enabled the consumer to discriminate more in regard to quality when purchasing vegetables.

This is true both for individual producers and for areas, since areas tend to be identified with a particular quality of product. In order for market growers in an area to maintain their position in the production of fresh vegetables, they not only must produce vegetables of high quality, but also must maintain that quality from harvest to consumer; at the same time they must meet quality and price competition of vegetables from other areas. In fresh sweet corn the maintaining of quality is particularly important. If improperly handled from the farm to the store or in the store, quality deteriorates markedly in a few hours.

Studies relating to the marketing of fresh sweet corn by the Minnesota Agricultural Experiment Station were made on the 1950, 1951, and 1952 crops. Those at the Indiana Agricultural Experiment Station covered the 1952 crop.

Review of Literature

QUALITY in sweet corn appears to be dependent on sweetness, flavor, tenderness, and succulence. Tenderness and succulence are used to determine the proper picking maturity, at which time the sugar content is near maximum. After harvest there is a rapid loss in the four quality factors, particularly sugar, unless the sweet corn is

quickly cooled below 40° F.

As early as 1919, Appleman and Arthur (1) presented data showing that sweet corn stored one day at 86° F. lost 50 per cent of its total sugar, while sweet corn stored at 68° F. lost 26 per cent; at 50° F., 17 per cent; and at 32° F., only 8 per cent of its sugar during the same period of time. These authors also found that, after harvest, sugar is lost from sweet corn until equilibrium is reached when the total sugar has decreased about 62 per cent and the sucrose about 70 per cent. Raising or lowering the temperature of the sweet corn simply hastens or delays the attainment of the equilibrium, which seems to be about the same for all temperatures.

At about the same time Stevens and Higgins (11) found that after one day's storage sweet corn stored at 68° F. contained approximately half as much sugar as did sweet corn stored at 50° F. More recently, a number of investigations (2, 3, 4, 5, 6, 7, 8, 9, 10) have demonstrated the desirable quality of properly cooled sweet corn. Several of these studies (2, 3, 6, 9, 10) include cost data for certain cooling and handling operations. None, however, include a breakdown of handling costs from farm to consumer for several types of precooled and not-precooled sweet corn, together with comparative net retail margins for the various types involved.



Minnesota

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THE WORK done during the 1950 season consisted of: (1) measurement of quality losses in properly precooled and not-precooled sweet corn from grower to consumer, as measured by moisture and sugar content and by taste-panel ratings; (2) cost of processing and handling precooled prepackaged sweet corn compared with the cost of handling precooled sweet corn in the husk and not-precooled sweet corn in the husk; and (3) preliminary studies on the effect on product quality of certain packaging films and methods of packaging.

During the 1951 season the measurement of quality losses was extended, under controlled experimental conditions, to include all losses from the grower to the retail store. Studies were continued on the effect of different packaging films on product quality, and preliminary studies were made to determine retailing costs and realized net retail margins for precooled and not-precooled sweet corn.

During the 1952 season a comprehensive study was made of retail marketing costs and margins. Taste-panel studies were also conducted to compare the palatability of "precooled" and

"not-precooled" sweet corn sold under nonexperimental conditions according to prevailing retail practices. Additional data were obtained on the effect on product quality of certain packaging films and methods of packaging.

MATERIALS AND METHODS³

The sweet corn used in 1950 and 1951 was mostly the Golden Cross Bantam variety, and was produced on a farm about 25 miles from the wholesale outlet in Minneapolis.

Two methods of precooling were used, as shown in figures 1, 2, and 3. One involved submerging the husked sweet corn first in cold, then in ice water, while the other consisted of covering each layer of the bagged, unhusked sweet corn with chipped ice during loading into an insulated truck. The one-row husker and the hydro-cooling equipment (figure 1) had a maximum capacity of about 2,500 dozen ears of sweet corn per 10-hour day.

The retail marketing cost data were obtained at nine medium-sized self-service chain stores in Minneapolis in 1952. "Unit times" were obtained for each operation performed at the stores in selling the sweet corn. These were then converted to labor minutes per dozen. Overhead could not be determined from store records.

Samples of sweet corn were purchased daily from two of these same

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³ Details of all experimental methods employed and packaging films used have been reported (13, 14, 15).



FIG. 1. Transferring corn from the initial cooling and washing tank (tank 1) to the iced tank 2. The sizing and packaging table is at the left background (1950).

stores plus five other stores and evaluated by a taste panel of six members.

The term "precooled" is used to denote sweet corn that was iced or hydrocooled within three hours after harvest and kept iced. Use of the term "iced" would be confusing because some sweet corn that was not precooled was iced after it reached the retail store.

RESULTS

Effect of Precooling and Handling Methods on Product Temperature

The rates of cooling of sweet corn precooled by the two methods used in 1950 are shown in figure 4. The two-stage hydrocooling method was more effective in removing field heat than was the method in which bagged, unhusked sweet corn was covered with chipped ice. The husked sweet corn in ice-water bath was approximately as

cold after 30 minutes as the unhusked, bagged corn cooled by chipped ice was after two hours. However, during packaging operations following hydrocooling, the cob temperature of the husked corn rose an average of 19° F. with the result that no appreciable differences in sugar retention were found in corn precooled by the two methods (see table 1).

Unhusked sweet corn iced in the truck was 37° F. upon arrival at the market the following morning, while sweet corn handled in the conventional manner—unhusked and not precooled—was at least 25° F. warmer on arrival.

During 1951 additional data were obtained on cob temperatures of precooled and not-precooled sweet corn. The precooled sweet corn was cooled by placing chipped ice between each layer of bags as the sweet corn was loaded at picking time into an insulated truck.



FIG. 2. Top icing the baskets of packaged sweet corn (1950).

Cob temperatures at various intervals from 0 to 54 hours after harvest are shown in figure 5 for store 2. The data for store 1 were similar but are not shown.

The temperature of the pre-cooled sweet corn was lowered 28° to 42° F. during the period it was held in the truck (for nine hours after harvest). In these tests, pre-cooled sweet corn reached a temperature of about 40° F. within nine hours after picking, regardless of the initial cob temperature. Handling of pre-cooled sweet corn in the store by holding it in a walk-in cooler did not result in further cooling of the sweet corn.

The temperature of not-pre-cooled sweet corn remained above 60° F. until placed in the cooler at the store (figure 5). At the end of the second day in the store (54 hours after harvest), the cob temperature was approximately 47° F., 26 degrees lower than the average initial cob temperature at harvest.

Within the pre-cooled and not-pre-cooled lots, the cob temperature changes followed the same general pattern during the three consecutive weeks of this study. There were, however, some differences, due largely to outside influences. For example, during week 2 (figure 5), the temperature of the not-pre-cooled sweet corn dropped rather rapidly before reaching the store cooler. This was due to a low air temperature (47° F.) that prevailed overnight. In other instances, when sweet corn arrived at the retail store it generally came in with a large order of produce. Most of this produce was put into the same coolers as those used for sweet corn. When such a load was placed in the cooler, the refrigerator temperature often increased sharply, thus slowing down the rate at which the sweet corn cooled.

