Quality and Yield of Brined Cherries

Effect of Maturity at Harvest, Delay Before Brining, Brine Composition, Addition of Hardening Agents, and Prebrining

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AUTHORS: Darrell V. Beavers is Assistant Professor of Food Science and Technology, Oregon State University; Carl H. Payne, former Assistant in Food Science, Department of Food Science and Technology, Oregon State University, is Director of Research and Control, Willamette Cherry Growers Inc., 1520 Woodrow NE, Salem, Oregon; R. F. Cain is Professor of Food Science and Technology, Oregon State University.

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DARRELL V. BEAVERS, CARL H. PAYNE, and R. F. CAIN

INTRODUCTION

This bulletin reports on an extensive study during the 1968 and 1969 seasons of various factors that affect yield and quality of brined Royal Anne cherries. The following factors were investigated: maturity at time of harvest, length of delay between harvest and brining, composition of the brine, use of various additives and hardening agents in the brine, and the practice of prebrining hand harvested and mechanically harvested cherries in The Dalles and the Willamette Valley areas.

PREVIOUS WORK

Among the many factors affecting the quality of brined cherries is a condition known as solution pockets. A solution pocket is defined as an internal rupture of the flesh, normally extending from the pit to the skin of the cherry. The waxy skin of the fruit is not broken as in the defect known as "brine crack." The internal fracture is filled with brine and can be easily seen through the clear waxy skin as a translucent area. Solution pockets vary in size from very small to large; in the latter case, the pocket may extend from the cavity to the distal end of the fruit and may be up to 3 or 4 mm at its widest part. Initially such fruit is quite turgid. The stem end is no longer concave but is convex, so that the stem attachment appears as if it were pushed from the cherry. After equilibration, the only evidence of solution pockets is the translucent area under the skin. In most cases, the small (1 x 2 mm) solution pockets do not affect the quality or yield of the brined cherry. Large solution pockets may affect these factors, depending upon the entrance and exit points of the pitting needle. This quality factor has been under investigation for a number of years.

Cameron (1966) and Cameron and Westwood (1968) examined a number of factors related to solution pockets. They found no correlation between the incidence of solution pockets and either topographic location or soil type. Nitrogen, applied at the rate of 3 pounds per tree, did not affect the degree of solution pockets.

The work of Cameron and Westwood shows a positive correlation between solution pockets and the maturity of the fruit. In all cases, the degree of solution pockets increased with maturity. A second, and important, correlation was related to air temperature; i.e., the cooler the air temperature at harvest, the higher the incidence of solution pockets. In regard to the turgidity of the fruit, they reported that with fruit containing more than 18% soluble solids, the percentage of solution pockets was less if the fruit was picked later in the day. However, in cases where it rained, the fruit did not lose turgor and the incidence of solution pockets did not decrease.

Cameron and Westwood also reported that "prebrining" with sugar solution or alcohol to draw water from the fruit decreased solution pockets markedly. They noted that procedures to reduce the water content of the fruit before brining (picking late in the day or allowing the fruit to desiccate prior to brining) would help to alleviate solution pockets.

Stebbins, Cain, and Watters (1967) determined that brining immediately into SO_2 (sulfur dioxide) brine increased solution pockets. Cain and Smith (1968) studied the effect of advance in maturity (as defined by soluble solids) and holding prior to brining on the solution pockets in Royal Anne cherries grown in The Dalles, Oregon. They reported a positive correlation of incidence of solution pockets with increase in soluble solids and showed that as the fruit began to dry and "mummify" on the tree, the percentage of solution pockets decreased. They further showed that a delay of 12 hours prior to brining reduced the incidence of solution pockets.

In an attempt to circumvent the effect of turgor pressure on solution pockets, Cain and Smith (1968) resorted to the immediate brining of cherries in hypertonic or near-hypertonic solutions of sodium chloride. Accordingly, they utilized solutions of 1½, 3, 5, and 7% salt solutions. The 1½ and 3% salt solutions did not prevent the formation of solution pockets or protect against fermentation during a 24-hour holding period. The 5 and 7% salt solutions increased the drained weight (which presumably represents an intake of water). However, in spite of the weight increase, the formation of solution pockets decreased as the length of time in the salt "prebrine" increased. Solution pocket formation also decreased with increase in salt concentration.

