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USE OF SUGAR, SUGAR SYRUP AND
ASCORBIC ACID IN FROZEN RED CHERRIES

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USE OF SUGAR, SUGAR SYRUP, AND ASCORBIC ACID
IN FROZEN RED CHERRIES

By

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INTRODUCTION

Red cherries are one of the most important fruit crops in Michigan. The average annual production during the recent years has been about 100,000 tons, which amounted to 50 per cent of the total production in the United States. Ninety-two per cent of this amount is annually processed for later use in pies or preserves; thirty-six per cent is frozen and sixty-four per cent is canned (13). Table I shows that the frozen pack of red pitted cherries has continued to increase in recent years, and that it is of considerable commercial importance in Michigan. The major varieties used for freezing are Montmorency, English Morillo, and Early Richmond (11). In Michigan the Montmorency variety is the one most generally processed.

In freezing red cherries it is important that the method used result in a product of maximum drained weight, good color, texture, flavor and appearance. Since most of the frozen red cherries are used in the bakery or preserve trade, dry sugar is generally preferred to the syrup pack, to obtain maximum drained weight, or minimum of juice.

In this study, red cherries were frozen with dry sugar and sugar syrup, with and without ascorbic acid to determine the effect on the drained weight, color, sol-

TABLE I
POUNDS OF FROZEN, PITTED CHERRIES PACKED
BY REGIONS 1942-1949¹

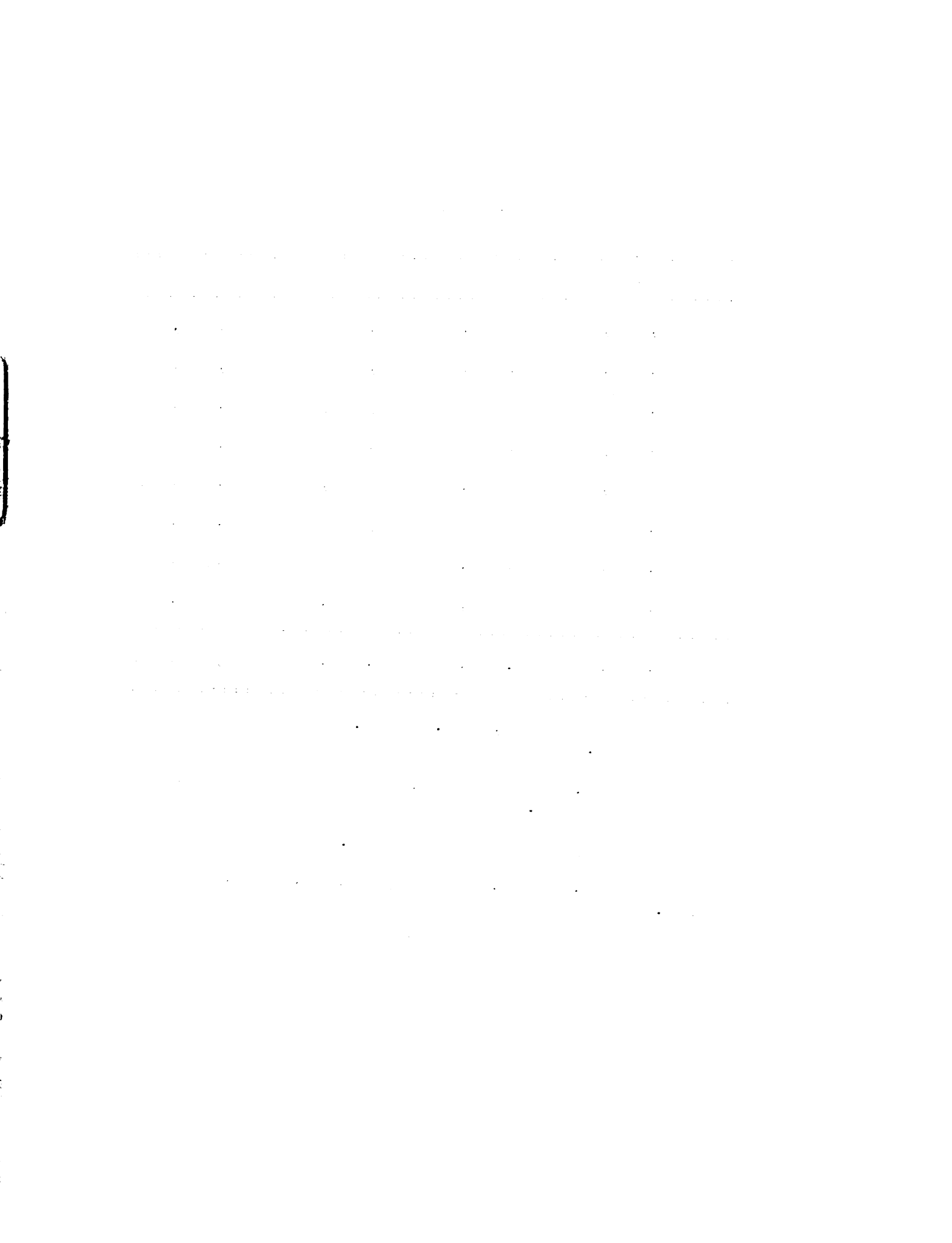
Year	Northeast ²	Midwest ³	West ⁴	Total
1942	25,655,882	12,503,090	3,660,912	41,819,884
1943	9,737,115	8,132,581	5,135,666	23,005,362
1944	18,007,037	24,042,753	13,009,159	55,058,949
1945	7,891,002	5,107,890	3,144,935	16,143,827
1946	24,591,742	52,843,091	10,626,568	88,061,401
1947	18,658,598	39,759,129	8,584,004	67,001,731
1948	26,396,599	52,869,582	8,531,518	87,797,699
1949	25,102,802	39,163,035	6,722,865	70,988,702
Average	19,505,097	29,302,643	7,426,954	56,234,694

¹ Pack Statistics, Nat. Assoc. Frozen Food Packers 1942 to 1949.

