A STUDY OF THE EFFECTS OF FUNGICIDES AND HARVEST MATURITY ON THE QUALITY OF FRESH AND PROCESSED MONTMORENCY CHERRIES

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THESIS

A STUDY OF THE EFFECTS OF FUNGICIDES AND HARVEST MATURITY ON THE QUALITY OF FRESH AND PROCESSED MONTMORENCY CHERRIES

By

Sheldon Robert Sabath

AN ABSTRACT

Submitted to the College of Agriculture
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A study was conducted during the 1956 season to investigate the effect of harvest maturity and spray materials on the quality of fresh, canned, and frozen Montmorency cherries.

Representative rows of at least eight trees each received different spray treatments; those treatments being Copper, Ferbam, Captan, Crag G, Crag GS, Crag PP, Vancide, and Thylate. Standard procedures were followed in applying the fungicides. The cherries were harvested at weekly intervals with the first harvest being on July 16 and the final harvest on August 20. The fruit was harvested at random in a manner as to keep bruising to a minimum and to obtain representative samples.

From each treatment 25 pound lots were weighed, placed in mesh bags, and cooled in a tank of refrigerated tap water 42°F. for four hours. The cherries were removed, drained, and sorted to remove the cull and light colored fruit. The sound fruit was pitted and filled into No. 2 cherry enamel cans. Six cans of each treatment were packed with sixteen ounces of fruit. For canning the fruit was covered with hot water, exhausted, closed, processed for twelve minutes in boiling water, cooled in running tap water, and stored at 55°F. The cherries being frozen were packed the same as for canning except that they had five ounces of cold 65% sirup added. The frozen pack was then closed, frozen at -10°F., and stored at $0^{\circ}F$. Both the canned and frozen packs were stored for three to four months.

The results of the examination of the fresh and processed fruit showed the pronounced effect that harvest maturity has upon the quality of the cherries. However, this effect did not show up uniformly on the canned and frozen fruit. Tissue disintegration, discoloration, and loss of texture which occurred in the latter harvests were much more easily detected in the frozen pack. Thermal processing tended to disguise these deficiencies. The quality of the fruit in the last two harvests was sufficiently poor to recommend their unsuitability for commercial use.

Deterioration in quality was indicated by the increases in amount of cull fruit, per cent juice loss, pH, and pitter loss. The drained weight, although showing definite trends, did not shift in the same way for both the canned and frozen packs. The canned cherries had an increase in drained weight, while in the frozen cherries the drained weight decreased.

Although differences were obtained for one or more quality factors, no definite conclusion could be drawn with respect to the selection of any one fungicide. None of the fungicides had any obvious detrimental effects on the processing quality of the cherries.

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INTRODUCTION

The production problems of the food industry, regardless of the type of product being processed, are basically concerned with obtaining a product that will be highly acceptable to the consumer. Unlike many other industries the final product, being a food, is only as good as the initial raw material used.

Processing of the red pitted cherry is an extremely important industry in Michigan. Production has been steadily increasing over the years from about thirty thousand tons in the early 1930's to sixty thousand tons in the late 1940's (5). According to the United States Department of Agriculture Sour Cherry Report for 1956 (55), Michigan has greatly surpassed the tonnage of the 1930's and 1940's reaching a high production tonnage of over seventy thousand tons. This means an annual crop valued in excess of fifteen million dollars (33). Michigan's red cherry industry is approaching the point where it can be said that it produces more than one half of the red cherries grown and processed in the United States (5, 40, 55).

Marshall (40) reported that although red cherries are still canned in greater proportion to those being frozen, the industry on the whole is shifting so that a larger percentage is being frozen each year. This trend does not necessarily mean that the canning industry is going to continue to decrease, but rather that the increased market for frozen cherries is causing a general increase in the total crop. Both canning and freezing will each have their own important share of the market with neither replacing the other entirely.

The optimum maturity for Montmorency cherries is always a difficult one to determine. Upshall and van Haarlem (64) define this optimum maturity as the latest a cherry can be wisely left on the tree and still retain good color and processing quality. Some growers impatient to reach the market with their crop will start picking as soon as the outside cherries show a red tinge (50). Immature fruit, such as these early pickings tend to produce, are frequently tough and of poor processing quality and give an undesirable processed product (62).

Numerous factors influence the physiology of the ripening and maturing process. According to Whittenberger (68), these factors are water, light, humidity, mineral nutrients, soil texture, and spray materials. Most of these constituents cannot be completely supervised by the grower. However, in the case of spray materials, the grower does have complete control in selecting which fungicidal agent is the most appropriate.

Of prime concern in selecting a fungicide is whether it will control *Coccomyces hiemalis* H., cherry leaf spot. Leaf spot is the major disease responsible for a large number of tree deaths, severe tree injury, low yields, and low fruit quality (41). It is not the only problem, however, for although the fungicide may control leaf spot it might not control certain other important diseases, nor be compatible with many of the basic insecticides used on Montmorency cherry trees. The quality of the fruit can also be impaired (36).

A given spray material does not usually act as an independent factor, but rather acts in combination with other important factors in affecting growth and solids content. The magnitude of this effect will depend on seasonal conditions, tree vigor, and time of harvest as observed by Mitchell and Moore (48).

The objective of this study is to determine the effect of the maturity and of the newer type fungicides on the quality of the canned and frozen Montmorency cherries.

REVIEW OF LITERATURE

The introduction of fungicides to control diseases evolved in the late nineteenth century more as an accident than as of any direct scientific research. The grape industry of France was losing a large amount of grapes each year off the vines through pilfering. To discourage this, the farmers made up a lime and copper sulfate mixture and applied it to the grapes. Not only did this prevent any further stealing, but it was noticed that mildew growth was greatly reduced. This mixture, called Bordeaux, was named for the locale in France where it was first applied (13).

Lime-sulfur sprays were introduced in the early nineteen hundreds, and that, along with fixed Copper and the Bordeaux mixture remained the only fungicides in common use until the development of Ferbam in 1939. Soon thereafter many other new organic fungicides were found. To understand the need for these newer types, some explanation is necessary as to the defects of Bordeaux and lime-sulfur sprays.

Dutton and Wells (14) were the first to report that Bordeaux mixture caused a dwarfing effect on sour cherry fruit. They observed that Bordeaux caused an increase in the rate of transpiration, thus causing the reduction in size.

