CERTAIN ASPECTS OF PACKING, FREEZING, AND EVALUATING SELECTED VARIETIES OF WATERMELON

by

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INTRODUCTION

Watermelons are harvested in Kansas from July to October. Often the season for fresh melons is extended by importing melons from the Southwestern section of the United States or from countries of the southern hemisphere. However, imported melons, especially those from foreign countries, are considered expensive and/or inferior in quality by many people. Watermelon might gain year around popularity if a satisfactory method of preserving locally grown watermelon could be developed.

Freezing, canning, and drying are common methods of food preservation. Freezing is the method most suitable for melons, having been used successfully with cantaloupe and honeydew melons. The frozen product is considered by some people to be similar to that of the fresh melon. For many food products, freezing affects color, flavor, and texture only slightly. However, because of the high moisture content of watermelon, freezing may be expected to cause detrimental textural effects.

Little work on the freezing of watermelon is reported in the literature. Suitable varieties must be found from existing varieties or new ones developed, if watermelon is to be frozen successfully. Information regarding the characteristics of watermelon, that produce an acceptable frozen product, will be beneficial in the development of varieties suitable for freezing. The present study was designed to investigate the effect of home packing, freezing, and storing on the quality and acceptability and to determine certain characteristics of three

varieties of watermelon commonly grown in Kansas.

REVIEW OF LITERATURE

Principles of Freezing

Commercial freezing is a relatively recent method of preserving foods. Interest in freezing of foods did not develop until the 20th century (Fitzergerald, 1950). It was not until the late '20s that freezing was demonstrated to be a practical method for the preservation of food (Birdseye, 1931). During the early developmental period, Plank (1926), Moran (1933), and Woodroof (1938), proposed theories on what occurred during the freezing process.

Lowe (1955) explained that freezing must control both post-harvest changes and the deteriorative changes brought about by microorganisms in order to be an effective method of preservation. Low temperatures effectively reduce the rate of chemical and physical reactions, the rate of slow-down depending upon the temperature and reaction involved. Although the rate of enzymatic reactions is reduced by freezing, Tressler and Evers (1957) stated that the reaction may continue at low temperatures. Therefore, vegetables and sometimes fruits are blanched before freezing to inhibit the enzymes. Also, many bacteria including Salmonella and Clostridium botulinum survive the temperatures used in the freezing of foods (Borgstrom, 1955). However, most yeasts and molds and many other bacteria can not endure the low temperatures.

Although an effective method of food preservation, freezing has several disadvantages as do all methods of food preservation available to date; none produce products identical to the freshly prepared raw food. Freezing may result in undesirable changes in flavor, color, and texture. Of the three types of change, the textural changes are more pronounced in some products, such as celery, lettuce, and watermelon than in others (Kalogeras, 1946).

Matz (1962) attributed the observable effects of freezing, including textural changes, to the physical distortion of cells, the dehydration of the hydrophilic colloids, and the concentration of soluble solids. As the temperature is lowered below the freezing point of water, the extracellular water forms small crystal nuclei (Meryman, 1956). If the temperature is lowered beyond a critical point, many crystals will form instantaneously both inside and outside the cell. However, if the temperature is higher than the temperature for crystal formation or if the temperature fluctuates allowing a portion of the small crystals to melt, the crystals grow in size. As the water freezes, the extracellular solute concentration is increased. Differences in intra- and extra-cellular pressures draw the water out of the cell where it freezes, thus increasing the size and/or number of crystals.

These observations were formulated into several theories to explain the damage during freezing. One explanation is the cell puncture or cell rupture theory (Woodroof, 1938).

The theory is that cell walls are ruptured or punctured by the growing ice crystals. Cell ruptures are very pronounced in mature fruits that consist of very thin parenchyma cells (Matz, 1962). The flabbiness observed in thawed fruits and vegetables may result from the withdrawal of more water, from the cells upon freezing, than can be reabsorbed upon thawing.

The osmotic damage theory, somewhat similar to the first one, does not require the cell wall to be injured (Woolrich and Bartlett, 1942). As previously stated, water is drawn from the cell as the extracellular solute concentration is increased because of the differences in pressures. The water is unable to re-enter the cell upon thawing.

The blocking of the re-entrance of water may be caused by the irreversible destruction of colloidal complexes attributed to changes in concentrations of solutes (Levitt, 1960; Woolrich and Bartlett, 1942). Changes in solute concentration may cause the irreversible precipitation of proteins, a colloidal system. This type of change has been compiled into irreversible-colloidal-change or protein precipitation theory.

A theory proposed in 1933 and finding favorable application in the explanation of freeze injury of plants is the Iljin's mechanical theory (Levitt, 1960). Extracellular ice formation in contact with the cell walls causes stresses and strains on the protoplasm that may lead to mechanical injury. However, changes observed in the freezing of fruits and vegetables probably involves to some extent all of these theories.

Two methods, either separately or combined, appear possible to prevent the deleterious effects of freezing (Meryman, 1960). The first is freezing at a rapid rate, thereby, forming only small ice crystals both within and without the cells. However, the dehydration and/or the effects on the colloidal system would not be eliminated. A rapid rate of freezing may not always be of primary concern. A relatively slow freezing might allow for the relocation of permeable constituents as the cellular fluid is concentrated by crystal growth (Meryman, 1960).

The second method would be to increase the amount of bound water and, thereby, prevent an increase in solute concentration (Meryman, 1960). Some water is bound to other compounds at the molecular level and, therefore, is not susceptible to freezing. Compounds such as glycerin, glycols, and many of the sugars bind water making it unavailable to freeze, thus keeping the solute concentration low.

Freezing of Melons

In general, workers agreed that if melons are to be frozen they must be firm and vine-ripened. However, there was disagreement in the literature as to whether melons, especially watermelon, yielded acceptable products after freezing and/or after various methods of packing. Melons (cantaloupe and honeydew) were reported frozen satisfactorily with a dry sugar pack or in 30 - 40% sirup (Joslyn and Hohl, 1948; Overholser et al., 1942; Tressler et al., 1953; Van Duyne, 1947; Winter,

1942; Seaton and Griswold, 1940). However, Diehl and Warner (1945) recommended adding no sugar to cantaloupe. Previous work at Kansas State University (Tinklin, 1964) indicated that watermelon balls packed in 10% sirup (table sugar) were more desirable than watermelon packed in 30 or 40% sirups.

Tressler et al. (1953) stated that watermelons were frozen successfully only as a puréed product. Joslyn and Hohl (1948) found that watermelon that had been frozen was flabby and often had a pumpkin-like flavor. Blanching before freezing resulted in a mushy, unacceptable product.

PROCEDURE

Watermelons Used

Crimson Sweet (CS) and Charleston Gray (CG) watermelons, field grown and harvested by the Kansas State University Department of Horticulture and Landscape Architecture, and Black Diamond (BD) watermelons, grown under similar conditions in the same area of Manhattan, Kansas, were used in the study. After harvesting, the watermelons were refrigerated for 1 to 3 days at approximately 2°C before they were processed for freezing.

The three varieties were selected since they are commonly grown in Kansas. The following is a description of the varieties. The Crimson Sweet watermelon, developed by the Kansas State University Department of Horticulture and Landscape Architecture, was available commercially in 1963 (Hall, 1963). The average melons are blocky-round and weigh approximately

25 lbs. The flesh is deep red, firm, and well-textured. The sugar content is usually 10 to 13%. The Charleston Gray variety, first available in 1954, was developed by the Southeastern Vegetable Breeding Laboratory in South Carolina (Anon., 1955). Growing well in most regions, the melon is long, gray-green in color, and uniform in shape with a hard rind. In 1949 the Superior Black Diamond (Black Diamond, Yellow Belly) was developed by Wm. A. Watson's Sons in Georgia (Anon., 1956). The Black Diamond melon has a dark green rind with a yellow underside, rich red flesh, and an excellent texture.

Experimental Design

A randomized complete block design for factorial treatments, with 8 replications, was employed to process the samples and to evaluate data obtained. Balls of 3 varieties of watermelon packed without and with sirup (10% table sugar) were evaluated at 4 periods: fresh, and after 10 days, 6 and 12 weeks of frozen storage. Sufficient balls for the evaluation periods (Table 1) were randomly distributed into polyethylene bags.

Sampling, Packaging, and Freezing

Balls for 1 replication were processed during a day. Melons were washed, dried, and weighed. Balls of 1-1/8 in. diameter were cut from the watermelons, avoiding seeds as much as possible. Ten balls were packed in a package. To one-half

Table 1. Balls required for various evaluation periods.

Evaluation period	Method of packing[a]	Balls per replication[b]
Fresh		40
10 days	-	40
	+	40
6 weeks	-	40
	+	40
12 weeks	-	40
	+	40

[a]Packed without (-) or with (+) sirup.

[b]Packaged: 10 balls per package.

of the bags 100 ml of sirup (10% table sugar) were added. Balls were packed as a single layer to allow for even defrosting. All bags were twisted, folded to a gooseneck, and secured with a plastic tie. The packages were placed in direct contact with the freezer shelf, each of which contained freezing coils. After freezing (24 hr), the packages were stored at -15 $\pm$ 5°C until evaluated.

Defrosting and Evaluating

The balls were evaluated fresh, and after 10 days, 6 and 12 weeks of frozen storage. Preliminary work indicated that defrosting in an incubator, maintained at 20°C, 180 min was a satisfactory time for sirup packed balls and 90 min for packages without sirup.

The following tests were performed to evaluate the balls:

Palatability. Each of 7 panel members scored one randomly selected ball of each variety and treatment, within 10 min after completion of the defrosting time, for desirability of flavor and texture and for general acceptability (Form 1, Appendix). All panel members evaluated 2 additional balls under the Macbeth Skylight for general appearance and color desirability.

Color. Color differences were measured with a Gardner Color-Difference Meter. Reflectance (Rd), redness (a+), and yellowness (b+) values were determined after the instrument was standardized with a red tile: Rd, 5.5; a, +26.8; b, +13.0. Color was expressed as Rd, reflectance, and as a/b, degree of redness.

Textural measurement. An indication of textural change was determined by measuring the depth of penetration of a plunger into a ½ in. thick disc, cut from the center of a ball. The depth was measured with a Universal Precision Penetrometer allowing a 52.5 g flat plunger to penetrate for 30 sec.

The percentage decrease in weight of balls after frozen storage also was determined as an index of textural change. Ten balls were weighed before and after freezing and the percentage weight decrease calculated.

Total solids. A watermelon homogenate was prepared for the remaining tests (total and soluble solids, pH, titratable acidity, and sugar content). Twenty balls were blended at

speed 60, for 5 min in a Waring Blendor connected to a Powerstat Variable Transformer.

Percentage of solids and moisture in any one sample was assumed to be 100. Therefore, total solids were calculated by use of the equation:

$$100\% - \%\ \text{total moisture} = \%\ \text{total solids}.$$

The percentage total moisture was determined with the C. W. Brabender Semi-Automatic Moisture Tester. Ten-gram samples of the homogenate were weighed in calibrated pans and subjected to a temperature of 115°F for 50 min.

