EFFECT OF VARIOUS COMBINATIONS OF CORN AND SUCROSE SYRUPS ON THE QUALITY OF CANNED AND FROZEN FRUIT

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ABSTRACT

EFFECT OF VARIOUS COMBINATIONS OF CORN AND SUCROSE SYRUPS ON THE QUALITY OF CANNED AND FROZEN FRUIT

By

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The suitability of blends of corn sugars and syrups with sucrose for canning Schmidt sweet cherries, Halehaven and Elberta freestone peaches and Bartlett pears, and for freezing Midway strawberries and Halehaven peaches was studied. Corn sugars and syrups used were dextrose, levulose, maltose, corn syrup #1631 (39% dextrose, 32% maltose and 29% higher saccharides), and invert syrup. Blends of corn sugars and syrups were formulated and substituted for 25% of the sucrose. The blends were compared to 100% sucrose by taste panels using the paired comparison procedure. The blends found sweeter than 100% sucrose were substituted at 25% and 33% levels for sucrose in fruit processing. Additional blends were also formulated and used in processing.

Panelists evaluated fruit packed in the various syrups for flavor preference using the rank procedure. Very few significant differences were found for canned

Schmidt cherries, Bartlett pears and frozen Halehaven peaches, although these fruits packed in 100% sucrose were generally preferred. Midway strawberries frozen in 100% sucrose and a blend of 67% sucrose, 13% levulose, 13% #1631 and 7% maltose syrups, and Halehaven peaches canned in 75% sucrose, 10% levulose, 10% #1631 and 5% maltose syrup were significantly preferred. Elberta peaches canned in 75% sucrose, 10% dextrose, 10% invert syrup, and 5% levulose and 75% sucrose, 15% levulose, and 10% dextrose syrups were preferred.

No significant differences were found between drained weights, soluble solids, pH's, total acidities or brix-acid ratios, respectively, of each fruit pack. These data indicated that any differences obtained among the various syrup packs were due to the degree of sweetness of the syrups and its effect on the flavor qualities of the fruit.

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TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

The U.S. production of corn for the year October 1, 1968--September 31, 1969 was 4,375 million bushels, 48.4% of the world total (Newspaper Enterprises, 1970). Most of the "field corn" grown is used for livestock feeding, however, the grain equivalent of the corn starches, corn syrups, corn sugar, corn meal, corn oil, corn flour and other foods containing corn that consumers buy amount to one bushel per person per year (Corn Refiners Assoc., 1968). In the U.S. this amounts to over 200 million bushels.

Corn sugar (dextrose) and corn syrups are used in the production of beverages, meat products, canned fruits and vegetables, breads, salad dressings, and dairy products (Corn Refiners Assoc., 1968).

Corn syrups are made from corn starch using either acid (HCl) or acid-enzyme hydrolysis. In the acid process, the corn starch, as a slurry, is placed in a converter, heated and dilute acid (HCl) is added. Hydrolysis is halted by addition of a neutralizing agent ($NaCO_3$). In the acid-enzyme process, the acid hydrolysis is followed by addition of a purified diastatic enzyme, resulting in a high maltose content syrup. The dextrose-maltose ratio

is influenced by both the type of enzyme employed and by the extent of preliminary acid conversion. The resulting hydrolyzate is skimmed (for fatty substances), filtered, partially evaporated, (to 60% solids) and passed through carbon filters for further clarification and decoloration. The resulting fluid is often passed through ion-exchangers for final purification (Corn Industries Research Foundation, 1965).

The sweetness of corn sugars and syrups, with respect to sucrose, is dependent on the concentrations employed, whether or not they are combined with sucrose, the degree of hydrolysis, dextrose equivalent (DE), and even the conversion and refining method used (Dahlberg and Penczek, 1941), (Neiman, 1958), (Lewis, 1956), (Joslyn, 1957), (Pangborn et al. 1959).

The FDA (Federal Food and Drug Administration) now allows the substitution of sucrose by corn sugars and syrups up to the 33% level as part of the standard of identity of canned cherries, peaches and pears. There are presently no standards of identity for frozen strawberries or peaches (The Almanac, 1970).

Much of the canned fruit today contains corn syrup as a partial sweetener, however, the industry is constantly searching for new blends to improve the flavor and overall quality of the products marketed. This study was undertaken to determine the suitability of various blends of

corn syrups with sucrose for canning freestone peaches, pears and sweet cherries, and for freezing freestone peaches and strawberries. The effect of the various combinations of sweetening agents on flavor was emphasized.

REVIEW OF LITERATURE

Dahlberg and Penczek (1941) tested the relative sweetness of various sugars as effected by concentration using sucrose as the standard for comparison. Using sucrose as a standard at 100, they reported that 10 percent solutions of levulose, maltose, dextrose, and enzyme converted corn syrup to be 114.9, 47.4, 78.7, and 55.9 as sweet, respectively. Twenty percent solutions gave values of 119.8, 56.5, 91.7, and 70.9, respectively, and 40 percent solutions of dextrose gave a value of 100.0, i.e., equal to sucrose, and corn syrup a value of 80.0. A definite effect of one sugar upon another was reported. In a test where solutions of 15, 25, and 40 percent sucrose were made up as standards, and test solutions were made up of 2/3 sucrose and the rest of dextrose or corn syrup necessary to bring the sweetness up to the level of the standard, the dextrose was rated at 94, 100, and 102 relative to sucrose at 100, and corn syrup at 79, 100, and 100, respectively. Thus, in a 25 percent solution dextrose was found to be as sweet as sucrose when in combination with sucrose (two parts sucrose to one part dextrose). Also, a high conversion corn syrup could replace sucrose on a pound for pound basis in a 25

percent solution. Both of these observations are also at the sucrose-dextrose 2:1 level.

Sjöström and Cairncross (1955) reported mixtures of isosweet solutions of sucrose (8.25%) and dried corn syrup D.E. 42 (22.0%) to be slightly sweeter than either solution by itself. Additional tests with these sweeteners showed similar trends at the 2.25% sucrose (9.25% dried corn syrup) sweetness level, but not at the 1.75% sucrose (6.75% dried corn syrup) level. A difference in the character of sweetness of sweeteners was noted. The intensity of sweetness of a 21% dextrose solution dropped off suddenly compared with a sucrose solution of equivalent sweetness (15%), which persisted for a longer time, disappearing gradually. The same comparison was noted with 3.75% dextrose and 2.0% sucrose solutions, but not with dextrose and sucrose solutions at their recognition threshold levels, 1.3% and 2.0% respectively.