² New York, Pennsylvania, and one other plant south of Pennsylvania.

³ Michigan, Ohio and Wisconsin.

⁴ Colorado, Idaho, Montana, Oregon, Utah, and Washington.



uble solids in juice and fruit, texture, flavor and pH of the fruit and juice.

Red cherries were held at room temperature after the addition of dry sugar or sugar syrup for 3 and 6 hours before freezing to determine the effect on the quality of the frozen cherries.

REVIEW OF LITERATURE

Marshall (14) reported that the frozen cherry industry started prior to 1920 but there seems to be no record of the first pack of pitted red cherries. Rogers (16) recalled that some pitted fruit was packed in barrels without sugar in 1921. These reports indicate that freezing of red cherries on a commercial scale began about or soon after 1920.

Red cherries were frozen in barrels without sugar (14). The red mature cherries were harvested soaked in water, as in the preparation of the canned product, pitted, packed in barrels and frozen. This procedure, however, resulted in a product inferior to that obtained when dry sugar or syrup was used (7). The dry sugar pack which is used by the frozen pack industry started at Traverse City, Michigan, in 1922 (14). Dry sugar is preferred by packers of frozen cherries for the use of bakers and preservers, since the use of dry, it was thought, makes it possible to avoid the large volumes of liquid that would have to be handled if sugar in the form of syrup is added to the fruit (14). The dry sugar is added to the cherries by one of the following methods (14): (1) sugar and cherries are alternately added to the container; (2) sugar is placed on top of the cherries in the container; (3) half of the sugar is placed

in the bottom container and half on top; (4) one third of the sugar is placed in the bottom, one third in the center and one third on top; or (5) sugar and cherries are mixed before packaging in a mechanical tumbler-type mixer.

Tressler (17) found that if the portion of fruit to sugar is greater than 5 to 1 the color and quality may not be protected. Wiegand (19) reported that the loss in weight of some berries frozen with sugar increased as the ratio of fruit to sugar decreased and in other berries there was no continuous and regular increase.

Diehl et al. (6) found that an increase in the concentration of cane sugar resulted in the increase in the amount of water extracted as shown by the increased percentage of soluble solids in the fruit.

Marshall (13) reported that a dry sugar pack makes possible a maximum drained weight of product on defrosting. This is of importance to pie makers some of whom purchase on the basis of drained weight. Tressler (17) also found that the dry sugar pack resulted in greater tissue shrinkage and a product of high drained weight.

The use of syrup to aid in the preservation of color, flavor and texture in frozen fruits was introduced by Cruess and others (3) in 1920. Cruess and Overholser

(4) reported that at freezing temperature, sugar solution modified the effect of freezing by decreasing the amount of cell destruction. Subsequent results have confirmed the fact that the addition of syrup has many advantages (2, 7, 8, 19) over a dry sugar pack. There is some difference of opinion among investigators as to the concentration of syrup that is best. Joslyn (10) found 40% syrup to be satisfactory and Diehl (6) suggested 55-60 per cent for red cherries. Joslyn (10) found that variation in concentration of syrup even over a range of 10°. Balling does not markedly affect the quality of the product. Such variations were more detectable in flavor than in appearance. Diehl (6) reported that increasing the volume of syrup beyond that necessary to cover the fruit is to be desired. A syrup pack is used for cherries frozen for use as desserts. Cruess, et al. (5) found that there was no relationship between syrup densities and drained weights. The drained pitted fruit weighed about 2.5 per cent less after freezing and storage for two weeks than at packing time.

Ascorbic Acid

Cherries are among the fruits which acquire a peculiar flavor and odor during freezing and thawing (9). Joslyn (9) stated that this may be due to anaerobic res-

piration. The use of ascorbic acid as an anti-oxidant which helps in preserving color and flavor of many other frozen fruits is recommended by many investigators.

Joslyn and Hohl (11) recommended its use for sweet cherries at the rate of 0.25 per cent by weight dissolved in 40° Brix syrup. But for Montmorency sweet and sour cherries they reported that there were no apparent advantages in using ascorbic acid with a syrup pack.

Strachan and Moyls (15) reported that ascorbic acid added at the rate of 120-200 mg. per 15 ounces of fruit and syrup gave satisfactory results and that after 16 months in frozen storage 80 per cent or more of the ascorbic acid was retained as biologically active vitamin C.