Records taken over a period of two weeks showed that temperatures of the not-pre-cooled sweet corn approached



FIG. 3. Sacked sweet corn goes directly from the field to an insulated truck, where it is held with chipped ice between each layer of sacks until the following morning, when it is delivered to market (1950).

room temperature (in the range of 65°-80° F.) within two hours after being removed from the cooler and placed on display. Cob temperatures of the precooled sweet corn placed on ice on the display rack remained between 35° and 45° F., with the bottom layer averaging about 38° F. and the top layer about 42° F.

Effect of Precooling and Handling Methods on Moisture Content of Product

Preliminary tests were run during 1950 with Golden Rocket sweet corn to determine the loss of moisture during varying intervals of time after harvest. It was found that in unhusked sweet corn stored for 20 hours at 75° F. the moisture content dropped 8 per cent, while that in sweet corn stored at 33° F. dropped only 0.3 per cent. The refriger-

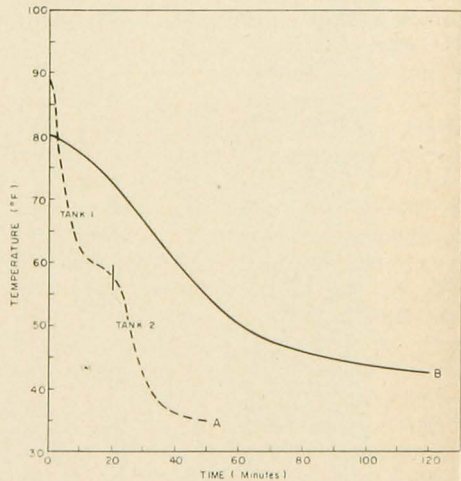


FIG. 4. Cooling rate of sweet corn (A) hydro-cooled in two stages with flowing water in tank 1 at 57° F. and iced water in tank 2 at about 33° F., and (B) in husks in burlap bags loaded on an insulated truck with ice between each layer of bags.

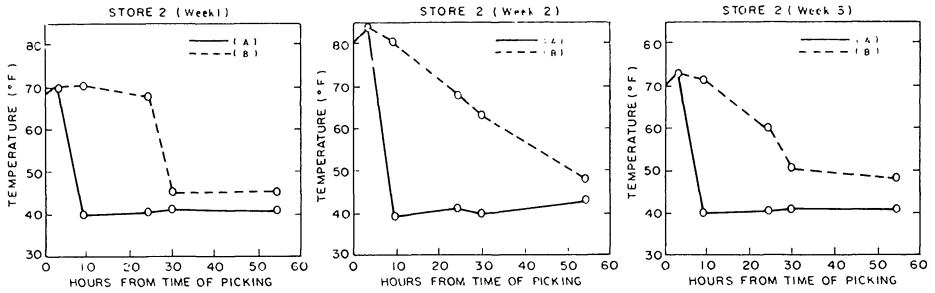


FIG. 5. Cob temperature in ears of iced (A) and noniced (B) Golden Cross Bantam sweet corn in handling from field to store during three consecutive weeks. Sampling points: 0 hours (field); 3 hours (packing shed); 9 hours (warehouse); 24 hours (store, a.m.); 30 hours (store, p.m.); 54 hours (store, p.m.). Unhusked sweet corn in burlap bags (1951).

erated samples were kept in a high-relative-humidity refrigerator of the cold-wall type.

Sweet corn harvested during the warmest days of the season contained an average of 73 per cent moisture and never varied more than 1 or 2 per cent. From the time the sweet corn was processed to the time it was sold to the consumer, it was kept in an atmosphere of high relative humidity. Thus, with the methods of handling and retailing which were studied, no appreciable

moisture loss could be detected even after 48 hours of storage.

During 1951 additional data were obtained on the moisture content of sweet corn during various stages of handling. It was found, as in 1950, that with the methods of handling and retailing used, no appreciable moisture loss was detected in precooled sweet corn for 54 hours from time of removal from the stalk. During the same period not-precooled sweet corn lost 10 to 15 per cent of its moisture.

Table 1. Changes in Total Sugars* Found in Golden Cross Bantam Sweet Corn during Its Movement Through Marketing Channels, Minnesota, 1950

		Sugar content of sweet corn and per cent loss when handled in indicated ways					
Stage in handling	Time after first sugar sample taken hours	A Husked, precooled, packaged, iced, and refrigerated		B Left in husk, iced, and refrigerated		C Left in husk without re- frigeration†	
		Sugar per cent	Loss per cent	Sugar per cent	Loss per cent	Sugar per cent	Loss per cent
On farm (when picked)	0	5.2	.....	5.2	.....	5.2	.....
On farm (before handling as indicated under A, B, and C)	2	4.6	12	4.6	12	4.6	12
In warehouse (25 miles from farm)	10	4.0	23	4.1	21	3.2	38
In store (start of day)	24	4.2	19	4.5	13	2.6	50
In store (end of day)	32	4.3	17	4.4	15	2.2	58

* Calculated as per cent maltose.
 † At air temperature of about 65° to 75° F.

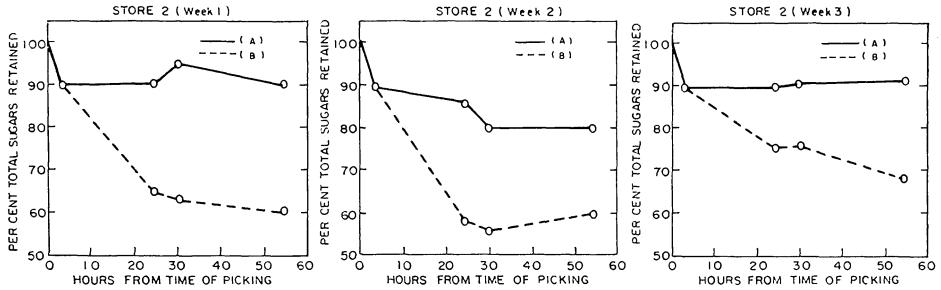


FIG. 6. Per cent total sugars* retained in iced (A) and noniced (B) Golden Cross Bantam sweet corn in handling from field to store during three consecutive weeks in two stores. Sampling points: 0 hours (field); 3 hours (packing shed); 24 hours (store, a.m.); 30 hours (store, p.m.); 54 hours (store, p.m.). Unhusked sweet corn in burlap bags (1951).

* Sugars calculated as per cent glucose.

Effect of Precooling and Handling Methods on Sugar Content

The sugar content decreased by about 47 per cent in unhusked Golden Cross Bantam sweet corn kept in burlap bags at an average temperature of 75° F. for 12 hours after harvest. For sweet corn that was husked, hydrocooled, then pre-packaged, the sugar loss was approximately 27 per cent during the same period (figures 7, 8).