Nieman (1958) summarized data on the relative sweetness of different sugars compared to a 10% solution of sucrose. With the sucrose value set at 100, he rated maltose 46, d-glucose 69, d-fructose 114, and invert syrup 65. Lewis (1956) reported dextrose (glucose) to be 62% as sweet as sucrose in 2% solutions. He also reported dextrose and sucrose to be equally sweet at the 40% solids level. Dahlberg and Penczek (1941) reported dextrose 62.5% as sweet as sucrose in 2% solutions.

Sather and Weigand (1948) reported on the application of corn syrup in the freezing preservation of fruit. The study consisted of freezing apricots, apples, blackberries, boysenberries, loganberries, peaches, pears, prunes, raspberries, rhubarb, sweet cherries, RSP cherries and strawberries in various combinations and concentrations of sucrose and three corn syrups. Superior texture, flavor and color were reported for packs with 40 or 50 Brix (B) ingoing syrup with 40% or 50% replacement of sucrose with either Red or Blue Label Karo brand corn syrup. Higher drained weights were also reported for these syrup treatments. Oxidation or browning was observed in the Red label syrup packs. Organoleptic panels rated the flavor, texture, color and general appearance of all packs. A panel of six trained food technologists was used. Data from this panel correlated well with data from a panel of twenty-four members of an academic class studying frozen foods which also rated the products.

In evaluating the effects of various sweetening agents on frozen strawberries for preserve manufacture, Aref et al. (1956) reported that a 25% replacement of sucrose by dextrose resulted in no significant difference in the drained weight, and a higher invert sugar content in the preserve than 100% sucrose. They also reported that the use of Frodex (a corn syrup) resulted in better colored whole berries than did sucrose, and that some of the effect

was noticeable in the preserves. There were indications that the sucrose pack had superior flavor than did packs using other sweeteners.

Leonard et al. (1953) reported that the Brix-acid ratio was a good criterion of cling peach flavor and found a ratio of 25 to 32:1 to be optimum. They also stressed that fruit flavor rather than sweetness was the most important factor in the determination of acceptability.

Simone et al. (1956) conducted consumer studies on the sweetness of canned cling peaches and reported that samples with cut-out Brix readings of 23.5 to 24.2 B were most acceptable. These corresponded to Brix-acid ratios of 73.7 to 85.4.

Joslyn et al. (1957) using Halford clingstone peaches reported no real differences in acceptability between 25% replacement of sucrose by dextrose or by corn syrups and the straight sucrose pack. Flatness and lack of fruit flavor in corn syrup samples at higher replacement levels (50 and 75%) was often noted. Moreover, granular dextrose did not affect loss in fruit flavor as much as the corn syrups used, but contributed to a peculiar and undesirable bitterness and off-flavor. They found that both sweetness and fruitiness were decreased in the corn syrup and dextrose packs. In adjusting the sweetness level in the corn syrup packs with sucryl, they found that sweetness was more important than fruitiness in flavor evaluation.

Slight changes in texture were noted for all blends at the 40% replacement level, but at 50% and above, panel members noticed the samples becoming "too firm, rubbery, or tough." With respect to the method of conversion and refining of the corn syrup, the 64 DE acid-enzyme converted to bone char and resin refined syrup was superior to the 54 DE and 42 DE acid-converted carbon refined syrups. At the 25% replacement level and 64 DE syrup was even preferred over sucrose, while at 50% replacement the sucrose pack was rated highest followed by dextrose and corn syrup packs.

With Elberta freestone peaches, Pangborn et al. (1959) reported the best sample was 40 B ingoing, 22.56 B cut-out, pH 3.75, total acidity .349%, Brix-acid ratio 64.52:1 when packs ranging from 30 B ingoing, 18.46 B cut-out, to 60 B ingoing 31.40 B cut-out were tested. They reported that texture differences closely resembled flavor differences.

Increased acid did not improve sample flavor acceptability or texture even in very sweet samples. Increasing percentages of corn syrups in the ingoing 40 B syrups decreased flavor acceptability, but at the 50 B ingoing level no significant difference was noted between sucrose and corn syrup packs. Off-flavor was detected with increasing amounts of corn syrup at the 40 B level. Excessive sweetness at the 50 B level masked flavor differences

at the lower replacement levels. In general, firmness of the fruit increased with increasing corn syrup content.

Pangborn and Leonard (1958) reported that in a consumer study on Bartlett pears of different total acidity canned with syrups of between 30 and 70 B readings, the fruit with high acidity (.160%) scored best (on a seven point hedonic scale) at a cut-out Brix of 22.8 B, while the low acid (.135%) scored best at 18.5 B. The respective Brix-acid ratios were 142.5 and 129.6. Flavor was most frequently mentioned as a favorable characteristic. The panel made a positive association between sweetness and flavor. Texture and color were reported as being unaffected by sugar levels.

Ranking tests require that judges arrange a series of two or more samples in ascending or descending order of intensity of a specific characteristic. In ranking tests for quality, the usual objective is to select one or two of the best samples rather than to test all samples thoroughly. Ranking is often used for screening inferior from superior experimental samples in product development and occasionally in training judges (Amerine et al. 1965).

Caul (1957) pointed out that inconsistencies in ranking may occur when a judge is asked to rank samples with only minor differences. The judge may then feel he has to distinguish between identical samples. Caul (1957) also stated that the major disadvantage of the ranking

method is that it disregards the degree of difference between samples.

Kramer (1960) stated that the ranking method is a simple, accurate and rapid means for determining whether observed differences are real in terms of statistical differences.

Bliss et al. (1953) compared the ranking, scoring, and checking of descriptive terms methods for taste tests with mealiness of potatoes. Six samples were tested. It was stated that both scoring and descriptive terms assume a standard against which all samples are judged, whereas ranking sets its own standard in each test and the assigned scores are merely relative values. It was also stated that the standard can be included among the unknowns as a reference point on the same scale as other points in the test. Boggs and Hanson (1949) referred to a standard as a means of relating unknowns to a sample whose quality is known. Bliss et al. (1953) reported that in computation, ranking is simplest.

Dawson and Dochterman (1951), in comparing ranking and scoring methods for evaluating three samples of apple juice with three levels of lemon juice added, found no significant differences between the methods, in percentage of correct order answers, though ranking showed a slightly higher actual percentage. They reported that the ranking data were more easily tallied than numerical scores because

the answers were more decisive in the ranking test. They did report, however, that the scoring method indicated degrees of difference that were not shown by ranking.

Murphy et al. (1954) reported the ranking method better than scoring for evaluating strawberry texture by trained judges, because of their failure to use the full five point scale.