These results were also described by Winter et al. (69), Rasmussen (53), and a number of other researchers (7, 29, 36, 41). Not only was this significant reduction in size noted, but Rasmussen also found that Bordeaux sprayed cherries were darker in color and had higher total solids content than those receiving a lime-sulfur treatment. Winter and Young (69) experimenting along the same lines as Rasmussen, observed that the decrease in fruit size as seen on Bordeaux sprayed trees was related to an increase in solids concentration. Rahn and Heuberger (52) obtained similar results testing cantaloupes as to changes in percent soluble solids.

Lime-sulfur sprays eliminated the problem of size reduction, but were not extensively used since they caused two types of undesirable foliage injury. One was a rapid yellowing with subsequent heavy defoliation several days after application; and the other, dead areas appearing in the leaves which later fell out (41). For these reasons it was evident that other fungicides were needed.

Langer and Fisher (31) reported that cherries obtained from trees sprayed with Ferbam were larger, lighter colored, and of lower soluble solids content than those obtained from trees sprayed with proprietary Copper. The results obtained by Groves, Miller, and Taylor (18), however, were less conclusive when these spray materials were compared in similar tests.

Data obtained by Bedford and Robertson (2, 4) showed no significant differences between the effect of the spray materials Ferbam and Copper. These results are not in agreement with those reported by Langer and Fisher (31).

Other findings such as those by McClure (43), and Hills et al. (21), cast some doubt upon the merits of Ferbam sprays. McClure (43) found that in tests run in Michigan after September 1st Ferbam sprayed trees had considerable infection followed by heavy defoliation. Hills et al. (21) showed that Ferbam could produce an off-flavor in canned sour cherries, if present in moderately high concentrations. However, under normal spray practice, it was concluded to have no effect on color, flavor, or storage life of the canned product.

The problems of post-harvest disease control were also examined by McClure (43). He found that of the three fungicides, Ferbam, Captan, and Crag G, Captan gave the best post-harvest control with Crag G a close second. Other results showed that Crag G gave better leaf spot control than fixed Copper, with no significant differences in cherry size as shown by the number of cherries per pound (36, 47).

Mills (45) reported that Crag G gave significantly less culls than Copper on an experimentally controlled cherry plot. He also noted that at the .01 level the Copper sprayed cherries had a significantly higher percent soluble solids than the Crag G sprayed lots. Crag G, in turn, was significantly higher than the Captan sprayed lots.

Marsh, Martin, and Crang (39) described the use of Captan as a control of Botrytis rot on strawberries. They found that moderate Captan residues gave a slight tainting to the processed fruit.

The other two basic fungicides, Vancide and Thylate, have not as yet been tested as to their effects on sour cherries. Vancide 51ZW, a precursor of the Z65 used in this study, has been experimentally used to control tomato damping off, but at effective concentrations it was too toxic to the tomato plant to be of any real value (19). Thylate has been extensively used as a seed protectant on corn, peas, beans, and cereals.

In studying the causal effects of fungicides on fruit quality, the other factors involved are frequently overlooked. These factors, such as tree vigor and soil management practices, will cause definite physiological changes in the fruit. A number of researchers have discussed these other factors (18, 28, 46, 48, 58, 60). An increased vigor in trees may result in a lowering of the soluble solids content of the fruit, and possibly a retardation of fruit development. Differences in tree vigor can offset the advantages in selecting one fungicide instead of another.

Drained weight is an important factor in any discussion of the quality of a processed product. Drained weight has been associated with pectic substances (68), fluid loss through cell leakage (26), and degree of tissue cohesiveness (22, 67).

Whichever may be the reason for variations in drained weight, its association with soluble solids has been extensively investigated. Langer and Fisher (31) have reported a relationship existing between soluble solids and drained weight. Bedford and Robertson (4) reported that there was no significant relationship present between these two factors, and Bedford and Robertson (3) obtained a correlation coefficient between soluble solids and drained weight of nearly zero (+.005). Mills (45) in his studies noted a positive coefficient of 0.500 at the .05 level tending towards agreement with Langer and Fisher.

Variations in drained weight occur between different spray materials. Copper sprayed fruit will in general average higher than those sprayed with Ferbam. According to Bedford (4), these differences are not significant. Many food processors have had the opinion that using different organic fungicides will result in wide deviations in drained weight contradicting the findings of Bedford.

Their opinions, however, do not have any scientific basis (58, 60).

It has been shown that for frozen sour cherries any extensive delay between packing and freezing will result in a decreased drained weight (12).

Soluble solids has been known to significantly increase as the fruit matured (1, 20, 59). Marshall (41) reported that the soluble solids content remains at a low level until the red color begins to develop. Soaking of cherries either for purposes of handling or for preprocessing generally reduces the soluble solids content (3, 33, 42, 51). Taylor and Mitchell (59) also noted that a heavy rainfall will substantially reduce the soluble solids if the fruit is harvested shortly thereafter.

Washing of cherries has been under study since 1936 where it was observed to successfully remove spray residues (24, 54). Peterson (51) ran extensive soak treatment tests in 1938 and showed conclusively the advantages of a soak of four to twelve hours duration. The cherries pitted more easily, and there was considerably less loss due to waste. Juice loss also was cut down during the pitting operation. Other investigators have demonstrated the advantage of using water for handling, i.e. movement of cherries from the orchards to the processing plants (32, 34). By reducing the delay in cooling the fruit after harvesting a better processed product can be obtained.

The stabilization of the red cherry color has been a major problem and has received considerable attention. Culpepper (11) in 1927 was the first to examine the relationship between different sour cherry varieties and their degree of retention of color brilliance in the canned fruit. He also noted that a good exhaust prior to sealing markedly reduced discoloration. In addition, Culpepper examined the anthocyanin pigments in cherries, but did not attempt to relate to any great extent what connection these pigments had to discoloration or color stability.

Miller (44) did not find any association between discoloration and the use of Copper sprays. His findings were performed at various concentrations of copper sulfate.

Joslyn (25) suggests that the discoloration is caused by changes in tint of the pigments as they form stannous salts. This probably would explain the reduction in discoloration when enameled cans are used, since the juice and cherries would not come into contact with the tin plate. Stein and Weckel (56) classified frozen cherry discoloration into two main types with tannins being the important reactant in each case. One is a darkening due to the formation of tannates when iron is present. The other is an enzymatic breakdown of tannin, with these resulting products forming a complex with the heavy metals thus causing the darkening. Another theory suggests that the darkening is due to an oxidation reaction (9, 27). The use of calcium phytate has been tried to reduce the tannate formation by tying up whatever iron is present in maraschino type cherries (8). Discoloration of other fruits has also been examined such as the Caldwell et al. (6) study of frozen peaches.