To determine the changes in sugar content of the sweet corn during its movement through marketing channels, three bushel lots were labeled and followed from farm to store. Lot A consisted of husked, hydrocooled, packaged sweet corn which was kept iced and refrigerated; lot B was unhusked sweet corn in burlap bags, iced in truck after picking, and kept iced and refrigerated; lot C was unhusked sweet corn in burlap bags kept in the shade at the farm until shipped and not iced or refrigerated. All samples were trucked to the warehouse and later to the store in an open truck. Air temperatures were about 65° to 75° F. during this test.

Treatments A and B were about equally effective in reducing sugar

losses (table 1). In the retail store 24 hours after harvest, the uniced sweet corn had lost 50 per cent of its sugar while the two refrigerated samples had lost about 16 per cent of their sugar. By the end of the day (32 hours after harvest), the unrefrigerated lot had lost 58 per cent of the original sugars while there was no further loss of sugar in the refrigerated lots.

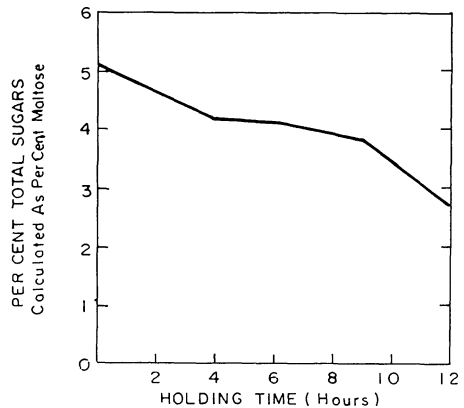


FIG. 7. Rate of sugar loss in Golden Cross Bantam sweet corn in husks when stored in the shade in burlap bags at an average air temperature of 75° F. (1950).

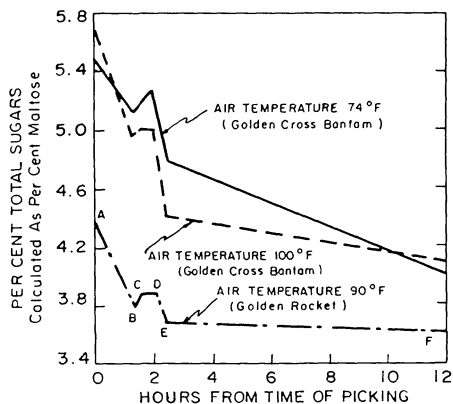


FIG. 8. Changes in total sugar content in two varieties of sweet corn during hydrocooling when outdoor temperatures were 74° F., 90° F., and 100° F. (1950). (A-B, field to packing shed; B-C, first cooling tank; C-D, second cooling tank; D-E, packaging; E-F, refrigerated storage.)

Further tests of sugar losses in 1951 showed that sweet corn lost from 8 to 12 per cent of its total sugars in the first three hours of handling from field to packing shed (table 2). At this point the rate of sugar loss in the sweet corn iced at that time was greatly retarded. However, the noniced sweet corn continued to decrease in sugar content until it reached the store, at which point it was also placed under refrigeration. During the first 54 hours after picking, sweet corn handled without precooling but iced after it reached the store lost an average of 35 per cent of its sugar,

while precooled sweet corn lost an average of only 14 per cent. These data, for one store, are shown graphically in figure 6.

In 1951 the sweet-corn harvesting season was exceptionally cool. It seems probable that there would be greater sugar losses in the not-precooled sweet corn during a normal season. For example, sugar losses in the not-precooled sweet corn were much higher in 1950, averaging 47 to 50 per cent in the first 12 to 24 hours after harvest (figure 7 and table 1).

There were no significant changes in the sugar content of either precooled or not-precooled sweet corn in the 30 hours after the sweet corn reached the stores where both were kept in the cooler (table 2).

Effect of Precooling and Handling Methods on Palatability

Taste-panel studies with precooled and not-precooled sweet corn were carried on during 1950, 1951, and 1952. All the sweet corn used in these studies during 1950 and 1951 was handled under controlled and supervised conditions. Samples of "precooled" and "not-precooled" sweet corn used during 1952 panel tests were obtained at random from retail stores, and were not handled under controlled conditions.

Prompt and adequate cooling significantly affected the retention of flavor

Table 2. Per Cent Sugar Loss in Precooled and Not-precooled Sweet Corn at 3, 24, 30, and 54 Hours after Harvest, Minnesota, 1951*

Method of handling	Per cent of initial sugars† lost at indicated hours after harvest							
	3 hours		24 hours‡		30 hours		54 hours	
	Range	Av.	Range	Av.	Range	Av.	Range	Av.
Precooled	8-12	10	8-14	11	5-22	13	8-26	14
Not-precooled§	8-12	10	22-48	34	23-44	36	29-38	35

* Average of data obtained in two stores during three consecutive weeks.

† Calculated as per cent glucose. Variety, Golden Cross Bantam.

‡ Sweet corn was placed in store coolers at about 24 hours after harvest.

§ Cob temperatures ranged from 68° to 84° F. prior to placing in store coolers.

(table 3). Sweet corn in the husk that was precooled and kept under refrigeration had an over-all average score of 6.9, compared to an average score¹ of 4.3 for not-precooled sweet corn. Statistical analysis of the data showed the difference between scores of precooled and not-precooled sweet corn to be highly significant.

Sweet corn judged 30 hours after harvest was scored significantly higher in flavor than sweet corn judged 54 hours after harvest, indicating, as is well known, that sweet corn deteriorates in quality with time elapsed after harvest. Precooled sweet corn retained its relative superiority for 54 hours. The average score for the precooled sweet corn 30 hours after harvest was 7.3 compared with 4.7 for the not-precooled sweet corn; 54 hours after harvest the average score of the precooled sweet corn was 6.5 compared with an average score of 3.8 for the not-precooled sweet corn.

¹ A panel of five judges rated the samples of sweet corn. In scoring, 1 was the poorest and 10 the highest possible score.

Furthermore, the quality score of precooled sweet corn 54 hours after harvest was significantly higher (score 6.5) than that of the not-precooled sweet corn only 30 hours after harvest (score 4.7).

Precooled sweet corn tended to be more uniform in quality week after week than not-precooled sweet corn. While there were no significant differences between weekly scores for precooled sweet corn, the scores for not-precooled sweet corn were significantly higher in the second, third, and fifth weeks than in the first- and fourth-week tests.

Higher air temperatures were encountered during the handling period in the first week (maximum 80° F.) and fourth week (maximum 89° F.) as compared with maximum air temperatures during similar periods in the second, third, and fifth week (72°, 77°, and 75° F. respectively). These temperature differences were reflected in the cob temperatures and in the sugar contents of the not-precooled sweet corn as well as in the taste-panel scores.