Murphy et al. (1957) used the three methods of paired comparison, ranking and terms-scoring scale in detecting differences among three strawberry varieties with known flavor differences reported that the ranking and terms methods took about the same amount of material and time, while the paired method took more of each. Wide quality differences were picked up by the ranking and term methods, while the paired comparison test was found to be a more precise test than the other two.

Giradot et al. (1969) reported that the paired comparison procedure and a three-sample rank order procedure could be used equally well to discriminate between various strengths of instant coffee. The consumer preference testing also showed a four-sample rank order procedure to be slightly poorer than the above two methods when differences between samples were small.

Consumer panels are very useful because they reflect a new product's projected acceptance into the marketplace. Cartwright et al. (1952) stated that the determination of a

consumer preference is a useful application of organoleptic evaluation, particularly in developing a new formula based on an established product. Languil (1949) stated that consumers all are, or should be, taste conscious, and pointed out that food manufacturers recognize this and stress it in their advertising. He stated that acceptability testing of products is done by both trained and consumer panels, and that little difference in taste preference was noted between men and women. However, Pangborn (1964) pointed out that a problem may arise when an untrained judge records his degree of liking by saying, "I like it because it has good flavor, and it has good flavor because I like it." It is generally recognized that certain people prefer their food (e.g., fruit) sweet, and others tart. The food industry should provide "natural" tasting products with the sugar-to-acid level where most people like it best.

MATERIALS AND METHODS

Materials

Sugars and syrups

Six basic sugars and syrups were used to formulate the syrup blends used in this study. The dry sugars were sucrose, dextrose, levulose, and maltose, and the syrups were invert syrup and Corn Products #1631 corn syrup. The invert syrup was 91% converted (9% sucrose by difference) with 72.1% soluble solids. The #1631 syrup was a 43 Baume (Be) (81.8% soluble solids), acid-enzyme converted, ion-exchanged and carbon refined corn syrup consisting of approximately 39% dextrose, 32% maltose and 29% higher saccharides. With the exception of sucrose the sugars used in this study were supplied by the Moffett Technical Center of the CPC International Inc.

Syrup blends and standards

Three standards were chosen for the study; 100% sucrose, 75% sucrose + 25% #1631, and 67% sucrose + 33% dextrose. Ten syrup blend formulas were made with 25% replacement of sucrose by various corn sugars, using available data in the literature on the relative sweetness of various sugars as a guideline. These formulas are shown in Table 1.

Table 1. Composition of corn and sucrose syrups.

	Sugars					
	Sucrose	Dextrose	Levulose	Maltose	#1631	Invert
Standards	Percent by weight					
SS	100	--	--	--	--	--
S1	75	--	--	--	25	--
S2	67	33	--	--	--	--
Blend Formulas Code No.						
1	75	10	10	5	--	--
2	75	--	10	5	--	10
3	75	--	10	5	10	--
4	75	10	5	--	--	10
5	75	--	5	10	10	--
6	75	--	5	--	10	10
7	75	5	10	5	--	5
8	75	5	--	5	10	5
9	75	5	5	5	--	10
10	75	5	5	10	--	5
Series I						
03	75	--	10	5	10	--
04	75	10	5	--	--	10
05	75	--	5	10	10	--
06	75	--	5	--	10	10
Series II						
A3	67	--	13	7	13	--
A4	67	13	7	--	--	13
A5	67	--	7	13	13	--
A6	67	--	7	--	13	13
Series III						
20	75	15	--	--	--	10
21	75	10	--	--	--	15
22	75	--	--	10	--	15
23	75	--	15	10	--	--
24	75	10	15	--	--	--
25	75	--	15	--	--	10

Fruits

Bartlett pears harvested in 1968, 1969, and 1970, Midway strawberries harvested in 1969 and 1970, Schmidt sweet cherries harvested in 1969, Halehaven freestone peaches harvested in 1969 and 1970, and Elberta freestone peaches harvested in 1969 were used. (Table 2)

Peaches were harvested at the firm-ripe stage and ripened at 70-75 F for 3-4 days before processing. Pears were stored at 32 F for 30-40 days after harvest and ripened at 70-75 F.

Table 2. Codes used to identify fruit packs by variety, processing method and harvest year.

Product	Year of Crop	Codes
Canned Bartlett Pears	1968	PD
	1969	PF
	1970	PK
Frozen Midway Strawberries	1969	STB
	1970	STC
Canned Schmidt Sweet Cherries	1969	CA
Canned Halehaven Peaches	1969	PA
	1970	PH
Frozen Halehaven Peaches	1970	PH
Canned Elberta Peaches	1969	PE

Methods

Blend formula testing

The syrup formulas were made up as 40 percent solutions (the ingoing B level of canned fruit) and evaluated for sweetness by a taste panel using the paired compairson procedure. Each pair consisted of one of the blend formulas (1-10) (Table 1) and a sucrose sample.

The panel results indicated that the 40 B syrups were too sweet and, at that level, it was difficult to distinguish between samples. Therefore, additional evaluations were made at the 25 B level, the approximate cut-out B level of canned fruit.

Fruit processing

Strawberries

Midway strawberries, 1969 crop, were obtained from the Keeler, Michigan area. They were washed, sliced and filled into 6 x 12 clear polyethelene bags to a put in weight of 7 ounces. Three ounces of 50 B syrup was added to each bag and the bags were heat-sealed and frozen at -10 F. A 50 B syrup was chosen in place of a 60 B because of the lateness of the season. The ripe to very ripe berries were considered to be low in acidity, thus oversweetness of a 60 B syrup was avoided.

The 1969 pack consisted of berries packed in Series I, II, and II blend syrups and the three standard syrups (Table 1).

Midway strawberries, 1970 crop, were packed as in 1969, however, 14 ounces of fruit and 6 ounces of 60 B syrup were filled into each bag. The syrups used were of SS, 03, A3, and S1 composition.

Sweet Cherries

Schmidt sweet cherries were obtained from the Hart-Shelby area of Michigan. They were washed and pitted with a Dunkeley junior cherry pitter. Pitted cherries were filled into 303 cherry enamel cans, covered with 160-170 F 40 B syrup, exhausted for approximately 7 minutes at 190 F, sealed and processed for 25 minutes at 210 F, cooled and stored. The put in weight of pitted fruit was 12 ounces. Syrups of the three blend series and the three standards were used.