METHODS AND PROCEDURES

Mature Montmorency cherries were harvested, transported to the laboratory in twenty-five pound boxes and soaked in water at 42° F. for eighteen hours. At the end of the soaking period the cherries were removed from the soaking tank and graded. The sound fruit was pitted and weight of pitted cherries, pits and juice determined. Representative samples were removed for determination of tenderness, color, and soluble solids. The pitted cherries were packed in paraffined paper bags and dry sugar or sugar syrup added. For the ascorbic acid treatment the ascorbic acid was dissolved in water (2.5 gram per 100 ml.) and the required amount added to each package before sealing. Eight bags of each treatment were packed. The treatments used are summarized in Table II. The sealed bags were frozen at -20° F., and then stored at 0° F.

Thawing

The samples were thawed in hot water (130° -- 150°) to a temperature of 60° F. The dry sugar packs were rotated back and forth several times to dissolve the residual sugar.

TABLE II
CODE AND DESCRIPTION OF THE CHERRY PACK

Code	Treatment of Fruit*	Composition	
		Fruit oz.	Sugar or sugar syrup oz.
I-A	Dry sugar (5+1)	12½	2½
I-B	Dry sugar (4+1)	12	3
I-C	Sugar syrup 40°B	12	4
I-D	Sugar syrup 50°B	12	4
I-E	Sugar syrup 55°B	12	4
I-F	Sugar syrup 60°B	12	4
I-G	Sugar syrup 60°B	12	5
II-A-1	Dry sugar I-A (5+1) plus 150 mg ascorbic acid per pkg.		
II-A-2	Dry sugar I-A (5+1) plus 175 mg ascorbic acid per pkg.		
II-A-3	Dry sugar I-A (5+1) plus 200 mg ascorbic acid per pkg.		
II-F-1	Sugar syrup 60°B (I-F) plus 150 mg. ascorbic acid per pkg.		
II-F-2	Sugar syrup 60°B (I-F) plus 175 mg. ascorbic acid per pkg.		
II-F-3	Sugar syrup 60°B (I-F) plus 200 mg. ascorbic acid per pkg.		
III-A-1	Frozen immediately after packing		(I-A)
III-A-2	Frozen 3 hours after packing		(I-A)
III-A-3	Frozen 6 hours after packing		(I-A)
III-F-1	Frozen immediately after packing		(I-F)
III-F-2	Frozen 3 hours after packing		(I-F)
III-F-3	Frozen 6 hours after packing		(I-F)

* 8 replicates of each of these treatments were packed.-

Drained Weights

Drained weights were determined according to the U. S. Standard for Frozen Red (sour) Pitted Cherries (18).

Soluble Solids

The per cent of soluble solids of the syrup was determined with a Brix hydrometer and the Abbe refractometer. For the determination of the percent of soluble solids in the fruit, the juice was pressed out of 10 to 15 grams of drained fruit and the readings made with the Abbe refractometer.

The pH Determination

The pH values were obtained with a model H-2 Beckman pH meter using the same samples used for the determination of soluble solids in juice and in fruit.

Tenderometer Determination

A method devised in the department (1) is used. The tenderometer values were obtained on 150 gram samples of pitted cherries, the readings were made on scale 2 of the tenderometer.

Color Determinations

The color determinations were made according to the method described by Bedford (1). Three to four hundred grams of freshly pitted cherries or 100 grams of thawed cherries and their representative juice were blended for three minutes, filtered first through standard single gauge milk filter discs and then through Reeve Angel No. 812 filter paper. A representative aliquot (3 to 5 ml) of the clear juice was diluted to 50 ml. with distilled water and transmittancy determined at 515 mu with the Evelyn colorimeter using distilled water as a reference solution. The results were expressed as optical density. Transmittancy determinations were also made at 420 mu on those samples frozen with ascorbic acid and those held before freezing as it has been reported by Lee, et al. (12) that an increase in optical density at 400 to 420 mu is an indication of development of yellow or brown color fruit juice.

Grading

The grades were determined according to the U. S. Standard for Frozen Red (sour) Pitted Cherries (18).

Consumer Preference

For this determination two samples of each treatment were thawed at the same time and judged by a taste panel of eight members of the Horticulture Staff who are familiar with red cherry qualities.

RESULTS AND DISCUSSION

Experimental results were obtained from four samples of each treatment except the determination of consumer preference. For this determination another two samples of each treatment were thawed at the same time and judged. The results are shown in the appendix tables 1, 2 and 3, and the average results of each treatment are given in Table III.

Drained Weight

This is of much importance to the frozen cherry industry as many pie makers purchase frozen cherries on the basis of drained weight. Marshall (14) and Tressler (17) reported that the dry sugar pack results in a product of higher drained weight than the syrup pack. The results obtained (Table III) showed no marked difference in drained weight between dry sugar pack and syrup pack when equivalent amounts of sugar were added. The drained weight, however, is affected to a certain extent by the concentration of sugar. When dry sugar is added to the fruit in the ratio of 5+1, a higher drained weight was obtained than when the ratio was 4+1. Also syrup concentrations lower than 55°B resulted in lower drained weights. The decrease in drained weight was