Table 3. Flavor Scores of Precooled and Not-precooled Sweet Corn
30 and 54 Hours after Harvest, Minnesota, 1951*

Method of handling	Week	Flavor scores of sweet corn sampled		Av.
		30 hours after harvest	54 hours after harvest	
Precooled†	1st	7.3	5.9	6.6
	2nd	7.3	7.0	7.2
	3rd	7.3	7.0	7.2
	4th	7.4	6.2	6.8
	5th	7.1	6.4	6.8
Precooled† (av.)		7.3	6.5	6.9
Not-precooled	1st	3.7	2.9	3.3
	2nd	5.4	4.4	4.9
	3rd	4.3	4.5	4.4
	4th	4.1	3.0	3.6
	5th	6.2	4.4	5.3
Not-precooled (av.)		4.7	3.8	4.3

* Tests conducted during five consecutive weeks. Average of two stores.

† Precooled by icing bagged sweet corn in the husk. Cob temperatures for lots handled through store 2 during three weeks are shown in figure 5. Weeks 1, 2, and 3 in figure 5 correspond to the 3rd, 4th, and 5th weeks in this table. Similar temperatures prevailed in lots handled through store 1.

Panel Quality Scores of 1952 Samples of Commercially Handled Sweet Corn

During 1952, 38 samples of "pre-cooled" sweet corn and 96 samples of not-precooled sweet corn were obtained at random from Minneapolis stores and judged for palatability. The average score for the sweet corn sold as pre-cooled was 4.1 and the average score for the not-precooled sweet corn was 5.1. Fresh-picked sweet corn, when used as a control, received an average score of 8.1.

In this study the sweet corn being sold as "precooled" sweet corn was not superior in palatability to the sweet corn that was not precooled. This was not in agreement with data of the two previous years when the sweet corn was handled under controlled and supervised conditions. These earlier studies indicated that precooled sweet corn, if properly handled, retained very satisfactory flavor for at least three days. It was obvious that the sweet corn represented as being "precooled" sweet corn sampled during 1952 was improperly handled as to time or temperature during the movement between farm and consumer.

The packages in one truckload of precooled sweet corn were marked during packaging on the farm. It was found that these marked packages first appeared in the retail stores seven days after prepackaging. Some of this sweet corn remained on sale for seven days after its initial appearance in the store. While other factors may have been responsible for some of the deterioration, it is apparent that in some instances delay in marketing was an important factor.

Flavor in Relation to Sugar Content

The correlation coefficients between sugar content and taste-panel flavor scores were found to be highly signifi-

cant (table 4). These coefficients indicate the degree of association between flavor scores and sugar content. The correlation coefficient of 0.730 (table 4) means that approximately 50 per cent of the variability in flavor scores was associated with variations in sugar content. The correlations for the precooled and not-precooled sweet corn show that the flavor of sweet corn was influenced more by variations in sugar content when the sweet corn was relatively low in sugar content than when the sweet corn was relatively high in sugar.

In spite of the high correlation between sugar content and flavor, taste-panel scores of the precooled sweet corn continued to decline during the period 30 to 54 hours after harvest (table 3), while the sugar content remained constant (table 2). This indicates that factors other than sugar content may determine to a great extent the palatability of sweet corn.

Prepackaging Films

Eight relatively impermeable packaging films were used during 1950, each film being used as a perforated and unperforated film. Off flavors were detected sooner in the unperforated than

Table 4. Mean Sugar Contents and Flavor Scores of Precooled and Not-precooled Sweet Corn and the Correlation Coefficients between Sugar Content and Flavor Scores, Minnesota, 1951

Type of corn	Number of samples	Av. sugar content	Av. flavor score	Correlation coefficient
		per cent		
Precooled*	12	4.9	6.9	+0.217
Not-precooled	12	3.7	4.4	+0.585†
Precooled and not-precooled ...	24	4.3	5.7	+0.730‡

* Precooled by icing unhusked sweet corn in burlap bags.

† Significant at 5 per cent level.

‡ Significant at 1 per cent level.

Note: Representative temperatures are indicated in figure 5.

in the perforated lots. There was little change in the flavor scores of sweet corn packaged in any of the perforated films during the first three days after harvest when the sweet corn was iced and held under refrigeration.

During 1951 sweet corn packaged in four different perforated films was judged by the taste panel after storage for three, four, and seven days at 36° F. Each test was repeated for three weeks and each sample was scored by five judges.

Sweet corn in the husk was rated significantly higher than that in any of the perforated films for the storage periods used in 1951 (table 5). As was expected, sweet corn stored only three days was scored significantly higher than sweet corn stored either four or seven days. However, the average scores for all packaging methods did not differ significantly between the four- and seven-day judging periods. None of the four perforated films differed significantly from the others in its effect on the desirability of flavor of the packaged sweet corn.

In 1952, the flavor scores for husked sweet corn prepackaged in a more permeable, unperforated film⁶ were sig-

⁶ Lumarith S 600-100.

Table 5. Flavor Scores of Golden Cross Bantam Sweet Corn after Storage for 3, 4, and 7 Days in Four Types of Perforated* Films and in the Husk, Minnesota, 1951†

Packaging material	Flavor scores of corn stored for			
	Three days	Four days	Seven days	Av.
Cellophane 450K202 (Saran coated)	5.3	5.3	4.5	5.0
Cellophane 450 LSAT	4.2	4.7	4.6	4.5
Pliofilm 80FF	5.7	4.6	4.1	4.8
Polyethylene .001	5.7	4.4	5.0	5.0
In husk	7.1	6.2	5.7	6.4
Av.	5.6	5.0	4.8	

* Five 1/4-inch holes per package.

† Tests conducted during three consecutive weeks with precooled sweet corn held at 36° F.

nificantly higher after four days at 38° F. than those for sweet corn in perforated cellophane⁶ (table 6). The sweet corn was held in iced baskets. No denting of the kernels due to desiccation was observed with either film, such as may result when a permeable film is used under less humid conditions. Sweet corn prepackaged in perforated cellophane without removal of the husk rated significantly higher than when similarly prepackaged without the husk. The differences between unpackaged sweet corn in the husk and any of the prepackaged lots were not significant.

Costs and Net Retail Margins

Costs of Picking, Handling, and Retailing⁷—The cost of marketing sweet corn varied by 15 cents a dozen, depending on the method of handling (table 7). Farm-precooled sweet corn prepackaged in the store was the most expensive method at 20.9 cents a dozen, while noniced sweet corn in the husk cost only 5.9 cents a dozen. Farm-precooled sweet corn in the husk that was store-iced cost 7.7 cents a dozen, or only 1.8 cents a dozen more than noniced sweet corn.

⁶ 450 LSAT.

⁷ Transportation costs not included.

Table 6. Taste-Panel Rating of Precooled Sweet Corn Stored at 38° F. for Four Days in Two Types of Packaging Films, Minnesota, 1952

Packaging film	Treatment	Av. ratings*
None (control)	Corn in husk	6.6
Cellophane, 450 LSAT (perforated)†	Corn in husk	7.0
Lumarith, S 600 (not perforated)	Corn in husk	6.6
Cellophane, 450 LSAT (perforated)†	Husk removed	6.0
Lumarith, S 600 (not perforated)	Husk removed	7.2

* Highest possible rating was 10; fresh-picked corn, when used as a control, received an average score of 8.1.