Peaches

Halehaven and Elberta peaches of the 1969 crop were obtained. Peaches were washed, de-stoned by hand and steam-peeled. Peach halves were filled into 303 cans, covered with 160-170 F 40 B syrup, exhausted for seven minutes at 190 F, sealed and processed for 25 minutes at 210 F, cooled and stored. The put in weight of peach halves was 12 ounces. The three blend series syrups and the three standards were used for each variety. Halehaven peaches, 1970 crop, were prepared and processed as above,

however, only 40 B syrups of SS, 03, A3, and S1 composition were used. Also, Halehaven peaches of the 1970 crop were frozen in 6 x 12 clear polyethelene bags with 12 ounces of fruit and 6 ounces of 40 B syrup filled into each bag.

Pears

Bartlett pears were hand-peeled and cored. Pear halves were filled into 303 cans, covered with 160-170 F 40 B syrup, exhausted for approximately 7 minutes at 190 F, sealed and processed for 25 minutes at 210 F, cooled and stored. The put in weight of fruit was 11 ounces.

Three small lots of 1968 crop Bartlett pears were canned in various syrups of the Series I and the three comparison standards (Table 1) at 40 B and 25 B levels. A larger pack was put up including all of the standards and Series I syrups at an ingoing 30 B level.

Bartlett pears of the 1969 crop were canned in 40 B syrups of the three series (Table 1). Standards were also packed. In 1970, pears were put up in 40 B syrups of the SS, 03, A3, and S1 composition.

Taste panel procedures

Syrup blends

The paired comparison procedure was used to compare the various syrup formulas with sucrose. All samples were served at room temperature in clear plastic 1 ounce cups.

At one sitting, three pairs were presented to each panelist, each pair consisting of one test sample and one sucrose. Each cup was accompanied by a cup of water, a ballot, a pencil, and a napkin. The test was performed under white light, since all samples appeared similar. The panelists were asked to choose the sweeter sample and record. Data was analyzed for significance (Kramer and Twigg, 1966).

Method of panel selection and testing environment

Procedures concerning the testing environment and serving the samples were carefully monitored using those cited by Amerine et al. (1965) as a guideline. Taste panels used to evaluate the 1968 and 1969 fruit packs were considered to be laboratory panels. They consisted of 15-20 randomly selected people who either passed by the testing area (room 100 Food Science) or were Food Science students and staff. An expert panel was not sought, thus neither screening nor sensitivity tests were administered. The testing environment was quiet, comfortable and as orderly as possible. The importance of these factors being emphasized by Boggs and Hanson (1949) among others. The tests were generally performed either mid-morning, 10:00--11:00 a.m. or mid-afternoon 2:00--3:00 p.m. Harper (1949) preferred to serve sweet samples from 10:00--10:30 a.m. so as to avoid the influence of mealtimes.

Fruit packs

Flavor evaluations.--The drained fruit was cut into small pieces, mixed thoroughly in an enamel pan to obtain a homogeneous mixture. The mixed fruit pieces and syrup were served in 1 ounce clear plastic cups. The cups were coded using a two-digit number from a random number table. The sample cups were randomly placed on a paper plate. This plate along with a ballot, a pencil, a cup of water, a spoon, and a napkin were served to each panel member. The panel members were not given specific instructions on whether or not to swallow the samples, what order to taste them, whether or not to rinse between tastes, or the time between tastes (Dove, 1947), (Laue et al., 1954), (Tompkins and Pratt, 1959). Panelists encountering trouble in distinguishing between samples were told to concentrate on tasting the syrup more than the fruit. The panelists were told that the samples were edible.

Ranking method and sample serving procedures

Samples from the 1968 and 1969 packs were analyzed similarly using the ranking method to differentiate between samples. In each test, each judge was presented with 5 or 6 coded samples in labelled cups. The judge was asked to rank all the samples according to his personal preference

by writing the codes for the samples in descending order on the ranking sheet (Table 16).

Whether the test would consist of 5 or 6 samples was determined by which standard or standards was compared with a series of sample blends. In each case, a set of four sample blends were used since each of the three series consisted of four blend samples. In one instance, the SS standard was compared with a blend series, making 5 total samples. Another set of tests compared the same blend series with the S1 and S2 standards, making 6 total samples. A replicate was run in each case, except for the 1969 strawberry pack.

Since the 1970 packs were packed for consumer panel evaluation, only four syrups were used. They were SS, 03, A3, and S1. The frozen peaches were presented to panels of 20 persons in duplicate. The canned peaches and pears and the frozen strawberries were subjected to evaluation by a panel of 50 individuals. It was important that judges had not participated in previous taste panels of this study.

Objective measurement

Drained weights, soluble solids of syrup, pH, and total acidity were determined for all canned fruits and the Brix-acid ratio calculated. In addition, color was determined for the cherries. Frozen peaches and

strawberries were analyzed only for soluble solids, pH, and total acidity of the drained juice and of the blended contents of each package.

Drained weight was determined according to the U.S. Standards for Grades (The Almanac, 1970). The soluble solids content of the drained juice was determined with an Abbe refractometer; pH and total acidity were determined using a Beckman glass electrode pH meter. For total acidity, 5 or 10 ml aliquots of juice in 50 ml distilled water were titrated to pH 8.0 with 0.1N NaOH. Color determinations on the cherry juice were made as described by Bedford and Robertson (1962). Twenty-five ml of juice were added to 25 ml of 0.5% oxalic acid mixed, let stand for 10-15 minutes, then filtered through Whatman No. 5 filter paper into an Erlenmeyer flask. The first 5 ml were discarded, 10 ml of the clear filtered syrup was pipetted into a 50 ml Volumetric flask, 9 ml of pH 3.4 citrate buffer was added, and made to volume with distilled water. The transmittance of the resulting solution was read at 515 nm on a spectrophotometer (Bausch and Lomb Spectronic-20). Transmittance readings were converted to absorbance values by using an appropriate conversion table.

Statistical analysis

The paired comparison test data were analyzed for significance by using the X^2 distribution and appropriately computed table by Kramer and Twigg (1966).

The taste panel data from the ranking of the pack samples were analyzed in more than one way. The rank sum method (Kramer, 1960, 1963) was applied as a test for significant differences between samples for the 1968 pack of pears. All ensuing data were analyzed by the data transformation for analysis of variance method, using the coefficient of concordance W, with modification for using the X^2 distribution to determine significance, (Friedman, 1937), (Kendall, 1948), (Reimer, 1957) and the normal score transformation method for analysis of variance. Both methods were applied to data from the sum of two replicates, and the latter to each separate panel. The multiple range test (Duncan, 1955) was applied where X^2 and F tests showed significance.