Soluble solids. The percentage soluble solids, in a filtrate of the homogenate, was determined with an Atage Hand Sugar Refractometer. A sample of homogenate was filtered through a cheesecloth pad of 4 layers and a reading (% soluble solids) taken on the filtrate.

pH. Ten g of the homogenate was suspended by means of a magnetic stirrer in 90 ml distilled water. Then pH was measured with a Beckman Expanded Scale pH Meter (Model 76) standardized against a commercial buffer solution of pH 6.86.

Titratable acidity. A mixture of 10 g of homogenate suspended in 90 ml of distilled water, by means of a magnetic stirrer, was titrated to a pH of 8.1 with 0.1 N NaOH (Thompson et al., 1962). Then the titratable acidity was calculated using the following equation:

$$\frac{\text{ml NaOH} \times \text{equiv wt citric acid}}{100} = \text{g citric acid/100 g watermelon.}$$

Sugar content. Sugar content was determined by the method of Mitchell (1964). Ten g of the homogenate were added to 100 ml of 95% ethanol, stirred, and filtered through a Büchner funnel; and the residue washed 6 times with 70% ethanol. The filtrate was diluted to 250 ml. After the ethanol was evaporated from 25 ml of the filtrate, 2 ml of saturated neutral lead acetate were added. The solution was diluted to 100 ml, mixed, allowed to stand 15 min, and filtered (by gravity through a dry cone). Then 2 ml of potassium oxalate were added to the filtrate, mixed, and refiltered. Five ml of concentrated HCl were added to 50 ml of the final filtrate. The solution was allowed to stand overnight at room temperature, then neutralized with 24% NaOH to a pH of 7 (using a pH meter), transferred to a 100-ml flask, diluted, and mixed. Five-tenths ml of the final sample filtrate, 1.5 ml water, and 3.0 ml of potassium ferricyanide solution (1.80 g potassium ferricyanide + 40g anhydrous $NaCO_3$, diluted to 1 liter, and stored in a brown bottle at room temperature) were mixed in a 15-ml graduated centrifuge tube. After mixing, the tubes were heated 5 min in a boiling water bath, cooled rapidly in an ice bath, diluted to 15 ml, mixed, and the color read at 420 mμ with the Beckman Spectrophotometer. A blank also was prepared. By use of a standard curve, the sugar content (g/100 g of watermelon) was calculated.

Statistical Analyses

Data for each measurement used to evaluate the watermelon

balls were subjected to the following analyses of variance.

For fresh balls:

Source of Variation	D/F
Replications	7
Varieties	2
Remainder	14
Total	23

For fresh and frozen-stored balls packed without sirup:

Source of Variation	D/F
Replications	7
Varieties (V)	2
Storage (S)	3
V x S	6
Remainder	77
Total	95

For frozen-stored balls packed without and with sirup:

Source of Variation	D/F
Replications	7
Varieties (V)	2
Storage (S)	2
Treatment (T)	1
V x S	4
V x T	2
S x T	2
V x S x T	4
Remainder	119
Total	143

If a significant F-value was found, least significant differences (LSD, $P < 0.05$) were calculated.

RESULTS AND DISCUSSION

Average palatability scores and values for objective tests for each replication appear in Appendix, Tables 14-29. The analyses of variance also appear in Appendix, Tables 30-32.

Fresh Watermelon

The average weights (Table 13, Appendix) of watermelons used in this study were: 27.8 lbs for the Crimson Sweet (CS), 30.6 lbs for Charleston Gray (CG), and 34.1 lbs for Black Diamond (BD). The watermelons were harvested in late September (1964), past the peak of the season. However, the size of the watermelons was typical of the varieties grown in Kansas.

When considering all factors measured, the 3 varieties appeared similar except for color desirability (Table 2). Variety BD had significantly ($P < 0.05$) lower color desirability scores than the other 2 varieties. The BD variety characteristically has a less red or a more orange flesh than the other varieties. Overall quality of balls, as indicated by palatability scores, ranged from "good" to "very good" (Table 2 and Form 1, Appendix). The fact that the balls failed to be rated "excellent" might be attributed to a decline in quality of fruits and vegetables generally observed near the end of the season. A significant difference among replications in degree of redness (a/b) ($P < 0.05$) and in pH ($P < 0.01$) (Table 30, Appendix) might be attributed to variation in biological materials or to increased variability in watermelons near the close of the season.

Table 2. Average scores or values and significant differences for varieties of fresh balls.

Factors	Variety[a] CS	CG	BD	LSD[b]
Palatability scores[c]				
General appearance	5.8	5.6	5.3	
Color desirability	5.8	5.7 *	5.1 *	0.5
Flavor desirability	5.8	5.8	5.6	
Texture desirability	5.9	6.0	5.7	
General acceptability	5.7	5.8	5.4	
Objective values				
Color: reflectance (Rd)	12.0	12.1	11.8	
Color: degree of redness (a/b)	2.14	2.15	1.95	
Penetration (0.1 mm)	9.2	8.8	9.2	
Total solids (%)	10.7	10.6	10.9	
Soluble solids (%)	10.8	10.7	10.9	
pH	6.00	6.00	6.00	
Titratable acidity (g/100g)	0.066	0.072	0.068	
Sugar content (g/100g)	9.76	9.66	9.98	

[a]CS, Crimson Sweet; CG, Charleston Gray; BD, Black Diamond.

[b]Least significant difference; *, $P < 0.05$.

[c]Ranged from 7 (excellent) to 1 (very poor).

Frozen and Stored Balls

General appearance. In general, average scores for appearance of balls tended to decrease upon freezing and storage (Table 3). When packed without sirup, BD balls had significantly ($P < 0.05$) lower scores than the other varieties (Table 4). Also, general appearance scores of balls of any variety packed without sirup decreased significantly ($P < 0.05$) with frozen storage for 10 days. A further significant decrease in appearance scores occurred with 12 weeks frozen storage. Packing balls in sirup had no significant effect upon the appearance scores (Table 32, Appendix).

Color. Average scores for color desirability indicated that the panel considered the color of the frozen balls between "very good" and "fairly good" (Table 5 and Form 1, Appendix). As noted with fresh balls, BD balls had significantly ($P < 0.05$) lower color scores than the other 2 varieties, whether frozen and stored without or with sirup (Table 6). Frozen storage for 10 days did not alter scores for color desirability appreciably, although either storage, without or with sirup, for 6 or 12 weeks reduced significantly ($P < 0.05$) the color scores. A similar trend in scores was noted for general appearance and color desirability. Therefore, differences in general appearance might be attributed to differences in color desirability.

An objective measure of color was made with the Gardner Color-Difference Meter. The reflectance (Rd) of the balls was reduced significantly ($P < 0.05$) after 10 days frozen storage

Table 3. Average scores[a] for general appearance.

Storage	Variety[b] and treatment[c]					
	CS		CG		BD	
	-	+	-	+	-	+
Fresh	5.8	---	5.6	---	5.3	---
10 days	5.2	4.8	5.4	5.2	5.2	5.2
6 weeks	5.3	4.8	5.2	4.7	4.7	5.0
12 weeks	4.7	4.8	4.9	4.8	4.8	4.9

[a]Ranged from 7 (excellent) to 1 (very poor).

[b]CS, Crimson Sweet; CG, Charleston Gray; BD, Black Diamond.

[c]Packed without (-) or with (+) sirup; frozen and stored.

Table 4. Significant differences: general appearance scores.[a]

Factors	Average scores				LSD[b]
Fresh and frozen-stored balls packed without sirup					
Variety[c]	CS	CG	BD		0.21
	5.25	5.28	* 5.00		
Storage	Fresh	10 days	6 weeks	12 weeks	0.24
	5.58 *	5.25	5.04	4.82	
Frozen stored balls packed without and with sirup					
Storage		10 days	6 weeks	12 weeks	0.18
		5.15 *	4.93	4.83	

[a]Ranged from 7 (excellent) to 1 (very poor).

[b]Least significant difference; *, $P < 0.05$.

[c]CS, Crimson Sweet; CG, Charleston Gray; BD, Black Diamond.

Table 5. Average scores for color desirability; average values for reflectance and degree of redness.

Factors and storage	Variety[a] and treatment[b]					
	CS		CG		BD	
	-	+	-	+	-	+
Color desirability[c]						
Fresh	5.8	---	5.7	---	5.1	---
10 days	5.6	5.6	5.6	5.6	5.6	5.6
6 weeks	5.5	5.2	5.4	5.2	4.8	5.0
12 weeks	5.0	5.1	5.2	5.1	4.5	5.0
Reflectance (Rd)						
Fresh	12.0	---	12.1	---	11.8	---
10 days	6.2	5.8	6.3	5.7	5.5	5.3
6 weeks	6.2	5.2	5.6	5.4	5.6	5.6
12 weeks	5.3	5.6	5.6	5.7	5.9	5.4
Degree of redness (a/b)						
Fresh	2.14	---	2.15	---	1.95	---
10 days	2.54	2.51	2.50	2.59	2.44	2.34
6 weeks	2.54	2.48	2.78	2.76	2.32	2.24
12 weeks	2.53	2.56	2.39	2.56	2.26	2.23

[a]CS, Crimson Sweet; CG, Charleston Gray; BD, Black Diamond.

[b]Packed without (-) or with (+) sirup; frozen and stored.

[c]Ranged from 7 (excellent) to 1 (very poor).

Table 6. Significant differences: color desirability scores; reflectance and degree of redness values.

Factors	Average scores or values				LSD[a]
Color desirability[b]					
Fresh and frozen-stored balls packed without sirup					
Variety[c]	CS	CG	*	BD	0.25
	5.49	5.48		5.00	
Storage	Fresh	10 days	6 weeks	12 weeks	0.29
	5.55	5.60	* 5.24	* 4.90	
Frozen-stored balls packed without and with sirup					
Variety[c]	CS	CG	*	BD	0.19
	5.35	5.36		5.09	
Storage		10 days	6 weeks	12 weeks	0.19
		5.60	* 5.21	* 4.99	
Color: reflectance (Rd)					
Fresh and frozen-stored balls packed without sirup					
Storage	Fresh	10 days	6 weeks	12 weeks	0.74
	11.95	* 6.03	5.79	5.60	
Color: degree of redness (a/b)					
Fresh and frozen-stored balls packed without sirup					
Variety[c]	CS	CG	*	BD	0.14
	2.44	2.46		2.24	
Storage	Fresh	10 days	6 weeks	12 weeks	0.17
	2.08	* 2.49	2.54	2.39	
Frozen-stored balls packed without and with sirup					
Variety[c]	CS	CG	*	BD	0.11
	2.52	2.60		2.30	

[a]Least significant difference; *, $P < 0.05$.

[b]Ranged from 7 (excellent) to 1 (very poor).

[c]CS, Crimson Sweet; CG, Charleston Gray; BD, Black Diamond.

(Table 6), but no significant reduction occurred with further storage, whether packed without or with sirup (Table 32, Appendix). A reduction of the Rd reading indicated that the sample absorbed more light or became darker. However, since the palatability panel noted no appreciable change in color desirability of balls upon frozen storage, reflectance or brightness of the ball apparently played a minor role, if any, in determining color desirability scores.