† Five 1/4-inch holes per package.

Table 7. Calculated Costs per Dozen Ears of Picking, Handling, and Retailing Precooled and Not-precooled Sweet Corn by Six Methods, Minnesota, 1950-1952*

	Cost in cents per dozen ears					
	Precooled (farm and store iced)				Not precooled or iced	
	In husk		Prepackaged		In husk	
	Displayed untrimmed	Trimmed in store	At farm	At store	Displayed untrimmed	Trimmed in store
At farm						
Picking, packaging, other labor†	2.0	2.0	6.8	2.0	2.0	2.0
Ice	1.1	1.1	1.5	1.1	.....	.....
Packaging materials	0.1	0.1	6.8	0.1	0.1	0.1
Depreciation, repairs‡	.....	.....	1.5	.....	.....	.....
At store						
Display, trimming, other labor†	2.7	7.4	2.5	13.0	2.7	7.4
Ice§	0.7	0.7	0.7	0.7	.....	.....
Packaging materials¶	1.1	0.9	.....	4.0	1.1	0.9
Total	7.7	12.2	19.8	20.9	5.9	10.4

* Transportation, store overhead, and expense for supervisory labor not included.

† Farm labor at rate of \$.85 an hour, store labor at \$1 an hour.

‡ From table 7.

§ Includes the labor cost of handling the chipped ice. The store cost was increased 1.0 cents per dozen ears when blocks of ice were used with chipped ice.

¶ Includes the cost of paper bags used in retail stores.

Note: The costs for prepackaged corn do not include an allowance for waste as no purchase price was involved prior to prepackaging. Waste was very low, estimated at only 1 per cent, equivalent to about 0.3 cents per dozen ears.

Trimming the sweet corn for display in the retail stores cost 4.5 cents per dozen over ordinary handling methods. This trimming consisted of cutting off the end of each ear and opening the husk on one side so that the kernels were visible.

Prepackaged sweet corn cost 7.6 cents more per dozen when done on the farm and 8.7 cents more when done in the retail store than unpackaged, unhusked, and trimmed sweet corn handled under similar conditions. In the retail store the extra cost of prepackaging was mostly in labor (11.3 cents over unhusked, untrimmed and 5.6 over trimmed sweet corn), with about three cents extra in bag and material costs. For farm-prepackaged sweet corn the extra cost was in labor at the farm level (4.8 cents a dozen), extra container costs (about 6.7 cents a dozen), and machinery and equipment cost of 1.5 cents a dozen (table 7).

The itemized costs of handling corn on the farm are given in table 8. Preparing precooled prepackaged sweet

corn on the farm cost 16.6 cents per dozen, as compared to 3.2 cents per dozen for precooled bulk sweet corn in the husk, and 2.1 cents per dozen for not-precooled bulk sweet corn.

An estimated annual cost of \$306 for depreciation and repair of machinery and equipment used was spread over 20,000 dozen ears for the season. Transportation costs were the same for both prepackaged and bulk sweet corn, but were not included in the tabulations.

Retail Marketing Costs—The cost of retailing sweet corn depends on the efficiency and volume of the retail store, the quality of the sweet corn, the way in which the sweet corn is prepared before it comes to the store, and the display, preparation, and packaging done in the store. Table 9 lists the variations in methods of handling sweet corn included in the cost study made in 1952.

The greatest costs to the retailer and the greatest variation among methods was that of the labor of displaying and selling. As shown in table 10, store-prepackaged sweet corn required 7.8

Table 8. Estimated Cost of Equipment, Labor, and Supplies for Three Methods of Handling Sweet Corn on the Farm, Minnesota, 1950

Item	Cost in cents per dozen ears		
	Husked, pre-cooled, packaged, iced, and refrigerated	Left in husk, iced, and refrigerated	Left in husk, without refrigeration
Labor*			
Harvesting	2.0	2.0	2.0
Husking and cooling	2.4	.....	.....
Packaging	2.4	.....	.....
Total labor	6.8	2.0	2.0
Supplies			
Cellophane 300 LSAT (13 x 18 in. sheets)	2.1	.....	.....
Sealing tape (locker tape)	0.9	.....	.....
Ice for top-icing master containers	1.3	.....	.....
Ice for precooling†	0.2	.....	.....
Ice for corn in burlap bags .....	.....	1.1	.....
Master container (bu. basket and cover)	3.8	.....	.....
Burlap bag (reused about 32 times) .....	.....	0.1	0.1
Total supplies	8.3	1.2	0.1
Equipment, depreciation, and repairs			
Precooling tanks, water system, cooler, tables, husking machine‡	1.5	.....	.....
Total cost per dozen ears	16.6	3.2	2.1

* Not including management overhead.

† Low cost for ice because cold well water accomplished about two-thirds of the cooling.

‡ Principally use of machinery and equipment. An estimated annual cost of \$306 was spread over 20,000 dozen ears for the season. Does not include cost of electricity for pumping water and operating husker and cooler.

minutes a dozen labor time as compared with 1.5 minutes a dozen labor time for farm-prepackaged sweet corn. Trimming required 4.4 minutes a dozen.

The total cost to the retailer varied from 17.7 cents a dozen for store-prepackaged to a low of 3.2 for farm-prepackaged sweet corn handled with com-

parable refrigeration (table 11). Store-prepackaged sweet corn cost about 8.7 cents a dozen more than store-trimmed and 13.2 cents more than untrimmed sweet corn in the husk under similar refrigeration.

Net Retail Margins—The highest average net retail margins per dozen

Table 9. "Types" of Sweet Corn Offered for Sale in Experimental Stores, Minnesota, 1952

Type	General classification	Processing on farm	Processing in store	Method of display
1	Precooled (farm and store)* ..	Precooled only	Trimmed only	Iced rack
2	Precooled (farm and store)* ..	Precooled only	Trimmed only	Refrigerated rack
3	Precooled (farm and store)* ..	Precooled-prepackaged	None	Iced rack
4	Precooled (farm and store)* ..	Precooled-prepackaged	None	Refrigerated rack
5	Precooled (farm and store)* ..	Precooled only	Prepackaged	Iced rack
6	Cooled at farm or store†	Not-precooled	Trimmed only	Iced rack
7	Cooled at farm or store†	Precooled-prepackaged	None	Dry rack
8	Cooled at farm or store†	Not-precooled	Prepackaged	Iced rack
9	Not-precooled or iced	Not-precooled	None	Dry rack
10	Not-precooled or iced	Not-precooled	Trimmed only	Dry rack

* Cooled through all stages of distribution.

† Cooled either at farm or store but not through all stages of distribution.

Table 10. Summary of Average Time Involved in Merchandising Sweet Corn in the Husk and Prepackaged Sweet Corn at the Retail Store, Minnesota, 1952

Time in minutes per dozen ears for indicated operations*							
Type of corn	Unloading from truck	Trimming	Packaging in store	Placing in rack	Transporting in store	Assisting sales	Total time
In husk, trimmed	.087	2.73		.34	.10	1.18	4.44
In husk, untrimmed	.087			.34	.10	1.18	1.71
Farm prepackaged	.087			.17	.19	1.07	1.52
Store prepackaged	.087	3.30	2.99	.17	.19	1.07	7.81

* Overhead time not included in these measurements.