The relationship between color development and the maturation process has been discussed (63). Gardner (15) showed that color development stops when the fruit is picked. Thompson and Spangler (61) demonstrated the importance of having a mature fruit in frozen cherries because of little color equalization during the freezing of the fruit.

METHODS AND PROCEDURES

Montmorency cherries were obtained from the Department of Horticulture orchards of Michigan State University. The orchard under study consisted of a two acre cherry plot under clean cultivation with sixteen rows of six and eleven year old trees. Representative rows received different spray treatments with each row having at least eight trees. The fungicides used and their respective dilutions applied at each spraying are given in Table 1.

Both lead arsenate and parathion were used with the fungicides. The lead arsenate was used to control the cherry fruit fly, and parathion was for curculio. The first of the three fungicidal treatments was applied at petal fall (June 6). At this time parathion was applied along with each fungicide at a dilution of one pound per one hundred gallons. The Copper spray also had three pounds of lime added.

The next spraying was on July 7 where two pounds of lead arsenate instead of parathion was applied with each of the fungicides. The Crag sprays also included an application of one-half pound of ferric sulfate plus one pound of hydrated lime per one hundred gallons. The fixed

TABLE 1

SPRAY MATERIALS AND THEIR ACTIVE INGREDIENTS

Commercial Name	Amount per 100 gallons of spray	Active Ingredients
Copper (Tennessee 26)	3 lbs.	copper sulfate
Ferbam	$1\frac{1}{2}$ lbs.	ferric dimethyl-dithio-carbamate
Captan	$1\frac{1}{2}$ pts.	N-trichloromethylthio-tetrahydrophthalimide
Crag G (Glyodin)*	$1\frac{1}{2}$ pts.	2-heptadecyl-glyoxalidine
Crag GS*	$1\frac{1}{2}$ pts.	2-heptadecyl-glyoxalidine
Crag PP*	$1\frac{1}{2}$ pts.	2-heptadecyl-glyoxalidine
Vancide (Z65)	$1\frac{1}{2}$ lbs.	zinc salts of dimethyl dithiocarbamic acid and 2-mercapto-benzothiazol
Thylate#	$1\frac{1}{2}$ lbs.	tetramethylthiuram disulfide

* The three forms of Crag or Glyodin all have the same active agent, 2-heptadecyl-glyoxalidine. The differences are in the surface adsorption ingredients. The two new types, Crag PP and Crag GS, as well as the regular Crag G are all manufactured by Union Carbide and Carbon Chemical Corporation.

\# Thylate is Dupont's trade name for Thiram.

Copper treatments received the same three pounds per one hundred gallons of hydrated lime.

The final spraying was applied on July 18 where the same fungicide and insecticide treatments were given as in the first treatment on June 6.

The fruit was picked at weekly intervals with the first harvest being on July 16 and the final harvest on August 20. The cherries were picked without stems and with a minimum of bruising. Cherries were picked at random from all the trees of each treatment to obtain representative samples.

The cherries were immediately transported from the farm to the processing laboratory. On arrival the cherries were weighed into twenty-five pound lots, placed in mesh bags, and put in a two-hundred-gallon soaking tank continually supplied with refrigerated tap water at the rate of approximately twenty-five gallons per hour and an average temperature of 42°F. (6°C.). The cherries were soaked for four hours, then removed, drained, and sorted to remove damaged and light colored cherries which were collected, weighed, and recorded. The sound fruit was pitted in a pilot-scale Dunkley cherry pitter and the resulting loss in weight due to pits and juice was recorded. The pits were collected in stainless steel cylindrical baskets, allowed to drain for ten minutes, and weighed.

The pitted cherries were collected in stainless steel sieves and pans and the fruit allowed to drain five minutes prior to weighing of the juice. The fruit was canned in No. 2 cherry enamel cans. Sixteen ounces of pitted cherries were filled in each can, covered with hot water, exhausted for seven minutes, and closed. The cans were processed for twelve minutes in boiling water, cooled in running tap water, and stored at 55°F. (13°C.). For freezing, sixteen ounces of fruit were packed in No. 2 cherry enamel cans with five ounces of cold 65% sirup, closed, frozen at -10°F. (-23°C.), and stored at 0°F. (-18°C.).

After three to four months, the processed fruit was removed from storage. The canned cherries were allowed to come to room temperature 68°F. to 70°F. (20°-21°C.). The frozen cherries were thawed in a constant temperature water bath, 68°F. (20°C.), until the temperature of the fruit in the center of the can reached that of the water bath (about two and a half hours).

Drained weights and grades were determined as specified by U. S. Standards for Grades of Frozen and Canned Red Sour (Tart) Pitted Cherries (65, 66). Total weight, vacuum, and headspace on the canned product and total weight and headspace on the frozen product were determined.

Representative samples of the pitted cherries were blended in a Waring Blendor for three minutes, removed and filtered through ED No. 619 grey filter paper, 25 cm. size. Soluble solids were determined on the filtered juice with an Abbe refractometer, and pH with a Beckman Model H2 glass electrode meter. The soluble solids and pH of the canned fruit were determined only on the drained liquid. However, for the frozen fruit, the soluble solids were determined on the blended drained fruit, sirup, and the blended mixture of the fruit and sirup. Only on the blended mixture of the frozen fruit and sirup was the pH determined.

Tenderometer values were obtained using 150 gram samples. The readings for the fresh and canned fruit were made on scale 1, and those of the frozen cherries on scale 2.

RESULTS

The results obtained are summarized in Tables 2 and 3. A complete presentation of the data obtained can be found in the appendix tables 4 - 11.

Fresh Cherries

The general increase in cull fruit, and pitter and juice loss from the fruit during pitting tended to be linear as the fruit matured with the larger deviations occuring in the fruit of the later harvests. The amount of cull fruit increased from 1.50 to 3.85 per cent and this increase occurred mainly in the last two harvests (Table 2).

The reduction in yield of pitted fruit was negligible when calculated on the basis of the original harvested fruit for the first four harvests, but decreased markedly the last two harvests. The yield of pitted fruit determined on the basis of the sound fruit showed minor fluctuations during the first four harvests, and then declined noticeably in the last two harvests.