Degree of redness (a/b) values were significantly ($P < 0.05$) lower for BD balls, than for the other varieties regardless of treatment (Table 6). As previously noted, scores for color desirability were lower for BD than for the other varieties, indicating that the judgment made in scoring color desirability might be at least partially based on the degree of redness of the ball. However, the degree of redness increased significantly ($P < 0.05$) with 10 days frozen storage but with no further significant change occurring with longer periods of storage. In contrast, the palatability panel noted no significant change upon frozen storage for 10 days but did note changes upon longer storage. Therefore, it appeared the objective values (Rd and a/b) and the palatability scores were not measuring exactly the same factors.

Flavor. Flavor scores for balls after frozen storage decreased from a rating of "very good" to only "fair" (Table 7 and Form 1, Appendix). Flavor scores of all balls markedly decreased after frozen storage for 10 days. Flavor of balls, packed both without and with sirup, and stored for 6 weeks had

significantly ($P < 0.05$) higher flavor scores than balls after 12 weeks frozen storage (Table 8). Although a significant ($P < 0.05$) difference was noted in treatment (Table 32, Appendix), flavor desirability scores of frozen stored balls, regardless of treatment, were considered in the "fair" range (Table 7 and Form 1, Appendix).

Of the factors measured, pH, titratable acidity, and sugar content might influence the score for flavor desirability. Varieties of balls in this study were all slightly acidic, having a pH of approximately 6 (Table 7). The pH was not significantly affected by 10 days frozen storage regardless of treatment (Table 8). However, with longer storage (6 to 12 weeks), pH significantly decreased ($P < 0.05$).

Titratable acidity of balls packed without sirup, frozen, and stored for 10 days was significantly ($P < 0.05$) lower than that of balls for other storage periods (Table 8). Significant differences in titratable acidity of frozen-stored balls, packed without and with sirup, were explained by the interaction of variety x storage x treatment. However, changes in titratable acidity did not seem to account for the noticeable change in flavor desirability that occurred with frozen storage.

The sugar content appeared similar, approximately 9.5 g/100 g of watermelon, regardless of variety or treatment (Table 7). However, there was a significant difference ($P < 0.001$) in sugar content among replications (Tables 31 and 32, Appendix), possibly a result of variation from location within watermelons or of variation in watermelons near the end

Table 7. Average scores for flavor desirability; average values for pH, titratable acidity, sugar content, and soluble solids.

Factors and storage	Variety[a] and treatment[b]					
	CS		CG		BD	
	-	+	-	+	-	+
Flavor desirability[c]						
Fresh	5.8	---	5.8	---	5.6	---
10 days	3.3	3.3	3.3	3.0	3.1	3.4
6 weeks	3.7	3.2	3.2	3.3	3.7	3.6
12 weeks	3.6	2.8	2.9	2.8	3.3	2.9
pH						
Fresh	6.00	---	6.00	---	6.00	---
10 days	6.02	5.92	6.08	5.92	6.11	5.99
6 weeks	5.67	5.73	5.71	5.74	5.77	5.81
12 weeks	5.64	5.61	5.69	5.62	5.70	5.72
Titratable acidity (g/100g)						
Fresh	0.066	---	0.072	---	0.068	---
10 days	0.064	0.051	0.059	0.050	0.061	0.049
6 weeks	0.072	0.058	0.074	0.057	0.071	0.058
12 weeks	0.069	0.072	0.078	0.063	0.070	0.069
Sugar content (g/100g)						
Fresh	9.76	---	9.66	---	9.98	---
10 days	9.51	9.15	9.54	8.98	9.29	9.34
6 weeks	9.39	9.50	9.74	9.40	9.77	9.71
12 weeks	9.20	9.78	9.50	9.41	9.86	9.86
Soluble solids (%)						
Fresh	10.8	---	10.7	---	10.9	---
10 days	10.1	10.0	10.3	9.7	10.6	10.0
6 weeks	9.9	10.0	10.6	9.9	10.6	10.4
12 weeks	10.2	10.1	11.0	9.9	10.7	10.3

[a]CS, Crimson Sweet; CG, Charleston Gray; BD, Black Diamond.
[b]Packed without (-) or with (+) sirup; frozen and stored.
[c]Ranged from 7 (excellent) to 1 (very poor).

Table 8. Significant differences: flavor desirability scores; pH, titratable acidity, sugar content, and soluble solids values.

Factors	Average scores or values	LSD[a]
Flavor desirability[b]		
Fresh and frozen-stored balls packed without sirup		
Storage	Fresh 5.73 • 10 days 3.26 — 6 weeks 3.54 • 12 weeks 3.25	0.29
Frozen-stored balls packed without and with sirup		
Storage	10 days 3.25 — 6 weeks 3.45 • 12 weeks 3.05	0.22
pH		
Fresh and frozen-stored balls packed without sirup		
Storage	Fresh 6.00 — 10 days 6.07 • 6 weeks 5.72 — 12 weeks 5.68	0.11
Frozen-stored balls packed without and with sirup		
Storage	10 days 6.01 • 6 weeks 5.74 • 12 weeks 5.66	0.07
Titratable acidity (g/100 g)		
Fresh and frozen-stored balls packed without sirup		
Storage	Fresh 0.069 • 10 days 0.061 • 6 weeks 0.072 — 12 weeks 0.073	0.006
Frozen-stored balls packed without and with sirup		
Variety[c] x Storage x Treatment[d]		

	CS		CG		BD		
	-	+	-	+	-	+	0.011
10 days	0.064	0.051	0.059	0.050	0.061	0.049	
6 weeks	0.072	0.058	0.074	0.057	0.071	0.058	
12 weeks	0.069	0.072	0.078	0.063	0.071	0.069	

Soluble solids (%)			
Fresh and frozen-stored balls packed without sirup			
Variety[c]	CS 10.26	CG 10.64 — BD 10.71	0.33

Table 8. (concl.)

Factors	Average scores or values		LSD[a]
Soluble solids (%)			
Frozen-stored balls packed without and with sirup			
Variety[c] x Treatment[d]	-	+	0.33
CS	10.08	10.04	
CG	10.63 *	9.84 *	
BD	10.64 *	10.21	

[a]Least significant difference; *, $P < 0.05$.

[b]Ranged from 7 (excellent) to 1 (very poor).

[c]CS, Crimson Sweet; CG, Charleston Gray; BD, Black Diamond.

[d]Packed without (-) or with (+) sirup; frozen and stored.

of the season. In this study randomizing balls for packages should have helped overcome differences in sugar content attributed to location within the melon.

Porter et al. (1940) stated that most of the soluble solids of watermelons could be accounted for by the sugar content. In the present study, CS variety had a significantly ($P < 0.05$) lower soluble solids content than the other varieties (Table 8) although there was no apparent difference in sugar content of varieties. With CG and BD varieties, frozen balls with sirup pack had a lower soluble solids content than did balls packed without sirup. Possibly more soluble solids were withdrawn from balls packed with sirup than from balls packed without sirup.

Changes in pH, titratable acidity, or sugar content of balls upon freezing and storage did not offer an explanation of changes that occurred in the flavor scores of balls. Therefore, other physical or chemical changes must have occurred.

Texture. Scores for texture desirability of balls decreased significantly ($P < 0.05$) with frozen storage for 10 days (Table 9) and decreased further with 12 weeks frozen storage regardless of treatment. As judged by average texture scores, packing with sirup had an undesirable effect on the CS balls ($P < 0.05$) although the other varieties did not appear to be affected appreciably by the type of treatment. In general, however, scores for texture of frozen-stored balls were only "fairly good" after frozen storage, whereas they had been "very good" before freezing (Table 10 and Form 1, Appendix).

An indication of the degree of softness of balls was obtained using a penetrometer to determine depth of penetration of a plunger. A marked increase in depth of penetration occurred after frozen storage (Table 10) indicating a softer product after freezing than before. After 12 weeks of frozen storage balls packed without sirup were significantly ($P < 0.05$) firmer, allowing less depth of penetration, than the other balls regardless of treatment and storage time (Table 9). No explanation can be given for this observation.

A further indication of textural breakdown was obtained by noting the percentage weight lost after defrosting the balls. The CG variety had lower percentage weight loss than the other varieties (Table 9). In general, approximately 25% of the

Table 9. Significant differences: texture desirability scores; penetration, weight loss, and total solids values.

Factors	Average scores or values				LSD[a]
Texture desirability[b]					
Fresh and frozen-stored balls packed without sirup					
Storage	Fresh	10 days	6 weeks	12 weeks	0.25
	5.86 *	4.45	4.64 *	4.19	
Frozen-stored balls packed without and with sirup					
Storage		10 days	6 weeks	12 weeks	0.17
		4.37	4.45 *	4.08	
Variety[c] x Treatment[d]		-	+		0.23
	CS	4.40 *	3.87		
	CG	4.30	4.18		
	BD	4.58 *	4.45 *		
Penetration (0.1 mm)					
Fresh and frozen-stored balls packed without sirup					
Storage	Fresh	10 days	6 weeks	12 weeks	4.58
	9.07 *	45.60	46.99 *	39.20	
Frozen-stored balls packed without and with sirup					
Storage x Treatment[d]		-	+		4.60
	10 days	45.60	46.20		
	6 weeks	46.99	47.91		
	12 weeks	39.20 *	48.63		
Weight loss (%)					
Frozen-stored balls packed without and with sirup					
Variety[c]	CS	CG	BD		2.54
	25.29 *	21.95 *	24.12		
Storage		10 days	6 weeks	12 weeks	2.54
		25.53	24.99 *	20.83	

Table 9. (concl.)

Factors	Average scores or values				LSD[a]
Total solids (%)					
Fresh and frozen-stored balls packed without sirup					
Storage	Fresh	10 days	6 weeks	12 weeks	0.44
	10.73	10.67	* 9.73	10.00	
Frozen-stored balls packed without and with sirup					
Storage x Treatment[d]		-	+		0.45
	10 days	10.67	* 9.97		
	6 weeks	* 9.73	9.81		
	12 weeks	10.00	9.89		

[a]Least significant difference; *, $P < 0.05$.

[b]Ranged from 7 (excellent) to 1 (very poor).

[c]CS, Crimson Sweet; CG, Charleston Gray; BD, Black Diamond.

[d]Packed without (-) or with (+) sirup; frozen and stored.

original weight was lost after frozen storage for 10 days (Table 10). Also, as indicated by penetration values, there was significantly ($P < 0.05$) less weight loss with 12 weeks frozen storage than with the other storage periods (Table 9). No explanation for the greater retention of weight with 12 week frozen storage or with CG variety can be offered. However, with 12 weeks frozen storage texture desirability scores decreased; whereas values for textural change, as measured by penetration and weight loss, increased, except for CG packed

Table 10. Average scores for texture desirability; average values for penetration, weight loss, and total solids.