TABLE III

EFFECT OF DRY SUGAR AND SUGAR SYRUPS WITH AND WITHOUT ASCORBIC ACID
ON THE QUALITY OF FROZEN MONTMORENCY CHERRIES

Treatment	Code	Net Wt.	Drained Wt.	Soluble solids		Juice Vol.	Score	Grade	Tender- ometer	Color		pH	
				Juice	Fruit					Optical Density		Fruit	Juice
										oz.	oz.		
Fresh						15.80			39.00	1.95			
Dry sugar (5+1)	I-A	15	10 1/4	45.2	22.80	102	81	C	49.00	8.05		3.27	3.20
Dry sugar (4+1)	I-B	15 1/8	9 1/2	46.5	24.90	127	81	C	49.80	8.80		3.21	3.20
4 oz. sugar or syrup 40°B ¹ (3+1)	I-C	16	9 1/2	27.7	19.55	169	83	C	49.50	6.18		3.27	3.22
4 oz. sugar or syrup 50°B (3+1)	I-D	16	10 1/2	32.4	20.75	135	83	C	49.70	6.35		3.27	3.35
4 oz. sugar or syrup 55°B (3+1)	I-E	16	10 3/4	34.8	21.55	136	83	C	47.85	6.45		3.30	3.30
4 oz. sugar or syrup 60°B (3+1)	I-F	16	11	37.6	22.55	130	83	C	47.00	6.53		3.29	3.30
5 oz. sugar or syrup 60°B (2½+1)	I-G	17	11	40.6	25.90	151	83	C	46.35	6.35		3.34	3.36
Same as(I-A) + 150 mg ascorbic	II-A-1	15 1/2	10 1/2	44.0	23.50	110	85	A	50.35	7.97	5.46	3.30	3.34
Same as (I-A) + 175 mg ascorbic	II-A-2	15 1/2	10 3/4	43.7	23.30	117	85	A	50.35	8.46	4.94	3.32	3.31
Same as (I-A) + 200 mg ascorbic	II-A-3	15 1/2	10 1/2	44.8	24.10	119	85	A	51.00	9.23	5.16	3.32	3.31
Same as (I-F) + 150 mg ascorbic	II-F-1	16	10 1/2	37.9	22.50	142	85	A	48.50	7.56	4.72	3.35	3.35
Same as (I-F) + 175 mg ascorbic	II-F-2	16 1/2	10 3/4	38.0	23.00	137	85	A	48.00	6.90	4.52	3.40	3.38
Same as (I-F) + 200 mg ascorbic	II-F-3	16 1/8	10 1/2	37.6	22.30	144	85	A	48.00	7.10	4.66	3.40	3.38
Frozen immediately after packing	III-A-1	15	10 1/2	43.7	25.40	95	81	C	50.70	8.35	5.46	3.30	3.30
Frozen 3 hrs. after packing	III-A-2	15	10 1/2	45.4	24.70	105	80	D ²	52.00	7.75	6.02	3.29	3.30
Frozen 6 hrs. after packing	III-A-3	15 1/4	10 1/2	43.4	25.50	118	79	D ²	54.00	8.24	6.10	3.31	3.27
Frozen immediately after packing	III-F-1	16	10 3/4	37.3	23.30	139	83	C	50.00	6.95	4.72	3.30	3.34
Frozen 3 hrs. after packing	III-F-2	16	10 1/2	36.0	24.50	146	82	C	53.00	7.02	4.93	3.30	3.27
Frozen 6 hrs. after packing	III-F-3	16	10 1/2	35.3	24.00	147	81	C	53.00	7.10	5.16	3.32	3.30

¹ B = Brix.² Color given 13 points.

found to parallel the decrease in the concentration of the sugar syrup.

Ascorbic acid had no effect on the drained weight and holding the product for 3 to 6 hours before freezing did not affect the drained weight of the thawed cherries.

Drained Juice Volume

The average drained juice by weight of all treatment was found to be 42 per cent of the net weight of the frozen cherries. The juice volume of the syrup pack was found to be greater than that of the dry pack due to the volume of water in which the sugar was added. In general the drained liquid volume was similar for all dry sugar packs and lower than in the syrup packs. Also the drained syrup volume tended to be greater in the treatments having the higher sugar concentrations. The data obtained showed a tendency towards increased syrup volume with longer holding times before freezing. The addition of ascorbic acid does not have any apparent effect on the juice volume.

Soluble Solids

The per cent of soluble solids in juice was higher in the dry pack than in the syrup pack. Table III shows that the per cent for 5+1 dry pack was 45.2 and in

the syrup pack in which the same amounts of sugar were added but in the form of syrup was 37.6. There was a slight difference between the 5+1 pack and the 4+1 pack. The per cent of soluble solids in the 5+1 pack was 45.2 while in the 4+1 pack it was 46.5. In the syrup pack the total soluble solids increased with the increase in the concentration of the syrup used in packing. From Table III it can be seen that neither the addition of ascorbic acid or holding had any effect on the per cent of soluble solids in the juice. There was an increase in soluble solids when syrup beyond that necessary to cover the fruit was used (I-G, Table III).

Table III shows that there was no difference between the soluble solids content in the fruit packed in dry sugar or in syrup pack when the same amount of sugar is added. In dry packs there was an increase in the per cent of soluble solids in the fruit when the ratio of fruits to sugar was raised from 5+1 to 4+1. There was a slight difference between the syrup packs. The soluble solid contents tended to increase with the increase in the concentration of the syrup used. Also when the amount of syrup was increased but at the same concentration, an increase in the soluble solids content of the fruit was noticed. This can be explained by the increase in the absolute amount of sugar added by increas-

ing the volume of the syrup. Ascorbic acid had no effect on the soluble solid contents of the fruit nor did the holding of cherries up to six hours before freezing.