GENERAL PROCEDURE

The texture and firmness of the cherry were measured by the Hunter Texture Instrument, as modified by Beavers, Payne, Soderquist, Hildrum, and Cain (1970). This instrument gives the force (in grams) required to compress the fruit 3/16 inch with a 7/16 inch disc. The reported texture values are the means of 40 cherries.

Solution pockets were classified as large or small, with large being designated as greater than 2 mm in length, or severe enough to cause weakening of the tissue support and softening.

The cherries were weighed, pitted on a Dunkley SP pitter, and reweighed to determine pitting loss. The pits were weighed separately to determine the percent of pits. The total weight loss was calculated (on the fresh fruit basis) as the sum of the desiccation loss, brine shrink, and pitting loss.

Calcium and SO_2 determinations were made in accordance with methods outlined by Payne, Beavers, and Cain (1969).

Defects determined by visual inspection were solution pockets, skin cracks, splits, torn pitter holes, unpitted fruit, soft fruit, and mechanical damage. Commercial quality grades (Nos. 1, 2, and 3), a combination of grades 1 and 2, and an unclassified grade (No. 4) were determined according to the Oregon Grade Standards for Sulfured Cherries issued by the Oregon State Department of Agriculture (1954).

EXPERIMENTAL RESULTS

Effect of Maturity and Delay Prior to Brining

One early-maturing and one late-maturing orchard of Royal Anne cherries were located near Salem, Oregon. Three uniform trees were selected in each orchard to provide the raw material for several of the 1968 studies reported herein. On June 19, 21, 25, and 28, fruit was randomly hand harvested in the morning from each of these trees. The fruit was brined after being sorted free of rotten, rain-cracked, bird-pecked, and stemless cherries. At each location and at each time of harvest, both mature and immature fruit were selected on the basis of degree of coloration and were brined separately. Maturity differences were confirmed later by the percent of soluble solids (as determined by the refractometer). Percent acid (calculated as malic) and pH also were determined on a representative ground sample. Brining was accomplished in one-pint glass jars on the basis of a 1:1 (brine:fruit) ratio. At each harvest date, fruit of each maturity was brined immediately and after holding at room temperature (75° F) for 6, 12, and 24 hours to permit loss of turgor. A standard 1.5% SO_2-Ca $(OH)_2$ brine at pH 2.7 was used throughout the study. Exact weights were determined for both fruit and brine. After four months of curing, the fruit was removed from the brine, wiped dry, and weighed. The percent brine shrink was calculated on the fresh fruit basis. Then the individual cherries were examined for solution pockets, skin cracking, and splitting.

The data were subjected to analysis of variance, where appropriate, to determine significant effects and the least significant differences. The statistical design was based on three replications, four dates of harvest, two maturities, and four delay-in-brining variables.

Results and discussion

The relationship of maturity to brining quality was examined over the entire harvest period and within individual harvest dates. At each date, mature and immature fruit were segregated on the basis of color, and the maturity was confirmed by the percent of soluble solids (Table 1).

Solution pockets. Effects of date of harvest, maturity, and delay in brining upon formation of solution pockets were highly significant at the one percent level (Table 2). The immature fruit (Table 1) did not exhibit solution pocketing until the fourth date of harvest when soluble solids of the cherries increased to 15.7%. In contrast, 10.8% of the mature cherries had solution pockets at the first harvest date, with a soluble solids content of 19.8% (Tables 1 and 2).

These results substantiated the earlier work of Cameron and Westwood (1968) and Cain and Smith (1968) indicating that advance in maturity, as expressed by the soluble solids, was associated with the degree of solution pockets and that the more mature cherries were more prone to exhibit this difficulty.