Factors and storage	Variety[a] and treatment[b]					
	CS		CG		BD	
	-	+	-	+	-	+
Texture desirability[c]						
Fresh	5.9	---	6.0	---	5.7	---
10 days	4.3	4.1	4.4	4.3	4.6	4.5
6 weeks	4.6	3.8	4.6	4.3	4.7	4.7
12 weeks	4.3	3.8	3.9	3.9	4.4	4.2
Penetration (0.1 mm)						
Fresh	9.2	---	8.8	---	9.2	---
10 days	48.4	46.5	45.2	44.8	43.2	47.4
6 weeks	50.2	50.0	48.2	47.9	42.5	45.8
12 weeks	34.8	48.1	45.1	51.5	37.7	46.3
Weight loss (%)						
10 days	27.7	29.3	26.3	17.0	28.0	25.0
6 weeks	26.5	27.5	23.5	21.6	26.8	23.9
12 weeks	20.5	20.2	18.3	25.0	18.7	20.0
Total solids (%)						
Fresh	10.7	---	10.6	---	10.9	---
10 days	10.4	10.1	10.6	9.9	11.0	9.9
6 weeks	9.5	9.7	9.9	9.7	9.8	10.1
12 weeks	10.0	10.2	9.9	9.8	10.1	9.7

[a]CS, Crimson Sweet; CG, Charleston Gray; BD, Black Diamond.

[b]Packed without (-) or with (+) sirup; frozen and stored.

[c]Ranged from 7 (excellent) to 1 (very poor).

with sirup. Therefore, the palatability panel members must have considered factors other than compressibility and softness when scoring texture desirability.

Total solids content varied less than 2% among the different varieties and treatments (Table 10). Although significant ($P < 0.05$) differences were noted (Table 9), differences were slight and seemed unrelated to changes in texture desirability.

General acceptability. Average general acceptability scores for balls decreased upon freezing (Table 11). Scores dropped from a rating of "good" or "very good" to "fair" or "fairly good" (Form 1, Appendix). Scores for balls stored 6 weeks, regardless of treatment, were as high or higher than the scores for balls of any other frozen storage period (Table 11). The same trend was noted with flavor desirability. Therefore, it appeared logical that flavor was possibly a major factor in scoring general acceptability of the balls. When considering frozen balls, regardless of treatment, BD balls had significantly ($P < 0.05$) higher scores for general acceptability than the other varieties (Table 12). Although a significant difference was noted with treatment (Table 32, Appendix), balls of all varieties were scored only "fairly good" after frozen storage (Table 11 and Form 1, Appendix).

Table 11. Average scores[a] for general acceptability.

Storage	Variety[b] and treatment[c]					
	CS		CG		BD	
	-	+	-	+	-	+
Fresh	5.7	---	5.8	---	5.4	---
10 days	3.7	3.5	3.8	3.5	3.8	3.9
6 weeks	4.0	3.5	3.8	3.7	4.0	4.0
12 weeks	3.8	3.2	3.3	3.3	3.8	3.4

[a]Ranged from 7 (excellent) to 1 (very poor).

[b]CS, Crimson Sweet; CG, Charleston Gray; BD, Black Diamond.

[c]Packed without (-) or with (+) sirup; frozen and stored.

Table 12. Significant differences: general acceptability scores.[a]

Factors	Average scores				LSD[b]
Fresh and frozen-stored balls packed without sirup					
Storage	Fresh	10 days	6 weeks	12 weeks	0.25
	5.63 *	3.74	3.92 *	3.61	
Frozen-stored balls packed without and with sirup					
Variety[c]	CS	CG	BD		0.18
	3.60	3.56 *	3.80		
Storage		10 days	6 weeks	12 weeks	0.18
		3.68	3.82 *	3.46	

[a]Ranged from 7 (excellent) to 1 (very poor).

[b]Least significant difference; *, $P < 0.05$.

[c]CS, Crimson Sweet; CG, Charleston Gray; BD, Black Diamond.

SUMMARY

Three varieties of watermelon, with 8 replications of each, cut into balls and packed without and with sirup (10% table sugar) were frozen and stored for periods of 10 days, 6 and 12 weeks. The balls were evaluated fresh and after each period of frozen storage. When a comparison was made of fresh and frozen balls packed without sirup, it was noted that with frozen storage for 10 days a significant decrease occurred in all palatability scores for the factors studied, except color desirability. The scores for general appearance, desirability of flavor and texture, and general acceptability were significantly lower after 10 days frozen storage than before freezing. In general, the color desirability and appearance scores decreased with 6 or 12 weeks frozen storage. However, the texture and flavor desirability and general acceptability scores increased slightly after 6 weeks frozen storage, then decreased again after 12 weeks.

The general appearance and color desirability scores were not affected significantly by the method of packing. The scores for desirability of flavor and texture and for general acceptability of the balls were reduced significantly by freezing and storing them packed in sirup.

Under the conditions of this study, none of the 3 varieties of watermelon yielded a satisfactory product. No one of the objective measurements offered a complete explanation for the

observed palatability changes. Apparently, a combination of the measured factors and/or some unmeasured factors accounted for the observed palatability changes.

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APPENDIX

Form 1. Scorecard for watermelon balls.

Name _____

Date _____

Factors	Sample number 1	2	3	4	5	6	Comments
General appearance Bright, attractive							
Color desirability							
Flavor desirability Fresh; not bitter, flat nor "off"							
Texture desirability Firm, yet tender not mushy							
General acceptability							

Rating form:
7 Excellent
6 Very good
5 Good
4 Fairly good
3 Fair
2 Poor
1 Very poor

Table 13. Weight of watermelons.

Crimson Sweet	Charleston Gray	Black Diamond
lbs	lbs	lbs
35.0	36.0	33.3
29.0	29.8	37.2
26.1	33.9	39.5
26.1	28.1	28.8
33.0	27.6	37.3
29.0	30.4	31.0
25.3	29.0	41.2
31.0	35.6	37.4
30.0	42.3	31.4
26.5	29.6	39.3
30.8	27.0	39.2
32.4	30.8	35.6
24.5	29.4	24.6
24.4	29.7	23.1
23.0	26.5	35.1
27.5	23.1	32.1
22.2		
24.7		
Av 27.8	30.6	34.1

Table 14. General appearance scores.[a]

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
Fresh						
1	5.8		5.8		5.0	
2	4.8		5.8		5.0	
3	6.0		5.4		5.0	
4	6.2		5.6		5.6	
5	5.7		6.0		4.3	
6	6.0		5.8		6.0	
7	6.0		5.7		5.7	
8	6.3		4.8		5.7	
Av	5.8		5.6		5.3	
10 days						
1	4.8	4.8	5.1	5.3	4.4	4.8
2	5.1	4.3	5.1	5.0	5.1	5.0
3	5.3	5.3	5.3	4.8	5.7	4.5
4	5.3	4.3	5.2	5.2	5.3	5.5
5	5.6	5.4	5.7	5.0	5.6	5.3
6	4.7	5.0	5.0	4.8	5.3	5.3
7	5.3	4.5	5.7	5.5	5.2	5.3
8	5.3	5.2	5.7	5.7	5.3	5.5
Av	5.2	4.8	5.4	5.2	5.2	5.2

Table 14. (concl.)

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	5.3	5.2	5.5	4.2	4.8	5.2
2	5.6	4.7	5.6	5.1	5.1	5.1
3	4.7	3.8	5.0	5.0	3.7	4.3
4	5.6	4.8	5.4	5.1	4.7	5.1
5	5.3	5.2	5.0	5.0	3.8	3.8
6	4.8	5.2	4.7	4.8	5.0	5.2
7	5.5	5.3	4.7	4.5	4.7	5.5
8	5.3	4.3	5.7	3.7	5.5	5.7
Av	5.3	4.8	5.2	4.7	4.7	5.0
12 weeks						
1	5.0	3.6	4.7	4.6	4.0	4.7
2	4.2	5.2	4.8	4.7	5.3	5.7
3	4.3	5.0	5.1	4.7	4.3	5.0
4	4.2	5.7	5.3	4.2	5.0	5.2
5	5.0	5.0	5.0	5.0	4.8	4.6
6	4.6	4.1	4.4	5.3	5.0	4.6
7	5.6	5.1	4.6	5.1	4.6	4.8
8	4.8	4.6	5.6	5.0	5.4	4.8
Av	4.7	4.8	4.9	4.8	4.8	4.9

[a]Ranged from 7 (excellent) to 1 (very poor).

[b]Packed without (-) or with (+) sirup; frozen and stored.

Table 15. Color desirability scores.[a]

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
Fresh						
1	6.0		5.7		4.5	
2	4.5		5.3		4.3	
3	6.1		5.7		4.7	
4	6.4		5.8		6.0	
5	5.8		6.1		3.8	
6	6.0		5.8		6.2	
7	6.0		5.7		5.7	
8	6.0		5.3		5.7	
Av	5.8		5.7		5.1	
10 days						
1	5.0	5.8	5.8	5.8	5.1	5.4
2	5.7	5.7	5.7	5.8	5.6	6.0
3	5.8	5.8	5.7	5.7	5.7	5.5
4	5.5	5.3	5.5	5.5	5.7	5.3
5	5.7	5.7	5.6	5.4	5.6	5.4
6	5.2	5.3	5.2	5.3	5.0	5.3
7	5.7	5.3	5.5	5.5	5.8	5.3
8	5.8	6.3	6.2	5.8	6.3	6.3
Av	5.6	5.6	5.6	5.6	5.6	5.6

Table 15. (concl.)

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	5.2	5.3	5.5	4.8	4.8	5.5
2	5.6	4.8	5.1	5.3	5.4	5.4
3	5.4	4.0	5.1	5.6	3.3	4.3
4	5.6	5.1	5.6	5.4	4.6	5.3
5	5.5	5.7	5.3	5.7	3.7	3.8
6	5.5	5.7	5.3	5.5	5.2	5.2
7	5.8	5.8	5.7	5.2	5.7	5.7
8	5.5	5.3	5.7	4.5	5.7	5.2
Av	5.5	5.2	5.4	5.2	4.8	5.0
12 weeks						
1	5.4	4.0	4.3	4.4	3.7	4.7
2	4.5	5.3	5.3	4.8	4.8	5.7
3	3.8	4.8	5.3	5.6	3.3	5.4
4	5.0	5.5	5.2	4.5	5.2	5.0
5	5.0	5.4	5.4	5.7	4.7	4.1
6	5.4	5.1	5.0	5.4	5.0	5.3
7	5.6	5.4	5.3	5.3	4.0	4.6
8	5.6	5.6	5.6	5.0	5.2	5.4
Av	5.0	5.1	5.2	5.1	4.5	5.0

[a]Ranged from 7 (excellent) to 1 (very poor).

[b]Packed without (-) or with (+) sirup; frozen and stored.

Table 16. Flavor desirability scores.[a]

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
Fresh						
1	5.7		6.3		6.0	
2	6.0		5.0		5.2	
3	6.1		6.3		5.6	
4	5.6		5.8		5.6	
5	5.4		6.0		5.4	
6	5.7		5.8		5.7	
7	5.8		6.0		5.7	
8	5.8		5.3		5.8	
Av	5.8		5.8		5.6	
10 days						
1	3.4	4.0	3.9	4.0	3.0	3.0
2	3.4	3.4	2.8	2.3	2.3	3.1
3	2.8	3.0	2.5	2.7	2.8	4.2
4	4.0	3.3	4.2	2.8	3.5	3.0
5	2.3	3.1	2.8	3.8	2.8	3.4
6	3.3	3.3	3.7	2.5	3.5	3.5
7	3.8	3.3	3.5	3.0	3.5	3.3
8	3.7	3.2	3.2	3.3	3.5	3.5
Av	3.3	3.3	3.3	3.0	3.1	3.4

Table 16. (concl.)