The tenderness of the fruit shown by the tenderometer readings was similar for all treatments. The frozen product was tougher than the fresh fruit, the tenderometer reading for the fresh fruit averaging 39 as compared to 50 for the frozen fruit. Although there was no apparent difference between the toughness of the different treatments shown by the tenderometer readings, slight differences were detected by the taste panel. Samples of frozen syrup with ascorbic acid (II-F-2) were judged to have the best texture, while cherries packed in 40° and 50°B syrup (I-C and I-D) were found to have the poorest texture. Cherries packed in 55°B and 60° syrup were found to be preferable to those frozen with dry sugar. Holding the product up to six hours before freezing did not affect the firmness of the product. The results of the tenderometer readings and the results of the taste panel suggest that the tenderometer is not sensitive enough to measure the small difference in tenderness or firmness in the frozen cherries.

Color

The color intensity measured at 515 mu showed no marked differences between the dry sugar packs or between the syrup packs of the same fruit-syrup ratio. However, in the syrup packs the color intensity was less, due to dilution. The addition of ascorbic acid had no apparent effect on the red color. There was an increase in the color intensity of the frozen products over that of the fresh product. No explanation can be given for this increase in color intensity at this time. It may be that during the freezing procedure, in the presence of sugar, leucoanthocyanins were converted to the red anthocyanin. In both the dry sugar and syrup packs without ascorbic acid held three and six hours before freezing, there was a noticeable increase in the optical density at 420 mu indicating browning (Table III). The increase in optical density was slightly greater in the dry sugar pack than in the syrup pack indicating that the syrup pack offered more protection against browning. No marked differences were found between the three levels of ascorbic acid used.

Visual observations of the thawed cherries showed differences in the brightness of the red color and in browning. The cherries frozen in syrup with added ascorbic acid had a brighter appearance and less browning.

There were no differences observed in red color or in browning between the three levels of ascorbic acid used. The brightness of the red color decreased and the browning increased in the following order: dry sugar plus ascorbic acid, syrup alone, dry sugar alone. There was less change in the syrup packed than in the dry sugar packed. The visual observations on the packs held before freezing were similar to those found colorimetrically. There was less brightness of red color and more browning in the packs held for six hours than those held three hours before freezing. These differences were more marked in the dry sugar pack than in the syrup pack.

Flavor

When the thawed products were graded for flavor there was a disagreement about the flavor preference between judges. Two judges preferred the oxidized flavor in the red sour cherries while others preferred the fresh flavor. When those who chose the red cherries were questioned as to their preference for the oxidized cherries they stated that these lots were more like those they normally purchased.

The syrup packs with ascorbic acid were preferred over all other treatments. There was no marked difference between syrup packs with different amounts of as-

corbic acid. Therefore the lowest amount added (150 mg ascorbic acid) was considered sufficient to maintain the fresh fruit flavor in the syrup packs. Next most desirable were the dry sugar packs plus ascorbic acid. Packs to which 175 mg and 200 mg of ascorbic acid were added were preferred over the one containing 150 mg of ascorbic acid. It was indicated that 175 mg of ascorbic acid was sufficient to maintain approximate fresh fruit flavor in the dry sugar packs. The syrup packs (60°B) were found superior in flavor to the dry sugar pack and the rest of the syrup packs.

In the packs held before freezing the most pronounced oxidized flavor was found in the dry sugar packs held for 6 hours and the least in the syrup packs held for 3 hours.

Grading

The frozen treatments were graded according to the United States Standards for frozen red sour cherries (18). The final scores and grades are shown in appendix tables 1, 2 and 3 and averages are shown in Table III. Dry sugar pack and syrup pack plus ascorbic acid were given A grades. The remainder of the packs were all graded down on color (Table III). The syrup packs were next and scored C, while the dry sugar pack was lower

but also scored C. The rest of the packs were also given C grade except the dry sugar pack which were held for 3 and 6 hours; they were given a grade of D, as they were given less than 14 points for color, which is the requirement for grade C. The pH values obtained were similar for all treatments (Table III).

SUMMARY AND CONCLUSION

In this study the following conclusions were drawn:

1. Syrup pack is much better for freezing the red sour cherries than the dry sugar pack.

2. The most suitable concentration for sugar syrup was found to be 55-60° B.

3. For the dry sugar pack the ratio of fruit to sugar of 5:1 was found better than 4:1.

4. The addition of ascorbic acid at the rate of 150 mg per pound package of syrup pack is advisable to have nearest to a fresh flavor product. For dry sugar pack 175 mg of ascorbic acid per pound package was found sufficient to maintain the fresh flavor of the red sour cherries.

5. The red sour cherries should be frozen immediately after pitting and packing. If conditions in the plant prevent this, syrup pack is recommended to get the least browning and oxidized flavor.

6. The tenderometer is not sensitive enough to show any difference in texture for the different treatments.

7. The pH of the fruit and the juice was not affected by any treatment.

8. The change in red color was measured by determining the optical density at 515 mμ and browning by an increase in optical density at 420 mμ.