Table 11. Calculated Costs of Retailing Seven Principal Types of Corn at Wage Rate of \$1 Per Hour, Minnesota, 1952

Type of corn	Cost in cents per dozen ears for:				Total costs
	Labor*	Chipped ice†	Paper bags	P, cellophane produce bags	
Unpackaged					
Trimmed (iced display)	7.4	0.7	0.9		9.0
Trimmed (noniced)	7.4		0.9		8.3
Untrimmed (iced display)	2.7	0.7	1.1		4.5
Untrimmed (noniced)	2.7		1.1		3.8
Prepackaged					
Farm prepackaged (iced display)	2.5	0.7			3.2
Farm prepackaged (noniced)	2.5				2.5
Store prepackaged (iced display)	13.0	0.7		4.0	17.7

* Calculated from total labor time shown in table 10.

† Includes the labor cost of handling the chipped ice. The cost was increased 1.0 cents per dozen ears when blocks of ice were used with chipped ice.

were obtained from sales of farm-prepackaged sweet corn (types 3, 4, 7) ranging from 14.3 to 21.0 cents, depending on the methods of handling (table 12). The average net margin for untrimmed, noniced sweet corn sold in the husk was 5.9 cents. In general, a higher mark-up percentage was made on prepackaged sweet corn.

The net margin was calculated by subtracting from the selling price the ice, bag, and labor costs and the price paid by the retailer for unsold sweet corn that was thrown away. The labor costs used in determining the net margins have been calculated on the basis of the practices within each store.

Table 11 shows that the labor cost for trimming was the major cost in the retailing of trimmed, unpackaged sweet corn. Apparently the retailer did not realize this, with the result that the gross margin for trimmed, precooled sweet corn that was iced in the store

was not sufficient to cover costs and therefore sales were made at a loss (table 12).

Table 12. Average Net Retail Margins per Dozen by Types of Sweet Corn, Minnesota, 1952

Type of sweet corn and method of display	Av. net margins per dozen ears
	cents
Precooled (farm and store)	
1 In husk, trimmed iced rack	Loss
2 In husk, trimmed refrigerated rack	4.8
3 Farm prepackaged iced rack	14.3
4 Farm prepackaged refrigerated rack	21.0
5 Store prepackaged iced rack	0.2
Cooled at farm or store*	
6 In husk, trimmed iced rack	3.1
7 Farm prepackaged dry rack	17.0
8 Store prepackaged iced rack	12.0
Not-precooled or iced	
9 In husk, untrimmed dry rack	5.9
10 In husk, trimmed dry rack	4.6

* Not cooled at both farm and store.



Indiana

Indiana Agricultural Experiment Station⁸ Purdue University

J. S. Vandemark⁹

MATERIALS AND METHODS¹⁰

THE WORK done by the Indiana Agricultural Experiment Station was designed to compare marketing costs, sales, and consumer acceptance of pre-cooled prepackaged sweet corn and pre-cooled bulk sweet corn. Each day a load of sweet corn delivered by one producer to a hydrocooling plant was pre-cooled and then divided into experimental lots. One lot was packaged and the other handled in bulk. During the study sweet corn came from several different producers.

The prepackaging plant selected was near Indianapolis. It provided good housing, cold-storage facilities, and market proximity with a steady supply of sweet corn available.

The prepackaged sweet corn was placed in containers holding 15 packages and the bulk sweet corn in paper bags holding 5 dozen ears. These containers were held in cold storage overnight and delivered directly to each of four cooperating supermarkets the day following harvest. Two of the stores were located in high-income areas and two in low-income areas.

The pre-cooled prepackaged sweet corn was pre-cooled mechanically, husked, trimmed and sorted, washed again, placed in a cardboard tray and

overwrapped with cellophane.¹¹ The number of ears per package was generally four, although when the ears were small five or six were placed in a tray to give the equivalent of four full ears.¹²

In the stores, the pre-cooled prepackaged and the pre-cooled bulk sweet corn were displayed side by side in comparable displays. The pre-cooled bulk sweet corn was tipped and the husks removed down one side before being displayed.

The pre-cooled bulk sweet corn was priced during the first half of the experimental period at 6 ears for 39 cents, while the pre-cooled prepackaged (4 to 6 ears) was priced at 29 cents per package. For the second half of the experiment the price for the pre-cooled bulk sweet corn was 6 ears for 29 cents and the pre-cooled prepackaged was 22 cents a package in the high-income stores and 19 cents in the low-income stores.

RESULTS

Effect of Prepackaging on Sales

The sales of prepackaged sweet corn in terms of percentage of all sweet corn sold in the four stores and at the varying price levels are given in table 13.

In stores in the high-income area, sales of prepackaged sweet corn were

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¹⁰Details of all experimental methods have been reported (12).

¹¹300 LSAT, trap door perforated.

¹²See figures 9 through 14 for methods of handling.



FIG. 9. Sweet corn is taken from the hydrocooling unit and placed in tank with ice for prepackaging. The paper bags in the background contain the precooled bulk sweet corn.

higher than sales of bulk sweet corn even though the prepackaged sweet corn was 9 cents per dozen higher during the first four weeks and 8 cents per dozen higher during the last three weeks. Sales of the prepackaged corn as a percentage of total sales were 62 and 60 per cent, respectively, in these stores, while prices were 78 cents per dozen for bulk sweet corn and 87 cents per dozen for prepackaged sweet corn. When the prices were changed to 58 cents per dozen for bulk sweet corn and 66 cents for prepackaged sweet corn, sales of the prepackaged sweet corn were 63 per cent and 61 per cent of the total sales in the two stores.

In stores in the low-income area, however, price had a definite effect on relative sales of the two types of sweet corn offered. During the first four weeks, when prepackaged sweet corn was priced 9 cents per dozen higher than bulk sweet corn, sales of the pre-

packaged sweet corn constituted 32 and 42 per cent of the total sales in the two stores, respectively. When the price differential between the two types of sweet corn was reduced to only 1 cent per dozen for the next three-week period, the sales of prepackaged corn increased to 44 and 51 per cent of total sales in the two stores, respectively. Thus customers increased their purchases of packaged corn in relation to bulk corn when the two types were sold at approximately the same price per dozen.