TABLE 2

EFFECT OF TIME OF HARVEST ON FRESH, CANNED, AND FROZEN MONTMORENCY CHERRIES[1]

Harvest Date	July 16	July 23	July 30	August 6	August 13	August 20	F Value	L.S.D. 5%	L.S.D. 1%
Fresh Fruit									
Cull fruit %	1.50	1.77	1.78	1.93	2.66	3.85	20.43**	.55	.73
Light colored fruit %	3.18	1.15	0.55	0.24	0.35	0.39	24.19**	.63	.85
Pit loss %	8.31	8.24	8.54	8.01	8.39	8.53	1.93	-	-
Juice loss %	5.16	6.06	6.78	7.23	8.66	9.47	44.95**	.67	.89
Pitter loss %	2.75	2.79	3.38	3.75	4.37	4.56	11.56**	.63	.85
Yield, harvested fruit %	85.9	84.9	86.1	85.6	84.4	83.4	7.51**	1.06	1.42
Yield, sound fruit %	88.9	88.9	88.8	88.2	87.3	86.9	12.82**	.76	1.02
Cherries per lb. No.	143	136	136	126	127	127	14.93**	5.18	6.91
Tenderometer, lbs/sq in.	36	34	36	34	33	35	6.30**	1.42	1.89
Soluble solids %	15.2	16.1	16.5	16.4	15.6	15.8	4.74**	.60	.80
pH	3.38	3.54	3.69	3.71	3.74	3.85	-	-	-
Canned Fruit									
Drained weight oz.	13.69	13.95	14.07	14.06	14.15	14.34	15.00**	.16	.21
Tenderometer, lbs/sq in.	8	15	19	21	24	23	134.37**	1.40	1.89
Soluble solids %	12.31	12.12	12.57	12.57	12.20	12.13	4.25**	.28	.38
pH	3.46	3.54	3.64	3.73	3.80	3.88	-	-	-
Frozen Fruit									
Drained weight oz.	14.52	14.38	14.43	14.10	14.04	13.94	.58	-	-
Tenderometer, lbs/sq in.	50	43	42	40	38	37	-	-	-
Soluble solids									
Fruit %	23.7	23.2	23.8	23.8	24.3	23.9	2.57*	.60	-
Sirup %	37.3	37.4	37.7	37.3	37.0	35.8	8.45**	.64	.86
Mixture %	28.2	27.9	28.5	28.5	28.8	28.1	3.28*	.50	-
pH	3.40	3.48	3.59	3.66	3.74	3.82	-	-	-

* Significant 5% level. ** Significant 1% level. [1]Mean values of all treatments.

TABLE 3

EFFECT OF SPRAY TREATMENTS ON FRESH, CANNED, AND FROZEN MONTMORENCY CHERRIES

Spray Treatments	Copper	Ferbam	Captan	Vancide	Crag G	Crag GS	Crag PP	Thylate	F Value	L.S.D. 5%	L.S.D. 1%
Fresh Fruit											
Cull fruit %	1.83	1.80	2.18	2.26	1.70	2.86	2.59	2.78	4.13**	.63	.85
Light colored fruit %	0.66	0.80	0.69	0.75	0.86	1.31	1.36	1.38	1.42	-	-
Pit loss %	8.17	8.37	8.22	8.37	8.24	8.40	8.41	8.57	0.56	-	-
Juice loss %	6.62	7.06	6.88	7.67	7.37	7.59	7.79	6.83	2.30*	.78	-
Pitter loss %	3.94	3.31	3.77	3.25	3.53	3.65	3.77	3.60	0.80	-	-
Yield, harvested fruit %	85.8	86.4	85.5	85.3	84.5	84.5	84.0	84.6	3.35**	1.23	1.65
Yield, sound fruit %	87.9	88.4	88.0	87.9	88.6	88.3	88.6	87.8	1.22	-	-
Cherries per lb. No.	139	138	128	129	133	131	127	135	4.93**	6.0	8.0
Tenderometer, lbs/sq in.	34	35	35	34	34	34	35	37	2.70*	1.6	-
Soluble solids %	16.8	16.8	15.8	15.4	15.4	15.9	15.4	15.8	1.33	-	-
pH	3.61	3.64	3.65	3.66	3.65	3.66	3.67	3.68	-	-	-
Canned Fruit											
Drained weight oz.	14.01	13.96	13.90	13.23	13.88	14.31	14.12	14.12	5.00**	.18	.24
Tenderometer, lbs/sq in.	21	21	20	18	19	17	15	16	13.39**	1.63	2.17
Soluble solids %	12.71	12.73	12.41	12.00	11.96	12.48	11.88	12.36	8.37**	.36	.43
pH	3.69	3.68	3.66	3.74	3.67	3.68	3.57	3.71	-	-	-
Frozen Fruit											
Drained weight oz.	14.50	14.21	14.13	14.08	14.15	14.30	14.26	14.26	.12	-	-
Tenderometer, lbs/ sq in.	39	42	44	43	39	29	42	43	-	-	-
Soluble solids											
Fruit %	24.7	24.7	23.4	23.3	23.2	23.8	23.4	23.6	5.65**	.76	1.02
Sirup %	37.2	36.6	37.0	36.4	37.0	37.6	36.3	37.7	3.28**	.76	1.02
Mixture %	29.0	28.6	27.9	28.9	28.0	28.3	27.9	28.2	4.64**	.58	.78
pH	3.57	3.56	3.58	3.62	3.63	3.65	3.58	3.66	-	-	-

* Significant 5% level. ** Significant 1% level.

The increase in pitter loss was not due to any increase in the pit weight itself, since there was no significant change in the pit loss. Hence, the loss must have come from the fruit, either directly as a loss in tissue by disintegration or by juice loss resulting from a decrease in tissue cohesiveness. This is substantiated by the highly significant results obtained for per cent juice loss and pitter loss.

Another change that occurred during the various harvest periods was a gradual increase in the size of the cherries to a maximum point which is followed by a leveling off where the size no longer changes. This was indicated by the reduction in the number of cherries required to make a pound of fruit. An increase in cherry size as the fruit matured was also observed by Hartman and Bullis (20). The leveling off stage occurred during the fourth week of harvest and continued through the sixth week.

Soluble solids of the fruit increased from the first to the third week, remained constant the fourth week, and then decreased the last two weeks. Rain occurred during the fourth harvest and prior to the fifth harvest thus accounting for the decrease. This curve was not quite perfect since the fifth week had a slightly lower value than the last harvest. The highly significant increase between the first and second weeks of harvest should also be noted (Table 2).