TABLE 1

Treat- ment	Net Wt.	Drained Wt.	Juice Vol.	Juice sol. solids		Fruit sol. Solids	Color Reading Optical Density		pH		Ten- derom- eter	Grade factors			Total Score	Grade	Remarks		
				Brix	Abbe		515mu	420mu	Juice	Fruit		Col- or	Absence of Defects	Char- acter					
I-A	1	15		10	104	45.5	44.5	22.2	8.23		3.3	3.2	47	14	34	33	81	C	Lack of uniform- ity in color and considerable browning
	2	15		10 1/4	94	45.6	45.6	22.2	8.23		3.28	3.2	47	14	34	33	81	C	
	3	15		10 1/4	105	45	45	23.4	7.93		3.22	3.2	52	14	34	33	81	C	
	4	15		10 1/2	103	45.3	45.5	23.4	7.93		3.28	3.2	50	14	34	33	81	C	
I-B	1	15		9 3/4	113	47.5	47.18	25.4	9.02		3.22	3.2	51	14	34	33	81	C	Lack of uniform- ity in color and considerable browning
	2	15	1/4	9 1/2	130	46	46.5	25.4	9.02		3.2	3.2	50	14	34	33	81	C	
	3	15	1/4	9 1/2	138	45.5	46	24.3	8.6		3.21	3.22	49	14	34	33	81	C	
	4	15		9 3/4	128	46.2	46.3	24.3	8.6		3.2	3.22	49	14	34	33	81	C	
I-C	1	16	1/8	9 7/8	171	28.1	28.6	19.5	6.02		3.2	3.21	51	15	34	34	83	C	Lack of uniform- ity but color is better and less browning
	2	16		9	172	28.2	28.8	19.5	6.02		3.3	3.21	50	15	34	34	83	C	
	3	16		9 1/2	169	26.8	27.3	19.6	6.35		3.28	3.22	50	15	34	34	83	C	
	4	16		9 3/4	164	26.5	27	19.6	6.35		3.28	3.22	47	15	34	34	83	C	
I-D	1	16		10 1/2	128	32	32	21.1	6.54		3.22	3.35	48	15	34	34	83	C	Better color but lack of uniform- ty.
	2	16		11	118	32.4	33.1	21.1	6.54		3.3	3.35	49	15	34	34	83	C	
	3	16	1/8	10 1/4	146	33	33	20.4	6.18		3.25	3.25	49	15	34	34	83	C	
	4	16		10 5/8	147	31.9	32	20.4	6.18		3.3	3.35	53	15	34	34	83	C	
I-E	1	16		10 1/2	146	35.2	34.9	21.6	6.73		3.3	3.35	46	15	34	34	83	C	Better color Less lack of uniformity
	2	16		11 1/4	128	33	32.8	21.6	6.73		3.3	3.35	50	15	34	34	83	C	
	3	16		10 3/4	133	36.4	36.5	21.5	6.18		3.3	3.3	48	15	34	34	83	C	
	4	16		10 7/8	136	34.9	35	21.5	6.18		3.3	3.3	47	15	34	34	83	C	
I-F	1	16	1/8	10 5/8	135	36.8	37.1	22.8	6.54		3.3	3.3	46	15	34	34	83	C	Bright color and less lack of uniformity
	2	16		11	128	37.7	38.3	22.8	6.54		3.3	3.3	47	15	34	34	83	C	
	3	16		11	128	37.7	37.9	22.3	6.54		3.25	3.3	48	15	34	34	83	C	
	4	16		11	130	37.8	37.8	22.3	6.54		3.3	3.3	47	15	34	34	83	C	
I-G	1	17		10 5/8	154	40.2	40.6	24.1	6.3		3.35	3.32	45	15	34	34	83	C	Bright color and less lack of uniformity
	2	17		11 1/8	154	39.1	39.6	24.1	6.3		3.32	3.32	46	15	34	34	83	C	
	3	17		11	149	40.7	41.5	27.7	6.3		3.35	3.4	47	15	34	34	83	C	
	4	17		11 1/8	148	40.4	40.4	27.7	6.3		3.35	3.4	47	15	34	34	83	C	