The effect of delay prior to brining upon the percent of solution pockets is shown in Table 3. The main effect occurred after a 12-hour delay; there was a 9.1% reduction in solution pockets during 12 hours holding, with only an additional 3.3% reduction in a 24-hour period.

During brining, the cherries absorb water until the tissue is killed by SO_2 and an osmotic equilibrium is reached. Desiccation during the delay prior to brining causes loss of water and turgor in the fruit. This permits the re-absorption of water into the tissue during brining without the development of solution pockets. The percent weight loss (desiccation) as a result of holding at 75° F for 24 hours is shown in Table 4.

Although each holding period resulted in a weight loss that was significantly different from the previous period, the effect on decreasing solution pocket development was not significant until the cherries had been held 12 hours (Table 3). The additional 3% weight loss during the 24-hour holding period (Table 4) gave a 3.3% decrease in solution pockets (Table 3). The critical period for significant reduction in solution pockets was the 12-hour holding period. Apparently, a definite amount of water must be lost before the formation of solution pockets is greatly decreased, and the subsequent losses of water do not bring about a proportional decrease in solution pockets.

Table 1. Harvesting Conditions, Percent Soluble Solids, Acid Content, and pH of Fresh Cherries

	Harvest dates									
	June 19		June 21		June 25		June 28			
Weather conditions	Light rain 1 hr. prior to picking		Slightly overcast		Clear and sunny		Cloudy			
Relative humidity, %	96		68		65		72			
Orchard temperature (°F)	61		60		75		56			
Picking time	10:30-11:30 a.m.		8-8:30 a.m.		8-8:45 a.m.		8:30-9 a.m.		Mean	
Maturity[1]	I	M	I	M	I	M	I	M	I	M
Soluble solids, %	14.1	19.8	14.1	20.0	14.1	21.3	15.7	22.8	14.5	21.1
Acid (as malic), %	0.70	0.65	0.63	0.64	0.70	0.66	0.68	0.71	0.68	0.69
pH	3.59	3.65	3.59	3.61	3.57	3.69	3.57	3.62	3.58	3.64

[1] I = immature, M = mature.

Table 2. PERCENT SOLUTION POCKETS AS AFFECTED BY HARVEST DATE AND MATURITY

	Harvest dates[1]				Maturity mean
	June 19	June 21	June 25	June 28	
Immature, %	0	0	1.7	8.3	2.5
Mature, %	10.8	10.2	23.8	47.9	23.2
Date mean, %[1]	5.4	5.1	12.7	28.1	......

[1] Least significant difference at the 1% level = 9.0.

Table 3. EFFECT OF DELAY PRIOR TO BRINING ON SOLUTION POCKETS, BRINE SHRINK, AND TEXTURE OF BRINED CHERRIES

	Hours holding time prior to brining				LSD .05[1]	LSD .01[2]
	0	6	12	24		
Solution pockets, %	19.5	14.4	10.4	7.1		9.0
Brine shrink, %	13.1	12.7	13.2	14.3	0.9	
Texture, gms, comp. force	643	654	665	671		13.1

[1] Least significant difference at the 5% level.
[2] Least significant difference at the 1% level.

Table 4. PERCENT WEIGHT LOSS DURING HOLDING PERIOD PRIOR TO BRINING

	Harvest dates								Mean[1]	
	June 19		June 21		June 25		June 28			
Maturity[2]	I	M	I	M	I	M	I	M	I	M
Zero hours holding time (control), %	0	0	0	0	0	0	0	0	0	0
6 hours holding time, %	0.8	1.3	2.9	2.8	2.7	2.5	1.7	1.7	2.0	2.1
12 hours holding time, %	2.9	2.7	4.6	4.6	4.2	4.4	3.3	3.5	3.7	3.8
24 hours holding time, %	5.2	5.5	7.0	8.1	7.5	7.9	5.8	7.1	6.4	7.1

[1] Least significant difference for time at the 1% level = 0.31.
[2] I = immature, M = mature.