There was a decrease in acidity as the harvest season progressed as denoted by a uniform change in pH from 3.38 at the first harvest to 3.85 at the final harvest. The middle three harvests had similar pH values indicating the optimum range of 3.70 for high quality ripe fruit. These findings are not in agreement with those obtained by Peterson (51), who found the pH remaining fairly constant as the fruit ripened.

The tenderometer values did not show any appreciable trend outside of the fact that those from the last three harvests were lower than those from the first three harvests.

The effects of the spray materials on the cherries were not as marked as those obtained for the harvest maturities. The following results were obtained (Table 3).

1) The cull fruit was significantly higher for Thylate, Crag PP, and Crag GS than for Crag G, Copper, and Ferbam.

2) The juice loss for Vancide, Crag GS, and Crag PP was higher than that for Copper, Ferbam, and Captan.

3) The cherries of the Captan, Vancide, and Crag PP treatments were significantly larger than those of the Copper and Ferbam treatments.

4) The soluble solids content of Copper and Ferbam

sprayed cherries was higher than any of the other treatments (over 1%). Groves et al. (18) reported that the organic fungicides gave a lower soluble solids content than the proprietary coppers.

5) The Thylate sprayed cherries had significantly higher tenderometer values than the other fungicides.

Canned Cherries

The drained weights of the canned cherries increased as the cherries became more mature but the increase was not linear (Table 2). The greatest increases occurred between the first and second harvest, and the fifth and sixth harvest. The increase in drained weight in the last two lots may be due, in part, to the fact that there was greater deterioration in the cherries resulting in a matting of the fruit on the screens preventing free flow of the liquid.

The tenderometer values increased significantly from harvest to harvest until the last harvest where no change occurred. This increase in the tenderometer values was difficult to explain since normally the reverse would be expected as the cherries ripened. One possible explanation could be the matting of the cherry skins due to tissue disintegration on the shearing surfaces. Another explanation is supplied by Hills et al. (23), who found that the tenderometer readings increased as the amount of bruised fresh cherries increased. This appeared to be in agreement with the results obtained here since the amount of cull fruit increased as the fruit became more mature.

The soluble solids of the canned fruit showed a similar trend to that obtained for the fresh fruit. In the spray treatments, the soluble solids contents of the Copper and Ferbam cherries were higher than those obtained for the other spray treatments, while Crag G and PP were significantly lower. The tenderometer readings for Crag PP, Crag GS, and Thylate were lower than Copper and Ferbam by at least four pounds per square inch (Table 3).

The drained weight of the Vancide sprayed cherries was significantly lower than the other spray treatments, and Crag GS was significantly higher (Table 3). In contrast to the findings of Langer and Fisher (31) no significant differences were found between the drained weights of Copper and Ferbam sprayed cherries (Table 3).

As the cherries matured, the pH values for the canned fruit increased from 3.46 to 3.88 (Table 2). The Vancide treated cherries were slightly less acid while those of Crag PP were more acid than the other spray treated lots.

Frozen Cherries

The drained weights showed a gradual decline as the fruit matured with a difference of over a half an ounce existing between the first and the last harvests. Most of this decrease in drained weight occurred after the third harvest. The tenderometer readings also declined as the fruit ripened during the six weeks (Table 2).

In contrast to the canned fruit no significant differences were found between the drained weights of the spray treatments. However the drained weights of the frozen cherries tended to show a similar trend as the canned fruit. The pH shifted along the same lines as was previously observed on the canned and fresh fruit. As the cherries matured, the pH increased.

The differences in quality between fruit picked during the optimum period of harvest and those picked during the post-optimum stages of maturity were quite apparent on examination of the frozen packed cherries. The first two harvests had light colored cherries of excellent texture, flavor, and overall good appearance. The lightness in color was reasonably uniform and characteristic of properly ripened fruit. The third and fourth harvests still retained all the traits of high quality frozen cherries, but there was some darkening. The last two harvests, although still retaining some good characteristics, could not be graded any higher than U. S. Standard, for much of the fruit was no longer structurally sound with some tissue breakdown. The overall good appearance observed in the four previous harvests was lacking. This was found to be true for all eight of the spray treatments. Any distinctions that could be attributed to the different spray treatments did not show up in the grading procedures. The effect of time of harvest is of much greater importance in this respect.

The quality differences between harvest periods of the canned fruit was not as sharply defined as that for the frozen pack. Darkening of color and tissue disintegration were observed in the last two harvests, but the extent of these deficiencies was not sufficiently pronounced to downgrade the product. These two harvests would still be grade A in quality, but at the low end of the grade.

DISCUSSION

The maturation effect on quality does not uniformly show itself on canned and frozen fruit. The later harvests exhibiting tissue disintegration, discoloration, and loss of texture were much more easily distinguished in the frozen pack. Thermal processing of cherries has a tendency to disguise the general appearance of the fruit so that these deficiencies in quality are not pronounced when examined organoleptically. The frozen packed cherries, on the other hand, readily exhibited all these defects in quality, enough so that the last two harvests had to be graded down. Due to the poor quality of cherries in the last two harvests, it would be suggested that for commercial purposes their use would not be profitable.

The rapid deterioration in quality of the fruit during these latter stages of overripening is shown by the fact that the amount of cull fruit increased two per-cent during the last three harvests. The significance of this is apparent when it is observed that over the entire six weeks in which the cherries were picked, there was only a total of two and a quarter per cent increase in the amount of cull fruit. Another factor that readily demonstrates the loss in tissue cohesiveness as the fruit matured was the highly significant results obtained in per cent juice loss at the .01 level. The steady rise in pH values as the fruit matured also serves as an indication of the physiological changes in the fruit.

An interesting observation that should be noted was the completely opposite results for drained weight when comparing the canned with the frozen packed fruit. While the drained weight for the canned cherries progressively increased from the first to the last harvest, the drained weight for the frozen cherries decreased as the fruit matured. Why the drained weight reacted in such an unusual manner remains unexplained. However, factors such as matting of the fruit on the drained weight sieve, absorption of sugar by the tissues, uneven breakdown of the tissues, i.e. that the internal tissues break down while skins remain relatively intact, and the physiological effects of either thermal processing or freezing of the tissues offer several possible solutions.

The variations in drained weight could not be correlated with the changes in soluble solids. This point of correlation of soluble solids with drained weight has been suggested as a possible means of estimating when optimum maturity is reached for Montmorency cherries. The results obtained can in no way be interpreted so as to corroborate this suggested quality control factor.