RESULTS AND DISCUSSION

Taste Panel Data

Syrup blends

Corn sugars and syrups are generally less sweet than sucrose, and since sweetness is an important factor in acceptability of canned and frozen fruit (Leonard et al., 1953), (Joslyn, 1957), (Pangborn and Leonard, 1958), syrup blends of sweetness comparable to sucrose were sought. Results of paired comparison tests of formulations 1-10 with sucrose showed syrup blends 3, 4, 5, and 6 to be significantly sweeter than sucrose. These four blends were selected for use in fruit processing (Table 3).

Table 3. Relationship between sweetness of each syrup blend and sucrose.

Syrup Blend	No. Panelists	No. Sweeter than Sucrose
1	15	8
2	15	8
3	15	12*
4	20	16**
5	20	15*
6	20	12
7	16	12
8	16	12
9	19	12
10	19	12

*significant at 5% level
**significant at 1% level

Strawberries

1969 pack

In the testing of the Series I blends with the SS (straight sucrose) as the standard, the SS sample was preferred, but was not significantly ranked over the 03 and 04 blends. Syrup blends 06 and 05 received the lowest total rank scores (Table 4).

In the Series II blends with SS, no significant difference between samples was obtained. Blend A3 had the lowest rank score. Comparison of the S1 and S2 blends with Series II blends showed no significant preference (Table 4).

No significant differences in flavor were found between 23, 25, 24, and 22 blends of Series III while blends 21 and 20 received the lowest scores (Table 4) and, therefore, were not used in further acceptance testing. Blends 22-25 showed no significant differences in preference when compared with the SS standard. The 22-25 blends were ranked slightly higher than the S1 and S2 blends.

1970 pack

A consumer acceptance type panel did not significantly differentiate between A3, 03, and SS syrup blend packs although A3 had the highest rank score. The S1 syrup blend was considered the poorest (Table 4).

Table 4. Consumer acceptance of frozen strawberries (STB, STC) in various syrups, 1969, 1970.

Code	Weighted rank	*	Code	Weighted rank	NS	Code	Weighted rank	NS
				1969				
SS	206		SS	95		A5	118	
04	193		A5	95		S1	112	
03	184		A4	94		A6	108	
06	160		A6	91		A3	104	
05	157		A3	75		S2	98	
						A4	90	
No panelists		60			30			30
x^2		11.95			3.89			4.68
		1969					1970	**
23	244		23	223		A3	149	
25	224		24	223		03	131	
24	213		25	218		SS	119	
22	206		22	207		S1	101	
21	196		S2	203				
20	177		S1	186				
No panelists		60			60			50
x^2		12.90			5.10			14.69

NS values not significantly different

*significance at 5% level; **significance at 1% level; Duncan's Multiple Range Test.

From these data it would seem that syrup blends A3, 03, and 04 could be used in place of straight sucrose syrup for packing of strawberries for freezing.

Cherries

No significant differences in preference were found within either Series I or Series II blends. Comparison of Series III blends with the SS standard also showed no significant differences. In testing of Series III blends with syrup blends S1 and S2, blends 22, S1, 24, and S2 were preferred over 23 and 25. For the entire pack, 03 and SS samples were preferred and 23 and A5 scored low (Table 5).

Peaches

1969 Halehaven

Comparison of Series I blends with the SS standard showed SS samples to be preferred but not significantly preferred over syrup blends 03 and 05. Comparison of Series I blends with the S1 and S2 blends showed 03, 06, and 05 to be preferred but not significantly different from 04 and S2. Blend S1 received the lowest total rank score (Table 6).

No significance was found when Series II blends were compared with the SS standard, although SS and blend A3 had the highest scores. When compared with S1 and S2 blends, A3 received the highest score but did not

significantly differ from A4, A5 and S1. Blends S2 and A6 received the lowest scores. (Table 6).

Table 5. Consumer acceptance of canned sweet cherries (CA) in various syrups, 1969.

40 Panelists								
Code	Weighted rank	NS	Code	Weighted rank	NS	Code	Weighted rank	NS
03	138		SS	130		SS	131	
06	124		A3	124		25	125	
05	120		A6	121		22	118	
SS	110		A4	113		24	117	
04	108		A5	112		23	107	
X^2		5.84			2.30			3.28
03	159		A4	160		22	168	
S2	144		S1	150		S1	153	
06	141		A6	150		24	147	
04	136		S2	131		S2	128	
05	133		A3	129		25	123	
S1	127		A5	120		23	121	
X^2		4.38			10.58			12.82*

NS values not significantly different

*Significance at 5% level; Duncan's Multiple Range Test.

No significant differences were found when Series III blends and the SS standard were compared. Blends 25, SS, and 24 were ranked higher than blends 22 and 23. In testing of Series III blends with the S1 and S2 standards, blends 25 and 24 were significantly preferred and blend S1 received the lowest score (Table 6).

Table 6. Consumer acceptance of canned Halehaven peaches (PA) in various syrups, 1969.

40 panelists								
Code	Weighted rank	NS	Code	Weighted rank	NS	Code	Weighted rank	NS
SS	147		SS	139		25	125	
03	130		A3	132		SS	124	
05	116		A4	116		24	123	
06	104		A5	108		22	114	
04	103		A6	105		23	114	
x^2		13.90			8.90			1.02
03	158		A3	162		25	189	
06	157		A4	149		24	166	
05	155		A5	147		23	144	
04	141		S1	146		S2	123	
S2	128		S2	120		22	120	
S1	101		A6	116		S1	98	
x^2		17.88**			11.62*			39.60**

NS values not significantly different

*significance at 5% level; ** significance at 1% level; Duncan's Multiple Range Test.

These data show blends 03, A3, and 25 to be preferred syrup blends in the canning of Halehaven peaches and of comparable flavor acceptance to a 100% sucrose pack. Blends S1 and A6 received low scores.

Evaluation of canned samples showed blend 03 to be significantly preferred over blends S1 and A3 but not significantly different from the SS standard. Blends 03 and A3 were preferred in separate testing in 1969, however, in 1970, it was shown that 03 was preferred over A3, and

was considered to be of comparable flavor acceptance to a 100% sucrose pack (Table 7).

No significant differences were found between frozen samples (Table 7).

Table 7. Consumer acceptance of Halehaven peaches (PH) canned and frozen in various syrups, 1970.

Canned			Frozen		
Code	Weighted rank	*	Code	Weighted rank	NS
03	145		SS	110	
SS	133		03	100	
S1	112		S1	100	
A3	110		A3	90	
No panelists	50			40	
X^2	8.19			3.00	

NS values not significantly different

*significance at 5% level; Duncan's Multiple Range Test.