Correlation coefficients ($n = 96$) were calculated between percent desiccation loss, delay in brining, and percent solution pockets.

Correlation Coefficients

Percent desiccation loss and delay prior to brining	+ 0.999
Percent solution pockets and delay prior to brining	− 0.972
Percent desiccation loss and percent solution pockets	− 0.980

These very high degrees of correlation indicate that solution pocket formation can be decreased by desiccation and by delay prior to brining.

Percent brine shrink. The percent brine shrink was not affected by a delay prior to brining until the 24-hour holding period, which showed an increase in brine shrink (Table 3). Apparently the effect of shriveling at the 24-hour holding period was so severe that the fruit did not entirely return to its original shape after brining.

As the harvest season progressed, there was a general reduction in brine shrink (Table 5). The brine shrink in the immature fruit was significantly less than in the mature fruit at the same harvest date.

Table 5. PERCENT BRINE SHRINK AS AFFECTED BY HARVEST DATES AND MATURITY

	Harvest dates				Maturity means[1]
	June 19	June 21	June 25	June 28	
Immature, %	13.2	13.9	12.8	10.6	12.6
Mature, %	15.9	15.8	14.1	10.2	14.0
Date means, %[2]	14.6	14.9	13.5	10.4	......

[1] Least significant difference at the 1% level = 0.6.
[2] Least significant difference at the 1% level = 0.9.

Interpretation of the data is rather enigmatic if one considers that harvest dates and maturity (as defined by percent soluble solids) are both indications of increasing maturity. The soluble solids content of the immature fruit is similar at each harvest date, and the soluble solids content of the mature fruit is also similar at each harvest date (Table 1), yet the brine shrink of both maturities progressively decreases at each harvest date. However, the percent of soluble solids may not give a true index of maturity. Evidence indicates that the percent of soluble solids reflects variations in climatic conditions such as sunshine, temperature, humidity, wind, and rain within a harvest season or between harvest years, rather than closely paralleling the actual fruit development.

Percent pitting loss. The percent pitting loss represents loss of liquid, flesh, and pit as a result of the pitting operation. This loss, as affected by harvest date and by maturity, is shown in Table 6.

Pitting loss progressively decreased as the harvesting season progressed and also decreased as the fruit matured. This decrease is probably due in part to the increase in ratio of flesh to pit size as maturity increases. These results are in agreement with the work of H. Y. Yang (1968).

Percent total loss. Percent total loss is defined as brine shrink plus pitting loss. The percent total loss progressively decreased throughout the harvest season (Table 6).

Table 6. PERCENT LOSS OF BRINED CHERRIES AS AFFECTED BY HARVEST DATE AND MATURITY

	Harvest dates				LSD .01[1]	Maturity		LSD .01[1]
	June 19	June 21	June 25	June 28		Immature	Mature	
Pitting loss, %	11.1	10.6	9.8	10.0	0.8	11.1	9.7	0.2
Total loss, %	25.7	25.5	23.3	20.4	1.1			

[1] Least significant difference at the 1% level.

Table 7. EFFECT OF HARVEST DATE AND MATURITY ON TEXTURE OF BRINED CHERRIES

	Harvest dates				Maturity mean[1]
	June 19	June 21	June 25	June 28	
	(grams compression force)				
Immature	772	731	684	648	709
Mature	636	649	579	565	607
Harvest mean[2]	704	689	631	607	......

[1] Least significant difference at the 1% level = 8.6.
[2] Least significant difference at the 1% level = 13.1.

Texture. As the season progressed, the fruit became less firm (Table 7). The more mature fruit was softer during the entire harvest season.

Texture increased slightly after a brining delay of 24 hours (Table 3), but the change was minor when compared to the effect of maturity and dates of harvest.