Of all the various factors that influence the physiology of the maturation process of the Montmorency cherry, none has come more into criticism than the use of organic fungicides and other spray materials. Many investigators have studied the effects of these materials and have reached numerous and varied conclusions.

Usually an attempt is made to simplify the findings so that clear cut distinctions can be shown enabling a selection as to which fungicide should or should not be used. The effects of the eight spray materials used demonstrates the difficulties involved in such simplification. Throughout these eight different treatments any significant differences that were found pertained to only one or two quality control factors. No universal trends were found for any one fungicide through all the quality factors studied.

If one of the eight spray materials were to be considered unsuitable for application on a basis of quality, the cherries sprayed with Vancide would be selected. Lower drained weight and increased juice loss makes the use of this fungicide undesirable.

To recommend any one or several fungicides from those under study would be exceedingly difficult on a basis of effect on quality of fruit. Other properties of these fungicides would have to be taken into consideration, such as, fungicidal control effects of specific plant diseases, wetting ability, residual effect, side effects on the tree itself, if any, cost of material, etc.

The results obtained in this study have shown that the selection of a proper harvest period, when the fruit is at optimum processing maturity, is of far greater importance than any other factor with respect to overall quality including all the fungicides studied in this report. This does not mean to detract from the existence of any deleterious or advantageous effect that might result from the use of spray materials, but rather to re-emphasize to the processor and grower the very important part that maturity plays in the effect of the quality of both fresh and processed fruit.

Harvesting at optimum maturity is the most influential factor exerted on the quality of the fruit. Although fungicides affect quality, this effect is not nearly as great as the timing of harvest. Observations based on the fungicides studied demonstrated that the relationship between these spray materials and the quality of the fruit is not simple nor direct. The complexity of this problem is such that no one fungicide provides a clear indication as to a completely good spray treatment with respect to quality. They all have some deficiencies which exclude them from being so defined.

Perhaps a more extensive analysis of the fresh and processed product with respect to nutrition, flavor, color, and texture will aid in the proper selection of one or more of these fungicides.

SUMMARY

The study was conducted to determine the effects of time of harvest and spray materials on the quality of fresh, canned, and frozen Montmorency cherries. Eight fungicides were used, namely Copper, Ferbam, Captan, Vancide, Crag G, Crag GS, Crag PP, and Thylate. The fruit was harvested at weekly intervals for six weeks.

An organoleptic examination of the fresh and processed cherries showed that the time of harvest influenced the quality of the cherries. The fruit of the first four harvests was of good quality, while that of the last two harvests had deteriorated to such an extent that it could not be considered suitable for commercial use. The loss in quality was indicated by the increase in the amount of cull fruit, juice and pitter loss, and pH in the fresh fruit and by texture loss, tissue disintegration and discoloration in the processed fruit. These deficiencies were more apparent in the frozen cherries than in the canned fruit.

Although significant differences were found between the various spray treatments for one or more of the quality factors, the overall quality of the cherries

for the various fungicide treatments was similar.

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A P P E N D I X

Effect of time of harvest and spray treatments on fresh, canned, and frozen Montmorency cherries

TABLE 4 FIXED COPPER

Harvest Date	July 16	July 23	July 30	August 6	August 13	August 20	Mean
Fresh Fruit							
Cull fruit %	1.31	1.62	1.88	1.75	1.95	2.50	1.83
Light colored fruit %.	1.50	1.43	0.65	0.25	0.06	0.12	0.66
Pit loss %	8.37	8.22	8.48	7.79	8.06	8.14	8.17
Juice loss %	4.63	4.98	6.44	6.70	8.20	8.84	6.62
Pitter loss %	2.45	3.10	3.95	4.38	4.89	4.87	3.94
Yield, harvested fruit %	86.5	85.7	86.7	85.3	85.7	84.8	85.8
Yield, sound fruit %	89.2	88.7	87.6	87.9	87.0	86.9	87.9
Cherries per lb. No.	145	137	149	131	137	137	139
Tenderometer, lbs/sq in.	38	33	34	33	32	34	34
Soluble solids %	15.8	17.0	17.8	17.0	16.4	16.8	16.8
pH	3.31	3.55	3.66	3.67	3.69	3.80	-
Canned Fruit							
Drained weight oz.	13.78	13.81	14.19	14.00	14.06	14.25	14.01
Tenderometer, lbs/sq in.	10	19	21	21	26	26	21
Soluble solids %	12.6	12.4	13.4	13.0	12.5	12.4	12.7
pH	3.46	3.58	3.68	3.72	3.81	3.90	-
Frozen Fruit							
Drained weight oz.	14.60	14.44	14.75	14.38	14.44	14.41	14.50
Tenderometer, lbs/sq in.	-	43	-	37	36	-	39
Soluble solids							
Fruit %	24.4	24.6	25.8	24.4	24.6	24.4	24.70
Sirup %	36.8	37.6	37.6	37.4	37.0	36.6	37.2
Mixture %	28.6	28.8	29.8	29.0	29.2	28.5	29.0
pH	3.31	3.43	3.55	3.62	3.70	3.80	-

TABLE 5 FERBAM

Harvest Date	July 16	July 23	July 30	August 6	August 13	August 20	Mean
Fresh Fruit							
Cull fruit %	0.75	0.75	1.56	2.06	2.47	3.25	1.80
Light colored fruit %	2.18	1.00	0.75	0.25	0.26	0.37	0.80
Pit loss %	8.14	8.22	8.35	7.94	8.40	8.91	8.32
Juice loss %	5.25	5.93	6.39	7.17	8.60	9.04	7.06
Pitter loss %	2.56	2.55	3.04	3.85	3.87	4.01	3.31
Yield, harvested fruit %	87.0	87.5	87.5	86.0	85.7	84.5	86.4
Yield, sound fruit %	89.2	89.3	88.6	88.2	87.7	87.1	88.4
Cherries per lb. No.	148	143	139	133	135	132	138
Tenderometer, lbs/sq in.	34	34	36	36	33	36	35
Soluble solids %	15.9	16.8	17.7	17.8	16.2	16.5	16.8
pH	3.39	3.58	3.68	3.66	3.71	3.86	-
Canned Fruit							
Drained weight oz.	13.75	13.81	14.10	13.75	14.00	14.35	13.96
Tenderometer, lbs/sq in.	9	18	22	20	30	26	21
Soluble solids %	12.2	12.6	12.6	13.4	13.0	12.6	12.7
pH	3.45	3.56	3.66	3.72	3.82	3.90	-
Frozen Fruit							
Drained weight oz.	14.25	14.38	14.41	14.25	14.25	13.75	14.21
Tenderometer, lbs/sq in.	-	43	-	43	40	-	42
Soluble solids							
Fruit %	24.6	24.1	24.5	25.4	25.4	24.0	24.7
Sirup %	36.3	36.9	37.1	37.4	36.8	35.3	36.0
Mixture %	28.2	27.9	28.8	29.2	29.4	28.0	28.6
pH	3.38	3.46	3.57	3.59	3.70	3.79	-