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	3.8	3.2	3.7	2.8	3.3	2.7
2	4.6	3.4	3.7	3.3	4.0	2.8
3	3.7	3.4	3.0	4.3	3.1	4.0
4	3.0	2.6	3.3	3.4	4.0	3.4
5	3.7	3.5	3.5	3.0	3.7	4.2
6	3.2	3.2	2.5	2.5	3.5	4.2
7	4.0	3.2	3.8	4.0	3.7	3.3
8	3.7	2.8	2.5	3.3	4.0	4.0
Av	3.7	3.2	3.2	3.3	3.7	3.6
12 weeks						
1	3.6	3.0	2.6	2.0	3.3	2.7
2	2.8	3.3	4.2	3.7	2.7	4.2
3	3.4	4.0	2.0	2.4	3.8	2.4
4	3.2	2.5	3.8	2.8	2.5	2.5
5	4.3	2.6	2.1	3.1	3.4	3.3
6	3.3	2.7	3.0	3.3	3.6	2.8
7	4.6	2.4	3.0	2.6	2.9	2.6
8	3.4	2.0	2.4	2.8	4.0	2.8
Av	3.6	2.8	2.9	2.8	3.3	2.9

[a]Ranged from 7 (excellent) to 1 (very poor).

[b]Packed without (-) or with (+) sirup; frozen and stored.

Table 17. Texture desirability scores.[a]

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
Fresh						
1	6.2		5.7		5.7	
2	6.5		6.2		5.7	
3	6.4		6.3		5.1	
4	4.8		6.0		6.2	
5	6.0		5.8		5.7	
6	5.7		6.0		5.7	
7	5.7		5.8		5.6	
8	5.8		6.0		6.0	
Av	5.9		6.0		5.7	
10 days						
1	4.1	4.0	4.4	4.0	3.8	4.3
2	4.4	3.4	4.1	4.3	4.4	4.6
3	4.0	3.7	3.8	4.0	4.3	4.5
4	4.7	4.3	4.5	4.5	5.2	4.2
5	3.8	4.7	4.8	4.7	4.6	4.8
6	4.8	4.7	4.5	4.7	4.8	4.7
7	4.2	4.0	4.7	3.5	4.5	4.3
8	4.7	4.0	4.3	4.7	5.4	4.5
Av	4.3	4.1	4.4	4.3	4.6	4.5

Table 17. (concl.)

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	4.8	3.2	5.0	3.3	4.8	4.3
2	5.3	3.6	4.6	4.7	4.7	4.4
3	4.8	3.8	3.8	4.8	4.7	4.8
4	4.1	3.8	4.6	4.1	4.6	4.6
5	4.5	4.2	4.3	4.0	4.8	4.8
6	3.7	3.5	4.8	4.8	4.5	5.2
7	5.2	4.2	5.2	4.8	5.0	4.5
8	4.2	3.8	4.7	4.2	4.7	4.7
Av	4.6	3.8	4.6	4.3	4.7	4.7
12 weeks						
1	4.3	3.6	3.0	3.4	4.4	3.6
2	3.5	3.7	4.3	4.3	3.3	5.0
3	4.0	4.0	3.1	3.6	4.7	4.0
4	4.7	4.2	4.5	3.8	4.2	4.5
5	4.8	3.3	4.0	4.0	4.7	4.4
6	4.3	3.4	4.4	4.1	4.4	4.1
7	4.6	4.6	4.1	4.7	4.7	4.1
8	4.0	3.2	3.8	3.4	4.8	4.0
Av	4.3	3.8	3.9	3.9	4.4	4.2

[a]Ranged from 7 (excellent) to 1 (very poor).

[b]Packed without (-) or with (+) sirup; frozen and stored.

Table 18. General acceptability scores.[a]

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	−	+	−	+	−	+
Fresh						
1	5.7		5.8		5.7	
2	5.5		5.3		5.3	
3	6.3		6.1		5.1	
4	5.5		5.8		5.6	
5	5.5		5.8		5.0	
6	5.7		5.9		5.6	
7	5.6		5.8		5.6	
8	5.6		5.5		5.7	
Av	5.7		5.8		5.4	
10 days						
1	3.5	4.0	4.2	4.0	3.3	3.5
2	4.0	3.3	3.5	3.0	3.7	4.3
3	3.5	3.3	3.0	3.0	3.5	4.2
4	4.6	3.5	4.3	4.0	3.9	3.5
5	2.6	3.3	3.4	3.8	3.6	3.7
6	3.5	3.3	3.8	3.3	3.8	4.2
7	4.0	3.5	4.1	3.1	4.2	3.8
8	4.0	3.6	3.8	3.7	4.0	3.9
Av	3.7	3.5	3.8	3.5	3.8	3.9

Table 18. (concl.)

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	4.0	3.4	4.3	3.2	4.0	3.2
2	4.8	3.6	4.3	3.8	4.0	3.4
3	4.3	3.5	3.3	4.2	3.4	4.1
4	3.4	2.8	3.8	3.8	4.5	3.8
5	3.9	3.9	3.6	3.3	3.9	4.4
6	3.3	3.3	3.2	3.3	3.9	4.5
7	4.0	4.0	4.0	4.3	4.2	4.2
8	3.9	3.7	3.6	3.8	4.4	4.1
Av	4.0	3.5	3.8	3.7	4.0	4.0
12 weeks						
1	3.7	3.0	2.7	2.8	3.4	3.1
2	3.0	3.7	4.5	3.8	3.8	4.6
3	3.5	4.2	2.4	2.9	3.7	3.0
4	3.8	3.3	4.4	3.3	3.4	3.4
5	4.2	2.9	2.5	3.5	3.6	3.7
6	3.3	3.1	3.6	3.6	3.9	3.2
7	4.6	3.0	3.6	3.3	3.7	3.3
8	3.9	2.2	3.0	3.2	4.5	3.2
Av	3.8	3.2	3.3	3.3	3.8	3.4

[a]Ranged from 7 (excellent) to 1 (very poor).

[b]Packed without (-) or with (+) sirup; frozen and stored.

Table 19. Color: reflectance (Rd) values.[a]

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
Fresh						
1	8.9		13.6		14.7	
2	12.6		14.8		12.6	
3	13.6		12.3		10.1	
4	9.3		9.5		11.3	
5	14.2		12.2		12.2	
6	11.6		10.5		9.5	
7	11.2		14.1		9.3	
8	14.2		9.8		14.6	
Av	12.0		12.1		11.8	
10 days						
1	6.8	6.8	6.2	5.2	5.7	6.9
2	7.2	5.6	6.1	7.4	4.9	4.5
3	5.8	8.3	7.0	5.6	4.9	4.3
4	5.5	4.3	6.6	5.6	5.2	5.2
5	6.9	5.7	6.1	5.7	5.7	5.9
6	7.6	5.8	5.6	6.1	5.8	4.7
7	5.4	4.4	7.0	4.8	6.1	5.3
8	4.8	5.7	5.9	5.4	6.0	5.6
Av	6.2	5.8	6.3	5.7	5.5	5.3

Table 19. (concl.)

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	8.4	5.8	5.4	5.9	5.5	4.9
2	7.5	5.2	4.3	5.2	4.8	5.0
3	5.7	5.5	5.0	5.3	5.6	6.0
4	4.8	4.5	6.8	4.4	5.0	4.7
5	6.4	4.7	6.0	5.8	6.2	6.6
6.	6.5	6.3	6.0	5.0	5.9	6.0
7	4.8	4.4	4.4	5.4	5.8	5.6
8	5.2	5.6	6.5	6.5	6.4	5.8
Av	6.2	5.2	5.6	5.4	5.6	5.6
12 weeks						
1	5.4	4.3	6.5	4.9	6.0	5.1
2	4.7	7.6	5.9	6.3	5.5	5.4
3	6.3	4.8	6.0	5.7	4.0	5.0
4	4.9	6.4	5.7	7.0	4.7	4.6
5	4.8	5.2	6.1	6.2	7.1	6.5
6	7.1	5.0	4.8	5.1	6.7	6.3
7	4.5	6.1	4.3	5.7	5.5	5.6
8	4.5	5.5	5.5	4.7	7.9	5.0
Av	5.3	5.6	5.6	5.7	5.9	5.4

[a]Gardner Color-Difference Meter measurement.

[b]Packed without (-) or with (+) sirup; frozen and stored.

Table 20. Color: redness (a+) values.[a]

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
Fresh						
1	36.0		28.3		30.5	
2	23.4		27.6		25.4	
3	29.4		35.6		29.3	
4	31.4		30.8		30.7	
5	27.2		32.8		26.4	
6	27.2		32.3		27.8	
7	28.9		26.5		31.5	
8	27.8		32.2		30.1	
Av	28.9		30.8		29.0	
10 days						
1	29.9	23.6	31.5	23.8	21.8	22.1
2	29.3	23.9	32.3	31.5	21.0	17.8
3	29.2	22.9	32.3	29.8	29.8	23.3
4	26.8	20.6	28.6	30.3	29.0	20.4
5	31.0	28.8	28.8	29.2	22.4	24.2
6	31.3	17.6	22.6	24.2	21.8	22.2
7	27.4	22.5	28.0	23.2	29.2	26.9
8	22.6	28.6	28.1	28.0	31.3	29.0
Av	28.4	23.6	29.0	27.5	25.8	23.2

Table 20. (concl.)

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	31.0	19.2	28.0	29.1	20.5	17.2
2	25.4	24.5	26.0	27.2	25.5	23.9
3	28.1	28.3	27.7	30.4	19.6	25.8
4	25.1	21.7	30.7	24.1	26.4	22.5
5	35.9	21.0	32.8	31.2	27.2	18.3
6	25.7	28.7	32.2	28.7	29.2	28.2
7	24.7	28.0	26.7	30.0	28.7	26.7
8	20.6	24.9	30.5	30.0	29.5	30.1
Av	27.1	24.5	29.3	28.8	25.8	24.1
12 weeks						
1	26.8	24.5	33.9	25.6	20.6	24.9
2	24.8	26.9	30.6	31.8	23.8	19.1
3	19.8	22.6	31.2	33.2	26.1	30.4
4	23.2	28.3	27.5	31.3	22.1	24.1
5	25.3	30.3	30.7	26.6	25.9	24.7
6	31.1	27.9	27.1	27.9	30.6	30.9
7	24.5	28.6	25.7	34.2	26.1	23.6
8	23.3	29.8	25.9	26.1	30.0	23.3
Av	24.8	27.4	29.1	29.6	25.7	25.1

[a]Gardner Color-Difference Meter measurement.

[b]Packed without (-) or with (+) sirup; frozen and stored.

Table 21. Color: yellowness (b+) values.[a]

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
Fresh						
1	14.9		16.1		17.1	
2	15.2		15.7		17.2	
3	13.5		14.6		15.2	
4	13.7		14.0		13.5	
5	13.5		14.7		15.3	
6	12.2		13.7		13.2	
7	12.4		14.0		14.0	
8	13.1		12.6		14.1	
Av	13.6		14.4		15.0	
10 days						
1	12.6	11.2	11.9	9.6	10.2	12.0
2	11.7	9.8	11.5	13.5	8.5	8.2
3	10.5	12.9	11.6	10.4	10.7	9.2
4	9.9	7.2	12.4	10.7	10.2	8.8
5	12.5	10.2	11.7	10.7	11.4	10.9
6	13.2	7.2	10.2	10.5	10.3	9.3
7	10.4	7.9	12.4	9.5	12.0	10.2
8	9.1	10.4	11.3	10.2	11.3	11.2
Av	11.2	9.6	11.6	10.6	10.6	10.0

Table 21. (concl.)