Additional Costs of Prepackaging

Inasmuch as both the prepackaged and bulk sweet corn were precooled, the costs of prepackaging constituted the only additional costs of preparing prepackaged corn for market. These additional costs, including waste but not overhead, were calculated to be ap-

Table 13. Sales of Precooled Prepackaged Compared with Precooled Bulk Sweet Corn, Retail, Indianapolis, 1951

Week	Percentage of total sales precooled/prepackaged						
	Low-income area			High-income area			Av. all stores
	Store 1	Store 2	Av. low	Store 3	Store 4	Av. high	
	Prepackaged 4 ears 29 cents			Prepackaged 4 ears 29 cents			
	Bulk 6 ears 39 cents			Bulk 6 ears 39 cents			
	per cent	per cent	per cent	per cent	per cent	per cent	per cent
1	29	39	33	63	60	63	45.3
2	33	32	37	64	68	65	48.9
3	32	50	38	65	50	58	47.5
4	32	26	32	53	53	56	41.6
Av.	32	42	36	62	60	62	46.7
	Prepackaged 4 ears 19 cents			Prepackaged 4 ears 22 cents			
	Bulk 6 ears 29 cents			Bulk 6 ears 29 cents			
4	50	52	51	72	61	65	58.6
5	39	50	44	59	62	60	51.2
6	47	40	48	62	57	61	52.3
Av.	44	51	47	63	61	63	54.2

proximately 17.2 cents per dozen ears throughout the experiment. The pre-packaging costs per dozen ears of sweet corn are itemized as follows:

	Cents
Cardboard trays (in lots of 25,000)	6.3
Labor (women \$.75, men \$1 per hour)	4.6
Cellophane (printed and perforated in 2,000-lb. lots)	2.4
Master container (less cost of bags) .....	.....
Ice for master container	-0.2*
Total (not including waste)	13.1
Waste (16.5 per cent)†	4.1
Total additional cost of pre-packaging per dozen ears	17.2

* Cost deducted, as about one pound more ice used per dozen ears for bulk sweet corn than for prepackaged.

† Deemed to be abnormally large due to extremely dry season which resulted in poorly filled ears.

The store managers were enthusiastic about the physical handling of prepackaged sweet corn. It offered them certain advantages when merchandising the item in their stores: freeing the labor that was ordinarily tied up trimming the corn for displays; eliminating the trimmings and the cost of their disposal; reducing the time needed for putting the sweet corn on display; and reducing waste.

Although the increased selling price at 15 cents per dozen at the wholesale level for the precooled/prepackaged sweet corn approximated the additional costs to the packer for performing the service, certain other advantages did accrue to him. He was able to remove all damaged and unfilled ears and damaged portions of ears, thus increasing the quality of the pack; he made more efficient use of icing to preserve quality of the sweet corn; and the shipping weight and shipping space were reduced by approximately one half. The



FIG. 10. Single-row Peerless corn husker cutting shank and removing husks. The operation requires a man to feed the husker from the tank. The husked corn is caught in a tub at the end of the husker.

average weight of the containers¹³ filled with five dozen ears was 22.4 pounds, while five dozen comparable ears in a wet-strength paper bag weighed 45.5 pounds. Where ice was added the box weighed 28.4 pounds and the bag 55.5 pounds. The reduction in weight would permit shipment of the prepackaged sweet corn at a lower unit freight cost with the advantages that this would give the efficient producer.

¹³ These containers were especially built of 200-pound test corrugated board to hold 15 packages of 4 ears to the package and 6 pounds of ice in a sealed polyethylene bag. The inside measurement of the box was 21 $\frac{1}{8}$ by 9 by 8 $\frac{1}{2}$ inches.

Color, Flavor, Moisture Content, and Temperature

No off colors were observed, no off odors were detected, and no differences in moisture content were obtained between the precooled prepackaged and precooled bulk sweet corn. The iced bags of bulk sweet corn, when held in storage overnight, had average temperatures at the center of the pack of 64° F., as compared with an average temperature of 53° F. at the center of the iced boxes of prepackaged sweet corn.



Summary and Conclusions

with Comparison of Equipment and Prepackaging Costs

EQUIPMENT COSTS

Comparative costs of equipment needed for prepackaging sweet corn are shown in table 14. For Minnesota, the plant and equipment investment was for a plant built and equipped largely for precooling and packaging sweet corn. The investment shown for Indiana includes only the special equipment needed in the operation.

COSTS INCURRED IN PREPACKAGING NOT INVOLVED IN BULK HANDLING

A comparison of packaging costs at Minnesota and Indiana not incurred in

Table 14. Estimates of Machinery and Equipment Investments for Precooling and Prepackaging Sweet Corn for Two Plants

Item	Original cost	
	Minnesota*	Indiana*
	dollars	
Tanks	40	75
Tables	100	.....
Husking machine†	200	200
Overwrap machine‡ .....	.....	1,600
Trimmer‡ .....	.....	125
Printing plates (for cellophane) .....	.....	135
Water system		
Pump	200 \$
Well	800 \$
Cooler		
Building (14 x 30 x 8 ft.)	1,200 \$
Refrigeration	2,000 \$
Total	4,840	2,135

* Capacity of operation about 250 dozen ears an hour.

† One-row used husker, capacity 250 dozen ears an hour. (Available, used, from \$50 up.)

‡ Capacity about 250 dozen ears an hour. This item of machinery not used in this precooling prepackaging operation in Minnesota.

§ No estimate made since the equipment was available and used for other operations and crops.

bulk handling of iced sweet corn is shown in table 15. These costs represent the added costs over those incurred in the bulk handling of iced sweet corn.

Waste at the processing plant is not included because of its highly seasonal variability. In 1950 the waste in Minnesota was about 1.0 per cent (0.3 cents per dozen ears) due to favorable growing conditions, but in Indiana (1952) the waste was 16.5 per cent (4.1 cents per dozen ears) due largely to extremely dry weather. Waste was not included in the Minnesota costs because no purchase price was involved prior to prepackaging.

SUMMARY AND CONCLUSIONS

This study of the marketing of fresh sweet corn was made at the University of Minnesota during the 1950, 1951, and

Table 15. Comparison of Prepackaging Costs at Minnesota and Indiana Not Incurred in Bulk Handling of Iced Sweet Corn*

	Additional cost in cents per dozen ears	
	Minnesota	Indiana
	1950	1952
Labor		
Husking, cooling, packaging	4.8	4.6
Supplies		
Cellophane (perforated)	2.1	2.4
Tape for sealing packages ..	0.9	.....
Cardboard trays .....	.....	6.3
Ice for master container	0.4	-0.2†
Master container‡	3.7	0.0
Total	11.9	13.1

* Not including management and equipment overhead and cost of sweet corn found to be unsalable when husked.

† Cost deducted, as about one pound more ice used per dozen ears for bulk sweet corn than for prepackaged.

‡ Master container cost less bulk container cost.



FIG. 11. Trimming tip to uniform length for packaging. This removes all tip damage and affords an opportunity to inspect the entire ear. Generally the sweet corn was trimmed to permit the packing of 4 ears per package.

1952 seasons, and at Purdue University during the 1952 season. Quality, including sugar content, moisture content, and the relation of these to taste-panel quality scores and to refrigeration and handling methods were studied. In addition, costs at the shipping point were calculated for handling by various methods, including the usual unhusked and noniced, precooled, and precooled prepackaged forms. Costs to the retailer in handling corn in various ways were also obtained.