TABLE 6 CAPTAN

Harvest Date	July 16	July 23	July 30	August 6	August 13	August 20	Mean
Fresh Fruit							
Cull fruit %	1.43	2.10	1.37	1.62	3.39	3.21	2.18
Light colored fruit %	2.00	0.95	0.50	0.25	0.47	0.00	0.69
Pit loss %	8.60	7.91	8.52	7.79	8.02	8.48	8.22
Juice loss %	2.42	6.02	6.69	7.47	8.87	9.86	6.88
Pitter loss %	2.04	3.08	3.28	4.12	5.21	4.90	3.77
Yield, harvested fruit %	87.5	86.4	87.2	85.5	83.7	82.9	85.5
Yield, sound fruit %	89.3	89.1	88.1	88.1	86.8	86.6	88.0
Cherries per lb. No.	136	128	134	122	122	123	128
Tenderometer, lbs/sq in.	36	34	36	32	34	36	35
Soluble solids %	15.2	16.3	16.5	16.1	15.1	15.6	15.8
pH	3.36	3.58	3.70	3.70	3.74	3.86	-
Canned Fruit							
Drained weight oz.	13.47	14.03	13.97	13.78	14.00	14.18	13.90
Tenderometer, lbs/sq in.	8	16	21	24	25	23	20
Soluble solids %	12.6	12.6	12.8	12.4	12.0	12.1	12.4
pH	3.49	3.50	3.61	3.70	3.78	3.90	-
Frozen Fruit							
Drained weight oz.	14.44	14.21	14.44	14.00	13.69	14.00	14.13
Tenderometer, lbs/sq in.	50	43	48	42	39	40	44
Soluble solids							
Fruit %	23.0	22.6	24.0	23.2	23.4	24.2	23.4
Sirup %	37.6	38.4	36.9	37.3	36.2	35.5	37.0
Mixture %	27.8	28.2	27.9	28.1	27.4	28.0	27.9
pH	3.36	3.40	3.57	3.64	3.73	3.78	-

TABLE 7 VANCIDE

Harvest Date	July 16	July 23	July 30	August 6	August 13	August 20	Mean
Fresh Fruit							
Cull fruit %	1.50	2.27	2.18	1.49	1.82	4.31	2.26
Light colored fruit %	2.06	0.97	0.50	0.06	0.65	0.31	0.75
Pit loss %	8.22	8.04	8.89	8.17	8.17	8.76	8.37
Juice loss %	6.16	5.94	7.40	6.78	9.17	10.60	7.67
Pitter loss %	1.80	2.97	2.96	3.74	3.19	4.84	3.25
Yield, harvested fruit %	87.5	85.7	85.5	86.4	84.1	82.5	85.3
Yield, sound fruit %	90.0	88.9	88.1	88.1	85.9	86.4	87.9
Cherries per lb. No.	137	129	133	125	123	128	129
Tenderometer, lbs/sq in.	35	33	36	35	33	34	34
Soluble solids %	14.5	15.6	16.0	16.2	15.2	15.2	15.4
pH	3.40	3.52	3.70	3.70	3.76	3.88	-
Canned Fruit							
Drained weight oz.	13.53	13.91	14.12	14.44	14.28	14.15	13.23
Tenderometer, lbs/sq in.	8	14	18	25	25	21	19
Soluble solids %	11.7	11.8	12.3	12.2	12.0	12.0	12.0
pH	3.53	3.59	3.71	3.78	3.86	3.98	-
Frozen Fruit							
Drained weight oz.	14.50	14.31	14.38	13.97	13.75	13.59	14.08
Tenderometer, lbs/sq in.	50	43	45	44	41	39	43
Soluble solids							
Fruit %	22.6	22.1	23.4	23.2	24.3	24.4	23.3
Sirup %	37.8	39.1	37.6	37.4	37.2	35.1	36.4
Mixture %	28.3	28.6	29.2	29.2	29.4	28.7	28.9
pH	3.39	3.46	3.60	3.70	3.76	3.80	-

TABLE 8 CRAG G

Harvest Date	July 16	July 23	July 30	August 6	August 13	August 20	Mean
Fresh Fruit							
Cull fruit %	1.56	1.25	0.87	1.87	2.53	2.12	1.70
Light colored fruit %	2.81	1.37	0.37	0.25	0.06	0.31	0.86
Pit loss %	8.39	8.33	8.67	7.92	7.85	8.33	8.24
Juice loss %	4.94	6.77	7.00	7.86	8.26	9.41	7.37
Pitter loss %	2.86	2.98	2.83	3.09	4.34	5.09	3.53
Yield, harvested fruit %	85.2	81.8	84.5	86.2	84.4	85.0	84.5
Yield, sound fruit %	88.8	88.6	91.0	88.9	87.8	86.5	88.6
Cherries per lb. No.	144	143	141	123	122	127	133
Tenderometer, lbs/sq in.	36	33	39	33	30	34	34
Soluble solids %	14.3	16.0	15.4	15.8	15.7	15.4	15.4
pH	3.38	3.54	3.70	3.70	3.74	3.84	-
Canned Fruit							
Drained weight oz.	13.62	13.94	13.75	13.88	13.85	14.25	13.88
Tenderometer, lbs/sq in.	8	15	17	27	24	22	19
Soluble solids %	11.7	11.6	12.4	12.2	11.9	12.0	12.0
pH	3.49	3.54	3.60	3.72	3.78	3.87	-
Frozen Fruit							
Drained weight oz.	14.60	14.41	14.31	14.00	13.94	13.66	14.15
Tenderometer, lbs/sq in.	47	42	38	36	36	35	39
Soluble solids							
Fruit %	22.1	23.0	23.2	23.0	24.8	23.4	23.2
Sirup %	38.0	36.6	37.4	36.7	36.6	36.3	37.0
Mixture %	27.0	27.5	27.7	28.1	28.8	28.5	28.0
pH	3.40	3.45	3.61	3.66	3.78	3.87	-