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	13.9	9.4	10.2	11.2	9.9	9.2
2	11.9	9.2	8.7	10.0	10.5	10.0
3	9.5	10.1	9.3	9.6	10.2	11.7
4	9.2	10.0	12.5	8.8	10.7	8.6
5	12.4	8.4	11.6	11.3	12.0	11.3
6	10.5	11.4	12.0	10.6	11.9	12.0
7	9.5	10.4	9.3	10.5	12.2	11.3
8	8.9	10.2	11.4	12.0	11.5	12.0
Av	10.7	9.9	10.6	10.5	11.1	10.8
12 weeks						
1	10.5	8.9	13.9	10.1	10.9	10.6
2	8.7	12.4	11.9	12.6	10.5	9.9
3	11.9	9.3	11.7	11.9	9.3	11.6
4	9.3	11.9	12.1	13.7	10.1	10.5
5	9.6	10.4	12.5	10.6	13.5	13.4
6	13.0	10.4	19.7	11.1	13.0	13.3
7	8.7	11.6	8.9	12.2	11.1	11.0
8	8.2	11.1	10.5	10.1	13.1	10.1
Av	10.0	10.8	12.6	11.5	11.4	11.3

[a]Gardner Color-Difference Meter measurement.

[b]Packed without (-) or with (+) sirup; frozen and stored.

Table 22. Color: degree of redness (a/b) values.[a]

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
Fresh						
1	2.41		1.76		1.78	
2	1.54		1.76		1.48	
3	2.18		2.44		1.89	
4	2.29		2.20		2.27	
5	2.01		2.23		1.72	
6	2.23		2.36		2.11	
7	2.33		1.89		2.25	
8	2.12		2.56		2.13	
Av	2.14		2.15		1.95	
10 days						
1	2.37	2.11	2.65	2.48	2.14	1.84
2	2.50	2.44	2.81	2.33	2.47	2.17
3	2.78	1.78	2.78	2.86	2.78	2.53
4	2.71	2.86	2.31	2.83	2.84	2.32
5	2.48	2.82	2.46	2.73	1.96	2.22
6	2.37	2.44	2.22	2.30	2.12	2.39
7	2.63	2.85	2.26	2.44	2.43	2.64
8	2.48	2.75	2.49	2.74	2.77	2.59
Av	2.54	2.51	2.50	2.59	2.44	2.34

Table 22. (concl.)

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	2.23	2.04	2.74	2.60	2.07	1.87
2	2.13	2.66	2.99	2.72	2.43	2.39
3	2.96	2.80	2.98	3.17	1.92	2.20
4	2.73	2.17	2.46	2.74	2.47	2.62
5	2.90	2.50	2.83	2.76	2.27	1.62
6	2.45	2.52	2.68	2.71	2.45	2.35
7	2.60	2.69	2.87	2.86	2.35	2.36
8	2.31	2.44	2.68	2.50	2.56	2.51
Av	2.54	2.48	2.78	2.76	2.32	2.24
12 weeks						
1	2.55	2.75	2.44	2.53	1.89	2.35
2	2.85	2.17	2.57	2.52	2.27	1.93
3	1.66	2.43	2.67	2.79	2.81	2.62
4	2.49	2.38	2.27	2.28	2.19	2.30
5	2.64	2.91	2.46	2.51	1.92	1.84
6	2.39	2.68	1.38	2.51	2.35	2.32
7	2.82	2.46	2.89	2.80	2.35	2.14
8	2.84	2.68	2.47	2.58	2.29	2.31
Av	2.53	2.56	2.39	2.56	2.26	2.23

[a]Calculated from Gardner Color-Difference Meter measurement.

[b]Packed without (-) or with (+) sirup; frozen and stored.

Table 23. Penetrometer[a] values.

Sample	Variety and treatment[b]					
	Grimson Sweet		Charleston Grey		Black Diamond	
	-	+	-	+	-	+
Fresh						
1	7.3		7.3		4.0	
2	23.0		4.3		11.3	
3	5.0		3.7		8.0	
4	2.3		9.7		13.0	
5	13.0		8.7		8.3	
6	4.7		13.7		7.3	
7	4.3		13.0		9.0	
8	14.0		10.0		12.7	
Av	9.2		8.8		9.2	
10 days						
1	35.3	36.0	33.3	33.7	38.3	44.3
2	51.7	48.3	41.7	38.3	37.0	40.7
3	50.3	45.7	53.7	42.0	56.3	45.3
4	44.3	35.0	39.0	53.0	37.0	51.0
5	55.3	50.7	50.7	55.3	43.0	50.0
6	56.7	50.3	39.0	45.0	45.7	42.3
7	45.0	50.7	51.7	35.0	47.3	46.0
8	48.3	55.3	52.7	55.7	41.0	59.3
Av	48.4	46.5	45.2	44.8	43.2	47.4

Table 23. (concl.)

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	84.3	52.7	42.0	52.7	38.0	38.0
2	35.7	51.7	30.0	36.7	21.7	37.7
3	39.7	56.0	45.7	61.7	51.0	54.7
4	45.3	44.7	52.7	35.0	41.7	45.3
5	53.7	39.3	60.3	49.0	52.3	33.3
6	41.7	57.0	52.0	48.0	48.3	59.3
7	53.3	50.0	49.3	49.3	46.7	50.0
8	48.3	49.0	54.0	50.7	40.0	48.0
Av	50.2	50.0	48.2	47.9	42.5	45.8
12 weeks						
1	41.3	45.0	58.7	56.0	30.0	44.3
2	35.3	50.7	28.3	57.7	30.0	33.0
3	26.3	54.0	56.3	65.0	34.0	61.0
4	31.0	49.3	39.3	54.3	39.0	49.7
5	42.3	50.3	51.3	34.3	41.0	39.0
6	40.0	54.0	51.0	56.7	45.7	44.0
7	29.7	39.3	39.3	39.7	38.7	49.3
8	32.3	42.0	36.7	48.3	43.3	50.3
Av	34.8	48.1	45.1	51.5	37.7	46.3

[a]Expressed as 0.1 mm penetration.

[b]Packed without (-) or with (+) sirup; frozen and stored.

Table 24. Percentage weight decrease upon frozen storage.

Sample	Variety and treatment[a]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
10 days						
1	12.1	33.3	16.8	13.1	25.2	22.0
2	21.6	25.0	17.3	13.1	20.8	21.8
3	33.1	30.5	27.9	14.7		41.0
4	24.8	23.2	30.3	17.6	25.0	22.5
5	32.7	49.1	27.9	22.4	30.1	20.0
6	28.4	15.4	24.5	13.8	23.4	24.1
7	33.9	23.4	33.0	21.0	34.0	26.8
8	35.1	34.5	32.4	20.4	37.2	21.4
Av	27.7	29.3	26.3	17.0	28.0	25.0
6 weeks						
1	22.4	27.9	26.1	19.8	38.2	22.9
2	20.0	24.8	11.6	15.0	13.2	14.3
3	23.9	25.9	23.6	28.1	26.7	20.7
4	25.0	19.0	21.2	20.9	29.2	23.3
5	44.5	23.1	35.2	17.6	34.8	23.7
6	29.4	33.3	29.6	22.6	33.0	31.3
7	24.0	26.2	24.5	18.3	30.6	26.1
8	22.9	39.5	16.4	30.9	8.9	29.2
Av	26.5	27.5	23.5	21.6	26.8	23.9
12 weeks						
1	10.0	20.5	31.4	22.6	24.4	17.9
2	19.4		2.6	17.8	12.5	21.0
3	21.5		19.6	26.3	23.0	21.2
4	23.3	21.2	17.8	28.1		
5	22.1	23.8	24.1	36.4	21.9	25.0
6	25.9	29.2	20.8	31.2	25.0	19.3
7	17.8	4.8	18.2	14.3	21.5	15.3
8	24.1	21.8	11.7	23.0	21.3	20.2
Av	20.5	20.2	18.3	25.0	18.7	20.0

[a]Packed without (-) or with (+) sirup; frozen and stored.

Table 25. Percentage total solids.

Sample	Variety and treatment[a]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
Fresh						
1	10.7		10.7		11.3	
2	10.3		11.1		10.6	
3	10.9		11.0		10.4	
4	11.0		10.1		10.4	
5	10.1		10.8		10.5	
6	9.9		11.3		10.2	
7	11.0		8.7		12.1	
8	11.5		11.4		11.6	
Av	10.7		10.6		10.9	
10 days						
1	11.3	10.0	11.1	10.2	10.7	9.0
2	9.9	9.7	12.4	10.0	11.7	10.2
3	11.0	10.8	12.0	11.1	10.8	10.0
4	10.5	10.5	10.1	9.7	10.4	9.1
5	10.4	10.2	10.6	10.4	9.8	8.5
6	10.1	9.5	9.8	8.6	11.5	10.8
7	10.0	10.3	8.2	9.0	12.1	10.8
8	10.1	10.0	10.9	10.4	10.7	10.5
Av	10.4	10.1	10.6	9.9	11.0	9.9

Table 25. (concl.)

Sample	Variety and treatment[a]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	9.8	9.8	9.6	10.0	11.0	10.8
2	10.5	10.5	10.8	10.5	10.0	10.5
3	11.0	10.4	9.7	10.3	10.1	10.7
4	10.2	9.4	10.2	9.4	9.2	10.6
5	10.1	10.5	10.8	10.3	9.5	9.8
6	8.0	9.2	9.3	8.5	9.0	9.7
7	8.1	9.0	9.3	8.9	8.9	9.0
8	8.5	8.5	9.7	9.5	10.3	9.6
Av	9.5	9.7	9.9	9.7	9.8	10.1
12 weeks						
1	9.5	9.6	10.0	10.3	9.7	8.4
2	10.3	9.4	9.8	10.1	11.3	9.9
3	10.1	11.1	10.2	10.4	9.5	9.6
4	9.2	13.1	9.6	8.9	8.7	11.1
5	9.4	10.7	9.9	9.2	9.4	10.4
6	10.5	8.6	9.4	10.5	10.5	8.6
7	10.6	9.9	10.5	9.1	10.4	8.8
8	10.7	9.4	9.6	9.6	11.1	10.6
Av	10.0	10.2	9.9	9.8	10.1	9.7

[a]Packed without (-) or with (+) sirup; frozen and stored.

Table 26. Percentage soluble solids.

Sample	Variety and treatment[a]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
Fresh						
1	10.8		10.8		11.2	
2	10.6		11.2		10.8	
3	11.0		11.2		10.8	
4	11.0		10.1		10.2	
5	10.4		10.8		10.8	
6	10.0		11.2		10.2	
7	11.2		9.2		12.2	
8	11.6		10.8		11.2	
Av	10.8		10.7		10.9	
10 days						
1	8.2	9.4	10.2	10.0	9.2	9.0
2	10.4	9.8	10.8	9.8	9.2	10.2
3	10.8	10.2	11.4	10.2	11.0	9.8
4	10.4	10.4	10.2	9.6	10.6	9.0
5	10.4	10.0	10.8	10.2	10.0	10.0
6	10.2	9.4	9.2	8.2	11.6	10.4
7	10.2	10.2	8.6	9.0	12.2	10.8
8	10.5	10.2	11.2	10.4	11.0	10.4
Av	10.1	10.0	10.3	9.7	10.6	10.0

Table 26. (concl.)