TABLE 2

Treat- ment	Net Wt.		Drained Wt.		Juice Vol.	Juice Sol.		Fruit Sol. Solids	Color Reading		pH		Ten- der- om- eter	Grade Factors			Total Score	Grade	Remarks
						Solids			Optical Density					Col- or	Absence of Defects	Char- acter			
						Brix	Abbe		515mu	420mu	Juice	Fruit							
II-A-1	1	15	1/2	10	104	42.1	42.7	24	7.97	5.46	3.3	3.3	49	17	34	34	85	A	Light color
	2	15	1/2	10 1/2	104	43.7	44	24	7.97	5.46	3.32	3.3	51	17	34	34	85	A	Less lack of
	3	15	1/2	10 1/2	120	44	44.3	22.9	7.97	5.42	3.3	3.38	51	17	34	34	85	A	uniformity
	4	15	1/2	10 3/4	110	45.3	45.5	22.9	7.97	5.42	3.3	3.38	50	17	34	34	85	A	
II-A-2	1	15	1/2	10 1/4	128	43.3	43.7	23.4	8.5	4.94	3.32	3.32	50	17	34	34	85	A	Bright color and
	2	15	5/8	10 1/2	114	43.2	43.7	23.4	8.5	4.94	3.32	3.32	50	17	34	34	85	A	less lack of
	3	15	1/2	10 5/8	114	43.2	43.7	23.2	8.5	5.00	3.3	3.3	48	17	34	34	85	A	uniformity
	4	15	1/2	10 3/4	112	44.5	44	23.2	8.5	5.00	3.32	3.3	53	17	34	34	85	A	
II-A-3	1	15	7/8	10 1/2	115	45	45.5	25.4	9.3	5.16	3.32	3.3	51	17	34	34	85	A	Bright color and
	2	15	1/2	10 3/4	115	44.6	44.7	25.4	9.3	5.16	3.32	3.3	50	17	34	34	85	A	less lack of
	3	15	1/2	10 1/4	130	43	44.6	22.8	9.16	5.04	3.32	3.28	51	17	34	34	85	A	uniformity
	4	15	3/8	10 3/4	115	45.3	45.7	22.8	9.16	5.04	3.32	3.28	53	17	34	34	85	A	
II-F-1	1	16		10	145	36.7	37.5	22	7.68	4.72	3.3	3.4	51	17	34	34	85	A	Very bright
	2	16		10 3/4	134	37.1	37.5	22	7.68	4.72	3.32	3.4	50	17	34	34	85	A	color
	3	16		10 3/8	146	37.7	38.3	23	7.48	4.69	3.4	3.3	47	17	34	34	85	A	Slight lack of
	4	16		10 1/2	144	38.5	39.5	23	7.48	4.69	3.38	3.3	46	17	34	34	85	A	uniformity
II-F-2	1	16	1/8	10 1/2	144	37.4	38.1	22.7	6.91	4.52	3.4	3.38	46	17	34	34	85	A	Taste no off
	2	16		11	130	37.5	38.1	22.7	6.91	4.52	3.4	3.38	50	17	34	34	85	A	flavor
	3	16	1/8	10 3/4	134	37.2	38.4	23.4	6.91	4.55	3.4	3.38	47	17	34	34	85	A	Very bright col- or and slight
	4	16	1/8	10 3/4	139	37.9	37.9	23.4	6.91	4.55	3.4	3.38	48	17	34	34	85	A	lack of uniform- ity
II-F-3	1	16	1/8	10 1/2	146	37.7	38.3	23.1	6.91	4.66	3.4	3.38	46	17	34	34	85	A	Taste no off
	2	16	1/8	10 1/2	150	36.8	37.5	23.1	6.91	4.66	3.4	3.38	47	17	34	34	85	A	flavor
	3	16	1/8	10 1/2	147	36.4	36.8	21.5	7.35	4.63	3.4	3.38	50	17	34	34	85	A	Very bright col- or and slight
	4	16		10 3/4	134	38	38.3	21.5	7.35	4.63	3.4	3.38	48	17	34	34	85	A	lack of uniform- ity

TABLE 2

Treat- ment	Net Wt.		Drained Wt.		Juice Vol.	Juice Sol.		Fruit Sol. Solids	Color Reading		pH		Ten- der- om- eter	Grade Factors			Total Score	Grade	Remarks
						Solids			Optical Density					Col- or	Absence of Defects	Char- acter			
						Brix	Abbe		515mu	420mu	Juice	Fruit							
II-A-1	1	15	1/2	10	104	42.1	42.7	24	7.97	5.46	3.3	3.3	49	17	34	34	85	A	Light color
	2	15	1/2	10 1/2	104	43.7	44	24	7.97	5.46	3.32	3.3	51	17	34	34	85	A	Less lack of
	3	15	1/2	10 1/2	120	44	44.3	22.9	7.97	5.42	3.3	3.38	51	17	34	34	85	A	uniformity
	4	15	1/2	10 3/4	110	45.3	45.5	22.9	7.97	5.42	3.3	3.38	50	17	34	34	85	A	
II-A-2	1	15	1/2	10 1/4	128	43.3	43.7	23.4	8.5	4.94	3.32	3.32	50	17	34	34	85	A	Bright color and
	2	15	5/8	10 1/2	114	43.2	43.7	23.4	8.5	4.94	3.32	3.32	50	17	34	34	85	A	less lack of
	3	15	1/2	10 5/8	114	43.2	43.7	23.2	8.5	5.00	3.3	3.3	48	17	34	34	85	A	uniformity
	4	15	1/2	10 3/4	112	44.5	44	23.2	8.5	5.00	3.32	3.3	53	17	34	34	85	A	
II-A-3	1	15	7/8	10 1/2	115	45	45.5	25.4	9.3	5.16	3.32	3.3	51	17	34	34	85	A	Bright color and
	2	15	1/2	10 3/4	115	44.6	44.7	25.4	9.3	5.16	3.32	3.3	50	17	34	34	85	A	less lack of
	3	15	1/2	10 1/4	130	43	44.6	22.8	9.16	5.04	3.32	3.28	51	17	34	34	85	A	uniformity
	4	15	3/8	10 3/4	115	45.3	45.7	22.8	9.16	5.04	3.32	3.28	53	17	34	34	85	A	
II-F-1	1	16		10	145	36.7	37.5	22	7.68	4.72	3.3	3.4	51	17	34	34	85	A	Very bright
	2	16		10 3/4	134	37.1	37.5	22	7.68	4.72	3.32	3.4	50	17	34	34	85	A	color
	3	16		10 3/8	146	37.7	38.3	23	7.48	4.69	3.4	3.3	47	17	34	34	85	A	Slight lack of
	4	16		10 1/2	144	38.5	39.5	23	7.48	4.69	3.38	3.3	46	17	34	34	85	A	uniformity
II-F-2	1	16	1/8	10 1/2	144	37.4	38.1	22.7	6.91	4.52	3.4	3.38	46	17	34	34	85	A	Taste no off
	2	16		11	130	37.5	38.1	22.7	6.91	4.52	3.4	3.38	50	17	34	34	85	A	flavor
	3	16	1/8	10 3/4	134	37.2	38.4	23.4	6.91	4.55	3.4	3.38	47	17	34	34	85	A	Very bright col- or and slight
	4	16	1/8	10 3/4	139	37.9	37.9	23.4	6.91	4.55	3.4	3.38	48	17	34	34	85	A	lack of uniform- ity
II-F-3	1	16	1/8	10 1/2	146	37.7	38.3	23.1	6.91	4.66	3.4	3.38	46	17	34	34	85	A	Taste no off
	2	16	1/8	10 1/2	150	36.8	37.5	23.1	6.91	4.66	3.4	3.38	47	17	34	34	85	A	flavor
	3	16	1/8	10 1/2	147	36.4	36.8	21.5	7.35	4.63	3.4	3.38	50	17	34	34	85	A	Very bright col- or and slight
	4	16		10 3/4	134	38	38.3	21.5	7.35	4.63	3.4	3.38	48	17	34	34	85	A	lack of uniform- ity