Summary

It was confirmed that solution pockets occur more frequently as the maturity increases and as the harvest season progresses. This apparently is due to a swelling of the cherry as it picks up water during the initial stages of brining. The greater weight increase with cherries of high soluble solids may be due to the equilibrating effect of osmosis and the resultant increase in turgor. Conditions which decrease the total water pick-up and decrease the turgor at equilibration should decrease the incidence of solution pockets. This was borne out by the beneficial effect of the desiccation of the cherries as a result of the holding time prior to brining.

The greatest effect upon decreasing solution pockets occurred at the 12-hour holding period. Increasing the holding time from 12 to 24 hours before brining had less effect upon decreasing solution pockets. Brine shrink, pitting loss, and total loss decreased as the harvest season progressed. Brine shrink increased slightly at the 24-hour holding period. Delay prior to brining had no effect upon pitting loss or total loss. Texture decreased as the harvest season progressed and as the fruit became more mature. Delay of 24 hours prior to processing resulted in a slight increase in texture.

Effect of Variation in Brine Composition

Brining variables of pH, SO_2 concentration, and neutralizing agents were investigated in 1968.

Three trees were selected in an orchard near Salem, Oregon, and cherries were harvested from 8 to 9:15 a.m. on June 27. Weather conditions were overcast and windy following two hot, sunnny days; relative humidity was 66% and orchard temperature was 65° F. The cherries were transported to Corvallis, and after six hours they were brined at a ratio of 1:1 (fruit:brine) on a weight basis. After curing for four months, they were carefully drained on a 1/8-inch mesh screen, wiped dry, and weighed. The loss in weight during brining (calculated on a fresh fruit basis) was designated as the brine shrink.

Variations in brine formulation and composition included pH ranges of 1.75, 2.00, 2.25, 2.50, 2.75, 3.00, 3.25, and 3.50, with SO_2 concentrations of 0.75, 1.00, 1.25, 1.50, and 2.00%. The brines were prepared with SO_2 gas and were partially neutralized to the various pH's with calcium hydroxide, calcium carbonate, magnesium hydroxide, or sodium hydroxide.

Fresh fruit analysis for percent soluble solids, acid content (calculated as malic), and pH are given in Table 8.

Table 8. PERCENT SOLUBLE SOLIDS, ACID CONTENT, AND pH OF FRESH CHERRIES

Tree no.	Soluble solids	Acid (as malic)	pH
	%	%	
1	22.7	.696	3.74
2	22.0	.671	3.65
3	22.1	.715	3.80
Mean	22.3	.695	3.73

Results and discussion

Fruit prepared with magnesium hydroxide brine was soft, cracked, split, and commercially unacceptable. Sodium hydroxide also produced soft, unacceptable fruit. Fruit processed in gaseous SO_2 brines below pH 2.25 and above 3.25 were seriously split and commercially unacceptable.

The only commercially acceptable cherries were prepared with calcium carbonate or calcium hydroxide brines within the pH range of 2.25 to 3.25. The subsequent statistical evaluation of these cherries follows:

Solution pockets. Many investigators have suggested that pH plays an important role in solution pocket formation. In this study it was determined that none of the variations in brining treatments (including pH) had a significant effect upon the formation of solution pockets. Solution pockets ranged from 15 to 62%, with an average of 45% in SO_2 brines containing calcium carbonate or calcium hydroxide. There was no change in solution pockets with change in pH, SO_2 concentration, or the neutralizing agents.

Percent brine shrink. Increasing the sulfur dioxide concentration had a highly significant effect upon decreasing the percent of brine shrink (Table 9). Brine shrink in the calcium hydroxide brines (Table 10) was significantly lower than in the calcium carbonate brines. None of the other treatments had an effect upon brine shrink.

Table 9. Brined Cherries as Affected by Sulfur Dioxide Concentrations of the Brine

	Percent sulfur dioxide					LSD
	0.75	1.00	1.25	1.50	2.00	.01[1]
Calcium in brine, ppm	1,147	1,421	1,735	2,025	2,557	.....
Brine shrink, %	14.3	13.9	13.6	13.2	11.8	1.5
Total loss, %	23.5	23.0	22.9	22.4	21.1	1.4
Texture, gms. comp. force	557	556	568	567	594	26.2

[1] Least significant difference at the 1% level.