Sample	Variety and treatment[a]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	10.0	9.9	10.8	9.8	11.0	10.8
2	10.5	10.2	10.9	10.4	10.8	10.0
3	11.0	10.8	10.0	10.2	11.0	10.8
4	10.0	9.2	10.2	9.2	9.1	10.6
5	10.0	10.0	11.1	10.1	10.8	10.6
6	9.0	10.0	10.8	9.5	10.8	10.0
7	9.4	10.6	10.5	9.8	10.2	9.8
8	9.5	9.6	10.8	10.2	11.0	10.5
Av	9.9	10.0	10.6	9.9	10.6	10.4
12 weeks						
1	9.3	9.2	11.0	10.0	10.9	9.5
2	9.8	10.2	11.0	10.2	11.4	10.8
3	10.6	11.0	11.0	10.2	10.9	11.0
4	10.0	10.2	10.9	9.0	9.8	11.0
5	9.6	10.2	11.0	9.9	10.5	10.4
6	10.4	9.4	10.9	10.2	10.7	9.5
7	10.6	10.5	11.1	9.8	10.5	9.6
8	11.0	10.4	10.8	10.2	11.2	10.6
Av	10.2	10.1	11.0	9.9	10.7	10.3

[a]Packed without (-) or with (+) sirup; frozen and stored.

Table 27. pH values.

Sample	Variety and treatment[a]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
Fresh						
1	5.90		5.85		5.90	
2	5.90		5.91		6.00	
3	5.79		5.72		5.95	
4	6.39		6.48		6.21	
5	5.60		5.81		6.05	
6	6.30		6.30		6.27	
7	5.83		5.78		5.91	
8	6.25		5.92		6.10	
Av	6.00		6.00		6.00	
10 days						
1	5.90	5.88	5.85	5.80	6.10	5.78
2	5.92	5.80	5.91	5.80	5.95	6.05
3	5.82	5.88	5.80	5.80	6.02	6.08
4	5.85	5.81	5.98	5.80	5.90	5.65
5	5.77	5.81	6.02	5.95	5.87	5.98
6	6.42	6.60	6.40	6.60	6.40	6.70
7	6.31	5.85	6.31	5.73	6.39	5.88
8	6.20	5.70	6.36	5.90	6.22	5.80
Av	6.02	5.92	6.08	5.92	6.11	5.99

Table 27. (concl.)

Sample	Variety and treatment[a]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	5.69	5.71	5.62	5.72	5.82	5.85
2	5.92	5.90	5.90	5.99	5.95	5.98
3	5.73	5.88	5.59	5.60	5.81	5.75
4	5.61	5.59	5.67	5.68	5.48	5.70
5	5.60	5.64	5.78	5.82	5.94	6.00
6	5.65	5.79	5.79	5.69	5.75	5.79
7	5.58	5.72	5.68	5.70	5.68	5.60
8	5.61	5.64	5.62	5.72	5.70	5.80
Av	5.67	5.73	5.71	5.74	5.77	5.81
12 weeks						
1	5.69	5.60	5.91	5.90	5.80	5.82
2	5.72	5.68	5.70	5.70	5.70	5.70
3	5.62	5.70	5.68	5.51	5.90	5.80
4	5.63	5.60	5.73	5.60	5.60	5.88
5	5.52	5.58	5.78	5.68	5.90	5.71
6	5.55	5.38	5.55	5.50	5.45	5.51
7	5.71	5.69	5.65	5.55	5.67	5.62
8	5.69	5.64	5.50	5.51	5.60	5.68
Av	5.64	5.61	5.69	5.62	5.70	5.72

[a]Packed without (-) or with (+) sirup; frozen and stored.

Table 28. Titratable acidity[a] values.

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
Fresh						
1	0.064		0.064		0.077	
2	0.054		0.077		0.090	
3	0.074		0.090		0.064	
4	0.064		0.054		0.067	
5	0.077		0.076		0.054	
6	0.070		0.077		0.058	
7	0.070		0.065		0.070	
8	0.058		0.077		0.064	
Av	0.066		0.072		0.068	
10 days						
1	0.051	0.048	0.070	0.051	0.058	0.045
2	0.067	0.054	0.067	0.054	0.058	0.051
3	0.069	0.045	0.084	0.058	0.070	0.069
4	0.093	0.055	0.032	0.044	0.059	0.051
5	0.037	0.064	0.065	0.051	0.063	0.045
6	0.051	0.033	0.045	0.029	0.051	0.031
7	0.069	0.045	0.042	0.058	0.058	0.045
8	0.077	0.064	0.064	0.051	0.070	0.052
Av	0.064	0.051	0.059	0.050	0.061	0.049

Table 28. (concl.)

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	0.067	0.051	0.064	0.045	0.064	0.067
2	0.061	0.045	0.064	0.045	0.058	0.051
3	0.070	0.045	0.083	0.063	0.083	0.059
4	0.067	0.058	0.067	0.051	0.067	0.063
5	0.074	0.058	0.083	0.061	0.064	0.048
6	0.083	0.061	0.074	0.064	0.067	0.061
7	0.084	0.075	0.084	0.061	0.086	0.067
8	0.068	0.074	0.074	0.064	0.076	0.051
Av	0.072	0.058	0.074	0.057	0.071	0.058
12 weeks						
1	0.061	0.058	0.070	0.058	0.070	0.070
2	0.061	0.058	0.069	0.058	0.062	0.061
3	0.073	0.067	0.083	0.060	0.070	0.065
4	0.079	0.056	0.067	0.059	0.077	0.061
5	0.080	0.072	0.072	0.053	0.049	0.058
6	0.075	0.065	0.093	0.084	0.090	0.108
7	0.051	0.140	0.078	0.059	0.062	0.063
8	0.074	0.064	0.096	0.074	0.083	0.064
Av	0.069	0.072	0.078	0.063	0.070	0.069

[a]Expressed as g of citric acid/100g of watermelon.

[b]Packed without (-) or with (+) sirup; frozen and stored.

Table 29. Sugar content.[a]

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
Fresh						
1	9.08		9.92		12.24	
2	8.16		10.60		9.20	
3	11.56		11.00		10.88	
4	9.48		8.64		8.88	
5	8.80		9.36		10.00	
6	9.88		9.96		8.76	
7	9.92		8.44		10.60	
8	11.16		9.32		9.28	
Av	9.76		9.66		9.98	
10 days						
1	8.72	8.80	10.20	9.40	8.32	7.68
2	10.36	8.44	10.64	8.80	8.88	10.88
3	10.28	9.88	10.80	10.84	9.64	9.04
4	9.28	9.32	8.76	10.60	9.32	8.52
5	9.20		10.84	8.44	8.72	8.40
6	9.12	8.32	7.76	7.40	10.28	10.12
7	9.60	10.08	7.60	6.44	9.80	10.64
8	9.52	9.20	9.76	9.96	9.36	9.40
Av	9.51	9.15	9.54	8.98	9.29	9.34

Table 29. (concl.)

Sample	Variety and treatment[b]					
	Crimson Sweet		Charleston Gray		Black Diamond	
	-	+	-	+	-	+
6 weeks						
1	10.20	9.56	11.12	9.56	10.96	10.56
2	10.16	9.04	9.52	9.32	10.00	9.64
3	10.24	10.12	9.20	9.32	10.00	9.88
4	8.36	8.72	9.12	9.24	7.72	9.76
5	9.56	10.52	10.64	10.16	10.20	10.08
6	7.64	9.04	8.36	8.88	9.20	8.84
7	9.52	9.88	9.40	8.96	9.44	8.52
8	9.44	9.16	10.56	9.72	10.64	10.40
Av	9.39	9.50	9.74	9.40	9.77	9.71
12 weeks						
1	9.88	9.12	10.64	9.60	10.32	9.12
2	8.64	9.72	8.80	8.92	10.20	9.88
3	9.88	10.40	9.76		10.08	11.32
4	7.96	9.12	8.64	7.80	7.36	10.20
5	8.68	10.12	10.28	9.20	10.92	9.00
6	8.40	9.28	9.44	9.60	9.72	8.80
7	9.36	10.08	9.20	10.60	9.40	10.56
8	10.84	10.40	9.20	10.16	10.84	10.04
Av	9.20	9.78	9.50	9.41	9.86	9.86

[a]Expressed as g/100 g of watermelon.

[b]Packed without (-) or with (+) sirup; frozen and stored.

Table 30. Analyses of variance for fresh balls.

Source	D/F	MS	F-value	Sig.[a]
Palatability scores				
General appearance				
Reps	7	0.1895	0.80	ns
Varieties	2	0.6379	2.68	ns
Remainder	14	0.2379		
Color desirability				
Reps	7	0.5971	2.00	ns
Varieties	2	1.1879	3.97	*
Remainder	14	0.2989		
Flavor desirability				
Reps	7	0.1267	1.33	ns
Varieties	2	0.0754	0.79	ns
Remainder	14	0.0954		
Texture desirability				
Reps	7	0.0655	0.36	ns
Varieties	2	0.1429	0.78	ns
Remainder	14	0.1824		
General acceptability				
Reps	7	0.0740	1.11	ns
Varieties	2	0.1950	2.91	ns
Remainder	14	0.0669		
Objective values				
Color: reflectance (Rd)				
Reps	7	4.1370	0.94	ns
Varieties	2	0.1954	0.04	ns
Remainder	14	4.3750		

Table 30. (concl.)

Source	D/F	MS	F-value	Sig.[a]
Color: degree of redness (a/b)				
Reps	7	0.1536	3.18	*
Varieties	2	0.0972	2.01	ns
Remainder	14	0.0483		
Penetration				
Reps	7	20.0076	0.78	ns
Varieties	2	0.4267	0.02	ns
Remainder	14	25.5319		
Total solids (%)				
Reps	7	0.3581	0.60	ns
Varieties	2	0.1454	0.24	ns
Remainder	14	0.5911		
Soluble solids (%)				
Reps	7	0.2099	0.45	ns
Varieties	2	0.1404	0.30	ns
Remainder	14	0.4642		
pH				
Reps	7	0.1413	9.27	***
Varieties	2	0.0126	0.83	ns
Remainder	14	0.0152		
Titratable acidity				
Reps	7	0.000056	0.45	ns
Varieties	2	0.000080	0.63	ns
Remainder	14	0.000127		
Sugar content				
Reps	7	1.4305	1.34	ns
Varieties	2	0.2217	0.21	ns
Remainder	14	1.0656		

[a]*, $P < 0.05$; ***, $P < 0.001$; ns, not significant.

Table 31. Analyses of variance for fresh and frozen-stored balls packed without sirup.