1969 Elberta

In the comparison of Series I blends with the SS standard blend 04 received the highest score and blend 05 the lowest score. Comparison with the S1 and S2 standards showed syrup blends 05 and 04 to be significantly preferred. Blend S2 received the lowest score (Table 8).

Table 8. Consumer acceptance of canned Elberta peaches (PE) in various syrups, 1969.

40 panelists								
Code	Weighted rank	NS	Code	Weighted rank	NS	Code	Weighted rank	NS
04	131		A3	133		24	139	
03	124		A6	125		23	120	
SS	120		SS	121		SS	116	
06	114		A4	114		25	113	
05	111		A5	107		22	112	
X^2	2.82			4.00			4.90	
05	169	|	A4	158		22	164	|
04	167	|	A6	158		24	161	|
03	143	| |	A3	148		25	155	| |
S1	130	| |	S2	132		S2	124	| |
06	121	| |	S1	126		S1	122	| |
S2	110	|	A5	118		23	114	|
X^2	21.00**			10.40			17.84**	

NS values not significantly different

**significance at 1% level; Duncan's Multiple Range Test.

No significant preference was found when Series II blends were compared with the SS or the S1 and S2 standards, however, blend A5 received the lowest score in both tests (Table 8).

Blend 24 received the highest score and blend 22 was the least preferred when Series III was compared with the SS standard. Testing with blends S1 and S2, blends 22 and 24 were significantly preferred and blend 23 was least preferred (Table 8).

Blends 04 and 24 could, therefore, be considered desirable syrups for the canning of Elberta peaches. Blend A5 is not recommended.

Pears

1968 pack

Pears packed in SS (straight sucrose) were found to be significantly preferred over the Series I blends. No significant differences were obtained when the Series I blends were compared with the S1 standard. Series I blends (06, 03, 04) were found to be significantly preferred over the S2 standard blend (Table 9).

No significant X^2 values were obtained in tests with the 1969 or 1970 packs. The 100% sucrose samples were preferred in the 1969 pack but not in the 1970 pack (Table 10).

Table 9. Consumer acceptance of canned pears (PD) in various syrups, 1968.

40 panelists								
Code	Weighted rank	*	Code	Weighted rank	NS	Code	Weighted rank	*
SS	150		04	130		06	135	
03	122		05	123		03	133	
04	121		06	120		04	127	
05	111		03	114		05	113	
06	106		S1	113		S2	92	
X^2	11.62			2.14			11.36	

NS values not significantly different

*significance at 5% level; Duncan's Multiple Range Test

Table 10. Consumer acceptance of canned pears (PF, PK) in various syrups, 1969, 1970.

Code	Weighted rank	NS	Code	Weighted rank	NS	Code	Weighted rank	NS
				1969				
SS	133		SS	126		SS	137	
05	133		A6	124		24	129	
06	116		A4	119		25	123	
03	112		A3	117		23	117	
04	106		A5	114		22	104	
No panelists	40			40			40	
x^2	6.14			0.98			6.44	
03	151		A4	155		23	151	
S2	151		A3	146		24	150	
06	142		S1	142		S1	149	
05	140		A5	136		S2	145	
04	134		S2	131		25	133	
S1	122		A6	130		22	112	
No panelists	40			40			40	
x^2	4.43			3.30			8.28	
				1970				
03	131							
A3	131							
S1	125							
SS	113							
No panelists	50							
x^2	2.60							

NS values not significantly different

Objective Measurements

Syrup blends

The mean soluble solids content of all the syrup blends were 40.1 and 25.1 B respectively, while those of 100% sucrose and of the other two standards (S1 and S2) were 40.1 and 25.0 B respectively, at the time of taste evaluation.

Fruits

The different syrup blends had no effect on the drained weight, pH, total acidity, soluble solids content or Brix-acid ratio of canned Schmidt sweet cherries, Halehaven and Elberta freestone peaches and Bartlett pears (Tables 11-18).

Frozen Midway strawberry and Halehaven freestone peach packs did not equilibrate, therefore, soluble solids content, total acidity and Brix-acid measurements of the drained juice were variable, although the pH values were relatively constant (Tables 19, 20).

The pH, total acidity, soluble solids and Brix-acid ratio of the blended composite of each treatment were not significantly different. The panel members were served a representative mixture of diced fruit and syrup, therefore, it is unlikely that judgments were influenced

by the lack of uniformity in the acidity and soluble solids determined on the drained juice.

Since the objective measurements for sweetness and acidity were not significantly different, the flavor differences found were based on the degree of sweetness and/or tartness of each treatment and the flavor effect of the individual sugars.

The Brix-acid ratios of the canned Elberta peaches as well as those of the canned pears were within the range reported by Pangborn et al. (1959) and Pangborn and Leonard (1958) for optimum acceptability.

Table 11. Objective measurements of canned sweet cherries (CA) in various syrups, 1969.

Code	Total weight oz.	Vacuum in.	Drained weight oz.	Soluble solids %	pH	Total acidity %	Brix-acid ratio	Color absorbance
SS	20.1	9.1	11.0	24.2	3.62	.925	26.2	1.341
S1	20.3	9.4	10.8	24.7	3.47	.944	26.2	1.298
S2	20.3	9.7	10.8	24.5	3.50	.945	25.9	1.318
03	19.9	9.5	10.8	24.3	3.49	.967	25.1	1.352
04	20.0	9.3	10.8	24.0	3.46	.969	24.8	1.354
05	19.9	9.8	10.8	24.4	3.48	.976	25.0	1.382
06	20.1	9.8	10.8	24.4	3.48	.960	25.4	1.362
22	20.2	9.4	10.8	25.5	3.60	.910	26.5	1.324
23	20.2	9.8	10.7	25.1	3.60	.907	27.5	1.310
24	20.2	9.5	10.8	24.9	3.60	.913	26.3	1.289
25	20.2	8.8	10.7	26.0	3.60	.908	27.1	1.317
A3	20.3	10.3	10.7	25.0	3.60	.964	27.5	1.288
A4	20.3	9.9	10.8	25.0	3.61	.913	27.6	1.280
A5	20.2	9.9	10.7	25.1	3.61	.946	27.5	1.315
A6	20.2	9.9	10.8	23.9	3.63	.958	26.3	1.280
Mean	20.1	9.7	10.8	24.8	3.56	.940	26.3	1.321

Table 12. Objective measurements of canned Halehaven peaches (PA) in various syrups, 1969.