TABLE 9 CRAG GS

Harvest Date	July 16	July 23	July 30	August 6	August 13	August 20	Mean
Fresh Fruit							
Cull fruit %	2.06	2.24	2.00	2.06	3.33	5.51	2.86
Light colored fruit %	5.56	0.88	0.75	0.18	0.42	0.12	1.31
Pit loss %	8.07	9.31	8.35	7.70	8.28	8.10	8.40
Juice loss %	6.34	6.16	6.88	7.51	8.65	10.05	7.59
Pitter loss %	2.20	1.58	4.97	3.63	4.98	4.56	3.65
Yield, harvested fruit %	86.0	84.5	85.0	85.5	84.1	81.7	84.5
Yield, sound fruit %	89.1	89.1	89.0	88.6	86.8	87.4	88.3
Cherries per lb. No.	156	140	127	122	120	120	131
Tenderometer, lbs/sq in.	36	33	34	33	33	34	34
Soluble solids %	16.1	16.0	16.2	16.1	15.6	15.8	15.9
pH	3.40	3.52	3.70	3.72	3.78	3.85	-
Canned Fruit							
Drained weight oz.	13.94	14.25	14.28	14.31	14.53	14.59	14.31
Tenderometer, lbs/sq in.	8	14	17	19	23	22	17
Soluble solids %	13.1	12.0	12.5	12.5	12.2	12.6	12.5
pH	3.43	3.53	3.64	3.78	3.87	3.80	-
Frozen Fruit							
Drained weight oz.	14.69	14.44	14.31	14.10	14.19	14.09	14.30
Tenderometer, lbs/sq in.	50	42	40	36	34	35	39
Soluble solids							
Fruit %	25.0	23.3	23.0	23.8	23.7	23.8	23.8
Sirup %	37.2	38.0	39.3	37.5	37.4	36.5	37.6
Mixture %	29.1	27.8	28.4	27.9	28.3	28.2	28.3
pH	3.44	3.51	3.61	3.68	3.80	3.90	-

TABLE 10 CRAG PP

Harvest Date	July 16	July 23	July 30	August 6	August 13	August 20	Mean
Fresh Fruit							
Cull fruit %	1.87	1.50	1.95	2.50	2.85	4.87	2.59
Light colored fruit %	4.56	1.37	0.45	0.50	0.33	1.00	1.36
Pit loss %	7.73	7.47	8.35	8.57	9.63	8.71	8.41
Juice loss %	5.42	6.94	6.95	7.92	9.32	10.23	7.79
Pitter loss %	3.97	3.17	3.21	3.38	4.37	4.52	3.77
Yield, harvested fruit %	83.5	84.5	86.2	84.8	83.4	81.5	84.0
Yield, sound fruit %	88.4	89.4	89.5	88.0	89.5	86.7	88.6
Cherries per lb. No.	140	130	132	124	117	121	127
Tenderometer, lbs/sq in.	36	33	35	36	35	33	35
Soluble solids %	15.0	15.3	16.0	16.0	15.1	15.1	15.4
pH	3.40	3.52	3.68	3.77	3.77	3.88	-
Canned Fruit							
Drained weight oz.	13.97	14.06	14.12	14.12	14.00	14.47	14.12
Tenderometer, lbs/sq in.	8	12	15	14	19	22	15
Soluble solids %	12.4	11.7	12.0	12.2	11.8	11.2	11.9
pH	3.32	3.42	3.54	3.61	3.68	3.77	-
Frozen Fruit							
Drained weight oz.	14.65	14.50	14.37	14.03	14.06	14.00	14.26
Tenderometer, lbs/sq in.	51	44	42	41	39	36	42
Soluble solids							
Fruit %	24.1	23.1	22.7	23.3	23.6	23.5	23.4
Sirup %	37.2	35.9	36.8	37.2	36.5	34.3	36.3
Mixture %	28.5	26.6	27.8	28.1	28.7	27.6	27.7
pH	3.39	3.42	3.54	3.62	3.70	3.80	-

TABLE 11 THYLATE

Harvest Date	July 16	July 23	July 30	August 6	August 13	August 20	Mean
Fresh Fruit							
Cull fruit %	1.56	2.47	2.50	2.12	3.00	5.04	2.78
Light colored fruit %	4.81	1.30	0.50	0.25	0.56	0.89	1.38
Pit loss %	8.37	8.44	8.78	8.26	8.78	8.83	8.57
Juice loss %	6.16	5.81	6.53	6.45	8.26	7.79	6.83
Pitter loss %	4.16	2.91	2.82	3.88	4.13	3.72	3.60
Yield, harvested fruit %	84.2	83.3	86.2	85.0	84.2	84.3	84.6
Yield, sound fruit %	87.5	88.6	88.5	87.8	87.1	87.4	87.8
Cherries per lb. No.	143	140	130	132	140	125	135
Tenderometer, lbs/sq in.	40	37	36	37	34	37	37
Soluble solids %	15.2	16.1	16.5	16.0	15.7	15.8	15.8
pH	3.42	3.53	3.70	3.76	3.78	3.90	-
Canned Fruit							
Drained weight oz.	13.53	13.85	14.10	14.21	14.53	14.50	14.12
Tenderometer, lbs/sq in.	8	10	20	19	19	20	16
Soluble solids %	12.2	12.3	12.6	12.7	12.2	12.2	12.4
pH	3.52	3.58	3.69	3.74	3.84	3.92	-
Frozen Fruit							
Drained weight oz.	14.47	14.40	14.50	14.10	14.06	14.06	14.26
Tenderometer, lbs/sq in.	48	44	43	42	38	-	43
Soluble solids							
Fruit %	23.7	22.8	23.6	23.8	24.3	23.6	23.6
Sirup %	37.8	37.0	38.7	37.6	38.2	36.9	37.7
Mixture %	28.5	28.0	28.3	28.4	29.4	27.4	28.2
pH	3.51	3.60	3.67	3.70	3.79	3.82	-

TABLE 12

FROZEN FRUIT SIRUP CONCENTRATIONS

Harvest Date	% soluble solids prior to freezing	% soluble solids after freezing
July 16	65.0	65.0
July 23	64.9	64.4
July 30	64.6	63.5
August 6	64.4	64.0
August 13	65.6	65.5
August 20	65.1	64.3

Date Due

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