Source	D/F	MS	F-value	Sig.[a]
Palatability scores				
General appearance				
Reps	7	0.2858	1.57	ns
Varieties (V)	2	0.7576	4.17	*
Storage (S)	3	2.5534	14.05	***
V x S	6	0.3055	1.68	ns
Remainder	77	0.1818		
Color desirability				
Reps	7	0.7881	3.20	**
Varieties (V)	2	2.4872	10.10	***
Storage (S)	3	2.4954	10.13	***
V x S	6	0.3233	1.31	ns
Remainder	77	0.2463		
Flavor desirability				
Reps	7	0.2521	0.98	ns
Varieties (V)	2	0.6351	2.47	ns
Storage (S)	3	34.5693	134.51	***
V x S	6	0.3447	1.34	ns
Remainder	77	0.2570		
Texture desirability				
Reps	7	0.1506	0.81	ns
Varieties (V)	2	0.1720	0.92	ns
Storage (S)	3	13.0949	70.31	***
V x S	6	0.2493	1.34	ns
Remainder	77	0.1862		
General acceptability				
Reps	7	0.3927	2.15	*
Varieties (V)	2	0.1254	0.69	ns
Storage (S)	3	21.3107	116.77	***
V x S	6	0.2289	1.25	ns
Remainder	77	0.1825		

Table 31. (cont'd.)

Source	D/F	MS	F-value	Sig.[a]
Objective values				
Color: reflectance (Rd)				
Reps	7	2.2636	1.38	ns
Varieties (V)	2	0.3294	0.20	ns
Storage (S)	3	226.8714	138.40	***
V x S	6	1.0192	0.62	ns
Remainder	77	1.6392		
Color: degree of redness (a/b)				
Reps	7	0.1205	1.42	ns
Varieties (V)	2	0.4482	5.28	**
Storage (S)	3	1.0336	12.18	***
V x S	6	0.0824	0.97	ns
Remainder	77	0.0848		
Penetration				
Reps	7	120.1469	1.89	ns
Varieties (V)	2	114.2334	1.80	ns
Storage (S)	3	7567.7519	119.27	***
V x S	6	99.3929	1.57	ns
Remainder	77	63.4483		
Total solids				
Reps	7	1.1498	1.95	ns
Varieties (V)	2	0.5304	0.90	ns
Storage (S)	3	5.9025	10.03	***
V x S	6	0.2129	0.36	ns
Remainder	77	0.5886		
Soluble solids				
Reps	7	0.7567	1.77	ns
Varieties (V)	2	1.8701	4.37	*
Storage (S)	3	1.1084	2.59	ns
V x S	6	0.4460	1.04	ns
Remainder	77	0.4277		

Table 31. (concl.)

Source	D/F	MS	F-value	Sig.[a]
pH				
Reps	7	0.0461	1.32	ns
Varieties (V)	2	0.0429	1.23	ns
Storage (S)	3	0.9530	27.30	***
V x S	6	0.0032	0.09	ns
Remainder	77	0.0349		
Titratable acidity				
Reps	7	0.000194	1.53	ns
Varieties (V)	2	0.000114	0.90	ns
Storage (S)	3	0.000669	5.26	***
V x S	6	0.000086	0.68	ns
Remainder	77	0.000127		
Sugar content				
Reps	7	3.8422	5.51	***
Varieties (V)	2	0.5378	0.77	ns
Storage (S)	3	0.5557	0.80	ns
V x S	6	0.3474	0.50	ns
Remainder	77	0.6975		

[a]*, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$; ns, not significant.

Table 32. Analyses of variance for frozen-stored balls packed without and with sirup.

Source	D/F	MS	F-value	Sig.[a]
Palatability scores				
General appearance				
Reps	7	0.3980	2.06	ns
Varieties (V)	2	0.1064	0.55	ns
Storage (S)	2	1.3077	6.76	**
Treatment (T)	1	0.6006	3.10	ns
V x S	4	0.2057	1.06	ns
V x T	2	0.5677	2.93	ns
S x T	2	0.2264	1.17	ns
V x S x T	4	0.2188	1.13	ns
Remainder	119	0.1935		
Color desirability				
Reps	7	0.7114	3.32	**
Varieties (V)	2	1.1575	5.41	**
Storage (S)	2	4.6027	21.50	***
Treatment (T)	1	0.0544	0.25	ns
V x S	4	0.2380	1.11	ns
V x T	2	0.4144	1.94	ns
S x T	2	0.2046	0.96	ns
V x S x T	4	0.1762	0.82	ns
Remainder	119	0.2140		
Flavor desirability				
Reps	7	0.0712	0.24	ns
Varieties (V)	2	0.6876	2.28	ns
Storage (S)	2	0.9005	6.29	**
Treatment (T)	1	1.3806	4.57	*
V x S	4	0.1492	0.49	ns
V x T	2	0.5452	1.80	ns
S x T	2	0.4414	1.46	ns
V x S x T	4	0.3373	1.12	ns
Remainder	119	0.3021		

Table 32. (cont'd.)

Source	D/F	MS	F-value	Sig.[a]
Texture desirability				
Reps	7	0.4612	2.75	*
Varieties (V)	2	1.8909	11.28	***
Storage (S)	2	1.8676	11.14	***
Treatment (T)	1	2.4025	14.33	***
V x S	4	0.1888	1.13	ns
V x T	2	0.6402	3.82	*
S x T	2	0.1690	1.01	ns
V x S x T	4	0.1354	0.81	ns
Remainder	119	0.1677		
General acceptability				
Reps	7	0.3560	1.76	ns
Varieties (V)	2	0.8268	4.08	*
Storage (S)	2	1.6358	8.08	***
Treatment (T)	1	1.5211	7.51	**
V x S	4	0.0405	0.20	ns
V x T	2	0.3897	1.92	ns
S x T	2	0.1052	0.52	ns
V x S x T	4	0.1416	0.70	ns
Remainder	119	0.2025		
Objective values				
Color: reflectance (Rd)				
Reps	7	1.1995	1.62	ns
Varieties (V)	2	0.3811	0.51	ns
Storage (S)	2	0.8270	1.11	ns
Treatment (T)	1	2.5600	3.45	ns
V x S	4	1.0244	1.38	ns
V x T	2	0.0534	0.07	ns
S x T	2	0.5700	0.77	ns
V x S x T	4	0.8430	1.14	ns
Remainder	119	0.7426		

Table 32. (cont'd.)

Source	D/F	MS	F-value	Sig.[a]
Color: degree of redness (a/b)				
Reps	7	0.1774	2.38	*
Varieties (V)	2	1.1289	15.11	***
Storage (S)	2	0.1142	1.53	ns
Treatment (T)	1	0.0005	0.01	ns
V x S	4	0.1758	2.35	ns
V x T	2	0.0706	0.95	ns
S x T	2	0.0360	0.48	ns
V x S x T	4	0.0072	0.10	ns
Remainder	119	0.0747		
Penetration				
Reps	7	205.8029	3.17	**
Varieties (V)	2	143.8055	2.22	ns
Storage (S)	2	150.3950	2.32	ns
Treatment (T)	1	480.7056	7.41	**
V x S	4	133.5678	2.06	ns
V x T	2	37.1764	0.57	ns
S x T	2	300.8819	4.64	*
V x S x T	4	34.9077	0.54	ns
Remainder	119	64.8569		
Weight loss				
Reps	7	192.1317	4.87	***
Varieties (V)	2	137.6669	3.49	*
Storage (S)	2	317.3352	8.05	***
Treatment (T)	1	37.2100	0.94	ns
V x S	4	74.0627	1.88	ns
V x T	2	30.0618	0.76	ns
S x T	2	86.0482	2.18	ns
V x S x T	4	88.4712	2.24	ns
Remainder	114	39.4334		

Table 32. (cont'd)

Source	D/F	MS	F-value	Sig.[a]
Titratable solids				
Reps	7	1.9598	3.13	**
Varieties (V)	2	0.1313	0.21	ns
Storage (S)	2	3.8036	6.08	**
Treatment (T)	1	2.1511	3.44	ns
V x S	4	0.4234	0.68	ns
V x T	2	0.5968	0.95	ns
S x T	2	1.9686	3.15	*
V x S x T	4	0.3830	0.61	ns
Remainder	119	0.6258		
Soluble solids				
Reps	7	1.3471	4.07	***
Varieties (V)	2	1.6326	4.93	**
Storage (S)	2	0.8813	2.66	ns
Treatment (T)	1	6.3336	19.12	***
V x S	4	0.1928	0.58	ns
V x T	2	1.7450	5.27	**
S x T	2	0.1880	0.57	ns
V x S x T	4	0.1376	0.42	ns
Remainder	119	0.3313	0.42	ns
pH				
Reps	7	0.0665	2.08	ns
Varieties (V)	2	0.0840	2.63	ns
Storage (S)	2	1.5676	49.09	***
Treatment (T)	1	0.0491	1.54	ns
V x S	4	0.0003	0.01	ns
V x T	2	0.0066	0.21	ns
S x T	2	0.0893	2.80	ns
V x S x T	4	0.0017	0.05	ns
Remainder	119	0.0319		

Table 32. (concl.)

Source	D/F	MS	F-value	Sig.[a]
Total acidity				
Reps	7	0.000326	2.95	**
Varieties (V)	2	0.000031	0.28	ns
Storage (S)	2	0.002745	24.82	***
Treatment (T)	1	0.003711	33.56	***
V x S	4	0.000019	0.17	ns
V x T	2	0.000133	1.20	ns
S x T	2	0.000302	2.74	ns
V x S x T	4	0.001532	13.86	***
Remainder	119			
Sugar content				
Reps	7	3.4954	4.99	***
Varieties (V)	2	0.5642	0.81	ns
Storage (S)	2	1.3809	1.97	ns
Treatment (T)	1	0.0600	0.09	ns
V x S	4	0.2294	0.33	ns
V x T	2	0.5120	0.73	ns
S x T	2	0.7508	1.07	ns
V x S x T	4	0.2160	0.31	ns
Remainder	117	0.7002		

[a]*, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$; ns, not significant.

CERTAIN ASPECTS OF PACKING, FREEZING, AND EVALUATING SELECTED VARIETIES OF WATERMELON

by

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The effects of home packing, freezing, and storing on the quality and acceptability of watermelon were investigated. Three varieties of watermelon, with 8 replications of each, cut into balls and packed without and with a 10% sirup (table sugar) were frozen and stored for periods of 10 days, 6 and 12 weeks. The balls were evaluated fresh and after each period of frozen storage. When comparing fresh and 10 day frozen-stored balls, packed without sirup, general appearance, desirability of flavor and texture, and general acceptability were significantly lower after frozen storage, although color desirability was not affected. In general, the desirability of color and general appearance decreased with 6 or 12 weeks frozen storage. However, the texture and flavor desirability and general appearance increased slightly after 6 weeks frozen storage, then decreased with 12 weeks.

General appearance and color desirability were not affected significantly by the method of packing. Whereas, the desirability of flavor and texture and the general acceptability of the balls were significantly reduced by freezing and storing them packed in sirup.

Under the conditions of this study, none of the 3 varieties of watermelon yielded a satisfactory product. No one of the objective measurements (reflectance, degree of redness, depth of penetration, total and soluble solids, pH, titratable acidity, and sugar content) offered a complete explanation for the observed palatability changes. Apparently, a combination of the

measured factors and/or some unmeasured factors accounted for the observed palatability changes.