Code	Total weight oz.	Vacuum in.	Drained weight oz.	Soluble solids %	pH	Total acidity %	Brix-acid ratio
SS	20.6	5.1	11.6	21.6	3.78	.507	42.6
S1	20.5	5.6	11.9	21.1	3.81	.528	40.0
S2	20.5	5.8	11.9	20.6	3.79	.510	40.4
03	20.4	4.7	12.0	21.7	3.78	.518	41.9
04	20.7	5.3	11.9	21.7	3.78	.518	41.9
05	20.5	4.3	11.8	22.1	3.70	.479	46.1
06	20.6	4.3	12.0	22.2	3.75	.510	43.5
22	20.5	4.1	11.8	20.6	3.81	.501	41.1
23	20.5	4.0	11.9	20.9	3.80	.497	42.2
24	20.5	4.4	11.8	21.1	3.84	.502	42.0
25	20.6	4.4	12.0	21.3	3.80	.513	41.5
A3	20.6	4.9	12.0	21.0	3.85	.480	43.8
A4	20.5	4.1	12.2	20.4	3.79	.547	37.3
A5	20.5	4.6	11.8	21.1	3.80	.524	40.3
A6	20.6	4.9	12.0	21.1	3.78	.529	39.9
Mean	20.5	4.6	11.9	21.1	3.80	.509	41.5

Table 13. Objective measurements of canned Halehaven peaches (PH) in various syrups, 1970.

Code	Total weight oz.	Vacuum in.	Drained weight oz.	Soluble solids %	pH	Total acidity %	Brix-acid ratio
SS	20.2	3.0	11.1	20.6	3.97	.359	57.4
03	20.3	2.5	10.9	20.6	3.98	.366	56.3
A3	20.1	1.2	10.6	20.2	4.00	.339	59.6
S1	20.0	2.5	10.9	20.5	4.03	.328	62.5
Mean	20.2	2.3	10.9	20.5	4.00	.348	57.2

Table 14. Objective measurements of canned Elberta peaches (PE) in various syrups, 1969.

Code	Total weight oz.	Vacuum in.	Drained weight oz.	Soluble solids %	pH	Total acidity %	Brix-acid ratio
SS	20.4	7.5	11.3	20.4	3.74	.317	64.4
S1	20.5	7.0	11.3	20.6	3.72	.311	66.2
S2	20.6	6.3	11.4	20.4	3.71	.317	64.4
03	20.2	9.3	11.2	20.2	3.67	.326	62.0
04	20.5	8.4	11.1	20.2	3.73	.312	64.7
05	20.5	9.0	11.3	20.4	3.73	.325	62.8
06	20.7	8.1	11.1	20.9	3.75	.311	67.2
22	20.4	6.9	11.1	20.2	3.74	.307	65.8
23	20.6	6.6	11.1	20.8	3.75	.308	67.5
24	20.4	7.8	11.1	20.4	3.74	.315	64.8
25	20.4	6.4	11.3	20.1	3.76	.329	61.1
A3	20.5	7.0	11.3	20.2	3.77	.325	62.2
A4	20.4	7.4	11.4	20.1	3.77	.349	57.6
A5	20.5	7.0	11.4	20.3	3.88	.296	68.6
A6	20.3	7.8	11.0	20.6	3.85	.299	68.6
Mean	20.5	7.5	11.2	20.4	3.75	.316	64.6

Table 15. Objective measurements of canned pears (PD) in various syrups, 1968.

Code	Soluble solids %	pH
SS	18.3	3.85
S1	18.6	3.85
S2	17.6	3.90
03	18.5	3.93
04	17.9	3.87
05	18.2	3.88
06	18.1	3.92
Mean	18.2	3.89

Table 16. Objective measurements of canned pears (PF), (PK) in various syrups, 1969, 1970.

Code	Total weight oz.	Vacuum in.	Drained weight oz.	Soluble solids %	pH	Total acidity %	Brix-acid ratio
SS	20.5	10.0	11.7	21.0	3.71	.194	108.2
S1	20.5	10.3	11.6	20.9	3.67	.188	111.2
S2	20.4	11.2	11.8	21.3	3.71	.207	102.9
03	20.3	9.9	11.5	20.7	3.79	.212	97.6
04	20.4	11.0	11.6	20.5	3.79	.208	98.6
05	20.5	10.4	11.6	21.1	3.80	.214	98.6
06	20.5	9.5	11.5	20.8	3.78	.224	92.9
22	20.5	10.6	11.3	21.0	3.61	.236	89.0
23	20.4	10.6	11.5	21.2	3.72	.210	101.0
24	20.5	11.4	11.3	21.3	3.73	.196	108.7
25	20.6	10.9	11.3	21.2	3.73	.200	106.0
A3	20.4	10.0	11.5	20.8	3.75	.214	97.2
A4	20.5	11.0	11.4	21.2	3.74	.201	105.5
A5	20.4	10.4	11.7	21.2	3.78	.217	97.7
A6	20.5	10.3	11.6	21.0	3.80	.196	107.1
Mean	20.5	10.4	11.5	21.0	3.74	.208	101.4
			1970				
SS	20.6	7.3	10.9	23.1	3.90	.169	139.8
03	20.4	10.5	10.8	23.1	3.90	.165	140.9
A3	20.4	6.5	10.5	23.2	3.93	.180	130.1
S1	20.4	8.8	10.8	23.5	3.85	.184	122.8
Mean	20.4	8.3	10.8	23.2	3.90	.175	133.6

Table 17. Objective measurements of frozen strawberries (STB), (STC), in various syrups--drained juice, 1969, 1970.

Code	Soluble solids %	pH	Total acidity %	Brix-acid ratio
		1969		
SS	53.0	4.00	.402	82.1
S1	31.4	3.95	.432	72.8
S2	28.8	3.93	.445	64.7
03	31.9	3.98	.432	76.5
04	31.2	3.98	.422	73.9
05	30.3	3.93	.473	64.0
06	32.2	3.93	.454	70.9
22	31.5	3.90	.409	76.9
23	30.0	3.93	.448	67.0
24	29.7	3.90	.467	63.6
25	31.0	3.93	.432	71.8
Mean	31.2	3.93	.437	71.3
		1970		
SS	35.3	3.53	.493	72.5
03	34.4	3.53	.543	63.9
A3	34.6	3.56	.495	74.6
S1	37.7	3.55	.459	82.4
Mean	35.5	3.54	.497	73.6

Table 18. Objective measurements of frozen strawberries (STB), (STC), in various syrups--blended, 1969, 1970.