TABLE 3

Treatment		Net Wt.	Drained Wt.	Juice Vol.	Juice sol. solids		Fruit sol. Solids	Color Reading Optical Density		pH		Ten- der- om- eter	Grade Factors			Total Score	Grade	Remarks
					Brix	Abbe		515mu	420mu	Juice	Fruit		Col- or	Absence of Defects	Char- acter			
III-A-1	1	15	10 1/2	91	43.7	43.6	25.1	8.35	5.46	3.3	3.3	48	14	34	33	81	C	Similar to IA
	2	15	10 7/8	83	44.2	44.1	25.1	8.35	5.46	3.3	3.3	52	14	34	33	81	C	
	3	15	10 5/8	97	46.4	46.3	25.7	8.35	5.46	3.3	3.3	50	14	34	33	81	C	
	4	15	10 1/2	110	43.4	43.8	25.7	8.35	5.46	3.25	3.3	53	14	34	33	81	C	
III-A-2	1	15	10 1/2	108	46.7	46.8	24	7.75	6.02	3.3	3.3	50	13	34	33	80	D	Browning was noticed and an oxidized off flavor
	2	14 3/4	10 1/2	103	46.3	45.8	24	7.75	6.02	3.28	3.3	51	13	34	33	80	D	
	3	15	10 1/2	102	44.6	44.5	25.5	7.75	5.98	3.28	3.3	54	13	34	33	80	D	
	4	15 1/8	10 3/4	108	44.4	44.3	25.5	7.75	5.98	3.3	3.3	52	13	34	33	80	D	
III-A-3	1	15 1/8	10 1/2	115	43.9	43.7	27.7	7.75	6.12	3.3	3.25	54	13	34	32	79	D	More browning and an oxi- dized off flavor
	2	15 1/8	10 1/2	120	44	43.6	27.7	7.75	6.10	3.3	3.25	55	13	34	32	79	D	
	3	15 1/4	10 1/4	120	44.5	44.5	23.3	8.74	6.08	3.32	3.3	53	13	34	32	79	D	
	4	15 1/4	10 1/2	115	41.6	41.4	23.3	8.74	6.10	3.32	3.3	54	13	34	32	79	D	
III-F-1	1	16	10 3/8	140	38.2	38.5	22.6	7.17	4.72	3.3	3.38	50	15	34	34	83	C	Similar to IF
	2	16	11	130	35.8	38.6	22.6	7.17	4.68	3.3	3.38	50	15	34	34	83	C	
	3	16 1/8	10 1/2	141	38	37.8	24	6.76	4.76	3.3	3.3	50	15	34	34	83	C	
	4	16 1/8	10 7/8	143	38	38.3	24	6.76	4.72	3.3	3.3	50	15	34	34	83	C	
III-F-2	1	16	10 3/8	151	36	36	25	6.45	4.93	3.3	3.25	55	14	34	33	81	C	Slight brown- ing and slight oxi- dized flavor
	2	16	10 7/8	142	35.9	35.7	25	6.45	4.97	3.3	3.25	54	14	34	33	81	C	
	3	16	10 5/8	142	35.2	35.5	25	7.64	4.89	3.3	3.3	50	14	34	33	81	C	
	4	16	10 1/2	150	36.8	36.3	25	7.64	4.93	3.3	3.3	54	14	34	33	81	C	
III-F-3	1	16	10 3/8	147	35.7	35.7	25	7.06	5.12	3.32	3.3	54	14	34	32	80	C	Dark color More browning and oxidized flavor
	2	16	10 1/2	152	33.8	33.6	25	7.06	5.12	3.32	3.3	54	14	34	32	80	C	
	3	16	10 1/2	145	35.8	35.9	23.1	7.10	5.2	3.32	3.3	53	14	34	32	80	C	
	4	16	10 1/2	144	35.9	35.9	23.1	7.10	5.16	3.32	3.3	51	14	34	32	80	C	

APPENDIX

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