Table 10. Percent Brine Shrink of Cherries as Affected by Calcium Carbonate or Calcium Hydroxide Brines

	Calcium carbonate	Calcium hydroxide
Brine shrink, %[1]	13.7	13.1
Calcium in brine, ppm	1,433	1,528

[1] Least significant difference at the 5% level = 0.6.

Although the brine shrink decreased with an increase in sulfur dioxide, it should be noted that the calcium content also increased as the SO_2 increased (Table 9). The decrease in brine shrink probably was brought about by the secondary effect of the increased calcium which is needed to partially neutralize the additional SO_2, rather than by the actual increase in SO_2.

The reason for the slightly lower brine shrink in the calcium hydroxide brines is not readily apparent, unless it can be accounted for by the slightly higher calcium content of the calcium hydroxide brines (Table 10).

Percent pitting loss. None of the brining treatments had a significant effect upon pitting loss. Pitting loss ranged from 8.8 to 9.6%, with an average of 9.1%.

Percent total loss. Increasing the sulfur dioxide concentration had a highly significant effect upon decreasing the percent total loss, probably as a result of its effect upon brine shrink (Table 9). Again, this effect may be due to the increase in calcium which is needed to partially neutralize the additional SO_2, rather than the actual increase in SO_2.

None of the other treatments had any effect upon total loss.

Texture. Increasing the sulfur dioxide concentration had a highly significant effect upon increasing the texture (Table 9). This increase in hardening is probably due to the additional calcium present in the higher concentration brines rather than the direct effect of sulfur dioxide concentration. This additional calcium can combine with the pectin and cause the increased firming, as suggested by Doesburg (1965).

Raising the initial pH of the brines had a highly significant effect upon increasing the texture (Table 11). The increase in calcium content of the brine as a result of increasing the pH from 2.25 to 2.75 provides additional calcium which can react with the pectin and increase the firming, as mentioned above.

Table 11. TEXTURE OF BRINED CHERRIES AS AFFECTED BY THE INITIAL pH OF THE BRINE

	Initial pH		
	2.25	2.75	3.25
Texture, gms. comp. force[1]	551	571	579
Calcium in brine, ppm	1,340	1,582	1,521

[1] Least significant difference for texture at the 1% level = 19.3.

The slight decrease in calcium content between pH 2.75 and 3.25 is to be expected, due to the formation of insoluble calcium sulfite at this pH (Payne, Beavers, and Cain, 1969).

The increase in firming at the higher pH (in spite of the lower calcium content) is directly attributable to less interference by the hydrogen ion, which allows more complete calcium binding of the pectin (Doesburg, 1965). The effect of more available calcium and more calcium binding with the pectin at the higher pH's accounts for the increase in texture.

Summary

Brining variables of pH, SO_2 concentration, and neutralizing agents had no effect upon solution pocket formation or upon pitting loss. Brines neutralized with magnesium and sodium hydroxide did not produce commercially acceptable cherries. Brine shrink and total loss decreased and the texture became more firm as the SO_2 concentration increased. This was probably due to the secondary effect of increased calcium, rather than a direct result of SO_2 concentration. Later in this bulletin these same effects upon brine shrink, total loss, and texture are shown to occur as a result of added calcium from calcium chloride. Raising the initial pH of the brine caused an increased firming of the cherries. This was probably due to increased calcium content of the brine and more complete calcium binding of the pectin as a result of less interference by the hydrogen ion.

Addition of Hardening Agents

Three trees were selected in an orchard near Salem, Oregon, and were hand harvested on July 3 and July 15, 1968. Three maturities were selected from the two dates of harvest. Maturity differences were later confirmed by percent soluble solids (as determined by refractometer).