Code	Soluble solids %	pH	Total acidity %	Brix-acid ratio
		1969		
SS	22.1	3.45	.498	44.4
S1	21.4	3.45	.523	40.9
S2	21.6	3.50	.487	44.4
Mean	21.7	3.47	.503	43.2
A3	21.2	3.55	.533	39.7
A4	20.6	3.50	.498	41.3
A5	21.7	3.55	.490	44.3
A6	21.6	3.50	.504	42.9
Mean	21.3	3.53	.506	42.1
		1970		
SS	22.5	3.37	.610	36.8
03	24.0	3.40	.576	41.7
A3	26.6	3.40	.537	49.5
S1	24.1	3.37	.590	40.8
Mean	24.3	3.39	.578	42.0

Table 19. Objective measurements of frozen Halehaven peaches (PH) in various syrups, 1970--drained juice.

Code	Soluble solids %	pH	Total acidity %	Brix-acid ratio
SS	25.4	4.05	.277	89.5
03	25.9	4.00	.273	93.0
A3	25.0	4.10	.269	91.0
S1	25.8	4.00	.269	95.9
Mean	25.5	4.04	.272	92.4

Table 20. Objective measurements of frozen Halehaven peaches (PH) in various syrups, 1970--blended.

Code	Soluble solids %	pH	Total acidity %	Brix-acid ratio
SS	20.5	3.85	.334	61.4
03	20.6	3.85	.380	54.2
A3	20.4	3.90	.328	62.7
S1	20.9	3.85	.348	60.1
Mean	20.6	3.86	.348	58.0

SUMMARY AND CONCLUSIONS

Syrup blends 03 (75% sucrose, 10% levulose, 10% #1631 and 5% maltose) and A3 (67% sucrose, 13% levulose, 13% #1631 and 5% maltose) were found to be the most preferred blends in 1968-1969 fruit processing. Corn syrup #1631 consists of 39% dextrose, 32% maltose and 29% higher saccharides. Therefore, in packing of 1970 fruit for consumer type taste panel evaluation blends 03 and A3 were used, along with SS (straight sucrose) and the S1 (75% sucrose and 25% #1631) blend for comparison.

Preference testing showed A3 to be the preferred blend for the freezing of Midway strawberries. Blends 03 and A3 were equally well preferred in canned Elberta freestone peaches. Blend 03 was selected as the best for canned Halehaven freestone peaches, A3 scoring low. All other packs--canned Bartlett pears, canned Schmidt sweet cherries and frozen Halehaven freestone peaches--showed little or no significant differences between samples. Therefore, the A3 (higher replacement) blend could be used with expected success in all but canned Halehaven freestone peaches, where the 03 (lower replacement) would have to be used.

The soluble solids content, pH and total acidity measurements for each sample were consistant with the entire pack for the most part, thus, differences in taste can be attributed to the different sugars used in a "homogeneous" fruit pack. No differences in color or testure were observed within any fruit pack, other than that due to normal variation in the raw fruit. Finally, results of this study indicate that the #3 formula (sucrose + levulose, #1631, maltose, X:2:2:1 respectively) of corn sugars and syrups could be used to replace up to 33% of sucrose without any loss in quality.

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APPENDIX

Sample Score Sheet

SCORE SHEET

Ranking Method of Flavor Evaluation

Judge_____ Date_____

Rank the samples in the order of how well you like them, giving the best sample or the one you like best a rank of 1 and rank the others below. You may use your own judgment whether to swallow or not to swallow the product, and the time to wait between samples.

Ranking

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

Table 21. Taste panel data evaluation procedure using data transformation for analysis of variance using the statistic W.

1969 Halehaven Peaches

Series I and SS standard (40 panelists)

No. times ranked	Samples (K)					No. times ranked	Samples (K)				
	SS	03	04	05	06		SS	03	04	05	06
First	14	8	5	8	5	First x5	70	40	25	40	25
Second	9	11	7	6	7	Second x4	36	44	28	24	28
Third	10	10	5	7	8	Third x3	30	30	15	21	24
Fourth	4	5	12	12	7	Fourth x2	8	10	24	24	14
Fifth	3	6	11	7	13	Fifth x1	3	6	11	7	13
Total (n)	40	40	40	40	40	Totals (x)	147	130	103	116	104
						Mean total $\bar{x}$ = 120					
						Deviations from mean $(x-\bar{x})$:	27	10	-17	-4	-16

$$W = \frac{12S(x-\bar{x})^2}{n^2(K^3-K)} = \frac{12(729+100+289+16+256)}{(1600)(125-5)} = .0869$$

$$X^2 = (n)(K-1)(W) = (40)(4)(.0869) = 13.90^{**}$$

Tabular X^2 for (K-1), 4d.f. 5% = 9.49
1% = 13.28

**significance at 1% level

Table 22. Taste panel data evaluation procedure using normal score transformation and multiple range test.

1969 Halehaven Peaches

Series I and SS standard (40 panelists)

Code	Weighted total	Transformation Total	Transformation Mean
PASS	147	15.26	.38
PA03	130	5.82	.15
PA05	116	-1.84	-.05
PA06	104	-9.38	-.23
PA04	103	-9.46	-.24

		Degrees Freedom	Mean Square	F
Total sums of squares	132.80	160		
Sample sums of squares	11.19	4	2.80	3.59**
Error sums of squares	121.61	156	.780	

Tabular F $\frac{4 \text{ d.f.}}{156 \text{ d.f.}}$ 5% = 2.45 1% = 3.48

$$S_{\bar{x}} = \sqrt{ms/n} = \sqrt{.780/40} = .140$$

$(S_{\bar{x}})(Q)=R_p$ ex: for SS vs. 05 P=3; for 03 vs. 04 P=4. R_p is minimum difference for significance.

For 1% significance (level of F value)

	P=2	P=3	P=4	P=5
Q	3.70	3.86	3.96	4.04
R_p	.52	.54	.55	.56

Significant Difference

SS
03
05
06
04

*significance at 1% level

Table 23. Composition of formula #3 blends

Corn Sugar Ratio

Sucrose + levulose + 1631 + maltose

	X	+	2	:	2	:	1
03	15.0		2		2		1
A3	9.5		2		2		1

#1631 corn syrup composition

39% dextrose, 32% maltose, 29% higher saccharides

25% replacement level

Blend 03		
75% sucrose		75% sucrose
10% levulose	OR	10% levulose
10% 1631		9% maltose
5% maltose		3% dextrose
		3% higher saccharides

33% replacement level

A3		
67% sucrose		67% sucrose
13% levulose		13% levulose
13% 1631		12% maltose
7% maltose		4% dextrose
		4% higher saccharides