University of Minnesota

1. Sweet corn lost from 8 to 12 per cent of its total sugars in the first two to three hours of handling from stalk

to packing shed. Corn precooled at this time and kept iced lost another 3 to 4 per cent of total sugars in the first 54 hours after harvest. Not-precooled sweet corn lost an average of 36 to 50 per cent of total sugars during the first 12 to 24 hours after harvest at temperatures ranging from 65° to 84° F.

2. There was no appreciable loss of moisture from precooled and iced corn up to 54 hours, while not-precooled noniced corn lost 10 to 15 per cent during this period.

3. High moisture and sugar contents were related to high taste-panel scores on palatability. Corn that had lost 36 per cent of total sugars (and 10 to 15 per cent of total moisture) was rated significantly lower in quality by the taste



FIG. 12. Semi-automatic overwrap machine in operation. The ears are packed in a tray and overwrapped with perforated cellophane.

panel than that having lost only 14 per cent of sugars (and less than $\frac{1}{2}$ per cent of moisture).

Precooling and icing prevented excessive loss of sugars and moisture and insured high taste-panel quality scores for at least three days. Icing not-pre-cooled sweet corn after it reached the store, 24 hours after harvest, was not effective in preventing loss of quality, although it prevented further sugar losses.

4. Sweet corn packaged in perforated film was not significantly different in flavor, sugar content, or moisture content than unpackaged corn at three days, when held at 36° to 38° F.

The flavor scores of sweet corn pack-

aged in permeable unperforated film (Lumarith S 600) were significantly higher after four days than those for sweet corn packaged in perforated but less permeable films.

5. Sweet corn purchased at random from Minneapolis retail stores in 1952 indicated that the sweet corn sold as "pre-cooled" and iced did not have a significantly higher flavor score than that handled in the ordinary manner. Further checking showed that the "pre-cooled" sweet corn was in the marketing process for periods exceeding one week. Dating the package during pre-packaging might encourage a more rapid movement through distribution channels.

6. The average retail net margin for unhusked, noniced sweet corn sold from a dry rack was 5.9 cents a dozen compared with 14.3 to 21.0 cents for prepackaged sweet corn. Sales of precooled and iced sweet corn that was trimmed in the store were made at a loss to the retailer. It appeared that the retailer did

not adequately consider either the small amount of labor and other costs of selling prepackaged or the large amount of labor and other costs for trimming corn in the store in setting his margins.

7. Effective precooling of sweet corn can be done at the farm with a small investment in equipment and at a rela-



FIG. 13. Prepacked sweet corn was packed 15 units per master container, to make an equivalent of 5 dozen per unit.

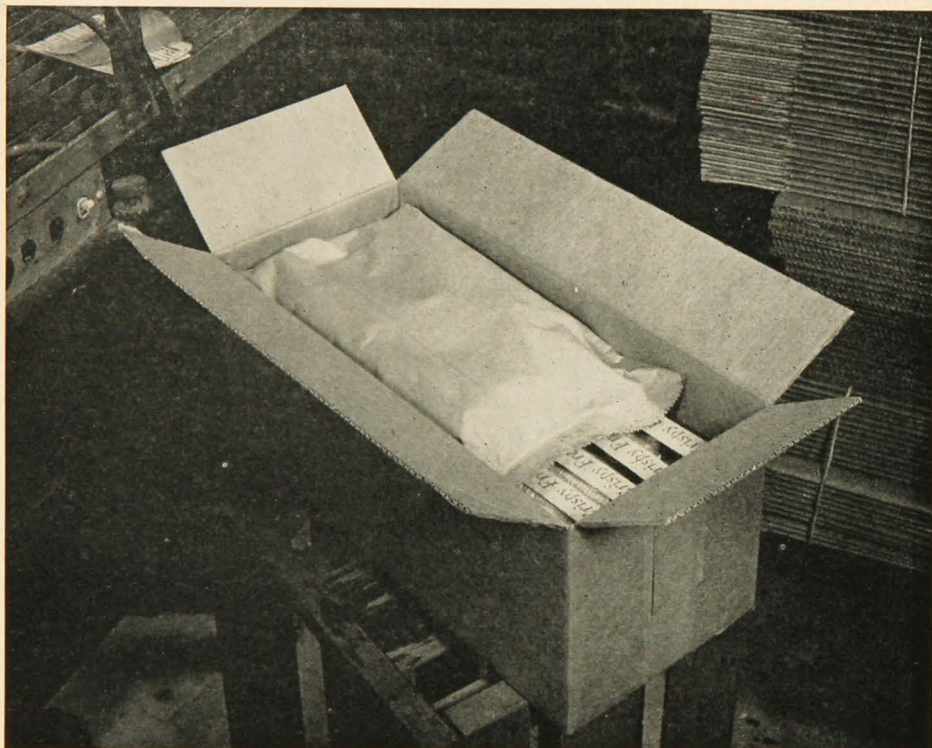


FIG. 14. Heat-sealed polyethylene-lined kraft bag containing 6 pounds of crushed ice was placed inside master container.

tively low cost of labor and supplies.

A maximum volume of about 2,500 dozen ears for pre-cooled and prepackaged was obtainable during a ten-hour day with the equipment used. A much greater volume of pre-cooled, unhusked corn could be handled through the same plant in a like period.

8. At the prevailing wage rates (approximately 85 cents an hour at the farm and \$1 at the retail store) the costs for labor, ice, materials, and farm packinghouse equipment for picking, handling, and retailing pre-cooled prepackaged sweet corn were 19.8 cents a dozen. Costs for pre-cooled and unhusked sweet corn handled in a similar manner were 7.7 cents a dozen.

Similar costs for sweet corn that was not pre-cooled, or iced and sold in the husk were 5.9 cents a dozen, or only 1.8 cents a dozen less than the iced, pre-cooled handling. Trimming in the retail store cost an additional 4.5 cents a dozen.

These costs do not include transportation.

Purdue University

1. From costs during the 1952 season it was estimated that pre-cooled sweet corn could be prepackaged in a normal season for a cost of about 13.1 cents per dozen¹⁴ more than the cost of handling

¹⁴ Not including allowance for waste and overhead.

precooled sweet corn in bulk. It appeared that this cost might be reduced some with volume output. In stores located among high-income customers, the volume of sales of precooled prepackaged sweet corn compared favorably with those of precooled bulk sweet corn.

2. A cardboard master container with a self-contained (polyethylene bag) ice pack alleviates some of the difficulties of shipping iced prepackaged sweet corn. Corn packaged in this way requires less space and reduces freight

costs. It also offers a good way to maintain low corn temperatures with a minimum of ice.

3. Iced bags of bulk corn and boxes of packaged sweet corn, when held in storage overnight, had average temperatures at the center of the pack of 64° F. in bags and 53° F. in boxes. The average gross weight packaged sweet corn with five dozen ears and six pounds of ice totaled 28.4 pounds. The average gross weight of bulk sweet corn in bags containing 10 pounds of ice was 55.5 pounds.

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