The cherries were transported to Corvallis, and six hours after picking they were placed in brines with added hardening agents as listed below. Fruit was brined at a ratio of 1:1 (brine:fruit) on a weight-to-weight basis. A series of brines was prepared by adding calcium chloride to a 1.25% SO_2 solution at levels of 0.5, 1.0, 1.5, 2.0, and 3.0%. Similar brine series were prepared using magnesium chloride and alum (potassium aluminum sulfate). After the hardening agents were added, these brines were adjusted to pH 2.75 with calcium hydroxide, calcium carbonate, and sodium hydroxide respectively.

Controls consisted of cherries brined in a 1.25% SO_2 brine which was adjusted to pH 2.75 with calcium hydroxide or calcium carbonate. No calcium chloride, magnesium chloride, or alum was added.

The experimental data on the calcium carbonate and calcium hydroxide neutralized brines were subjected to analysis of variance, and two least significant difference figures were calculated. "Control least significant difference" is used to determine significant differences between the control and treatments. "Treatment least significant difference" is used to determine significant differences between treatments only.

Table 12. HARVESTING CONDITIONS, PERCENT SOLUBLE SOLIDS, ACID CONTENT, AND pH OF FRESH CHERRIES

	Harvest dates		
	July 3		July 15
Weather conditions	Slightly cloudy		Cloudy after rain previous day
Relative humidity, %	76		75
Orchard temperature (°F)	67		62
Picking time	8:30 to 10:50 a.m.		8:30 to 10:00 a.m.
Maturity	Immature	Mature	Overmature
Soluble solids, %	15.2	19.6	22.3
Acid (as malic), %	0.78	0.73	0.8
pH	3.58	3.62	3.60

Harvesting conditions and fresh fruit analyses for percent soluble solids, acid content (calculated as malic), and pH are given in Table 12.

Results and discussion

All of the cherries processed with added magnesium chloride were cracked so severely that they were completely unacceptable for commercial usage.

The cherries processed in sodium hydroxide adjusted brines were generally soft. However, the sodium hydroxide brine with 2% added alum produced commercially acceptable cherries with a texture of 600 grams, a brine shrink of 2.7%, a pitting loss of 9.1%, and a total loss of 12.4%.

Solution pockets. As indicated in Table 13, solution pockets increase with maturity. The overmature fruit did not give a significant increase in solution pockets and this may be due to the fact that the

Table 13. BRINED CHERRIES AS AFFECTED BY MATURITY

	Immature	Mature	Over-mature	LSD .05[1]	LSD .01[2]
Soluble solids, %	15.2	19.6	22.3		
Solution pockets, %	32.8	40.3	39.8	7.5	
Pitting loss, %	9.4	9.4	8.3		0.4
Total loss, %	17.8	18.3	16.5		1.3
Texture, gms. comp. force	629	616	504		16.2

[1] Least significant difference at the 5% level.
[2] Least significant difference at the 1% level.

fruit was slightly shriveled when picked and was flaccid rather than turgid.

Statistically there is a highly significant difference between the effect of adding calcium chloride or alum upon the formation of solution pockets in brined cherries (Table 14). Although calcium chloride decreased solution pockets slightly and alum increased solution pockets slightly, neither treatment was significantly different from the control. Therefore, it must be concluded that additions of calcium chloride or alum in concentrations of 0.5 to 3.0% do not affect solution pocket formation.

Table 14. Brined Cherries as Affected by Added Calcium Chloride or Alum

	Treatments			Control versus treatments		Within treatments
	Control	Calcium chloride	Alum	LSD .05[1]	LSD .01[2]	LSD .01[1]
Solution pockets, %	39.5	31.7	43.5	10.8		6.2
Brine shrink, %	13.3	10.6	6.5		2.5	1.1
Pitting loss, %	9.5	9.2	8.8	0.6		0.3
Total loss, %	22.8	19.9	15.3		2.5	1.1
Texture, gms. comp. force	577	601	565	21.8		12.5

[1] Least significant difference at the 5% level.
[2] Least significant difference at the 1% level.

The effect of maturity combined with added calcium chloride or alum and their concentrations was a slight increase in solution pocket formation with increasing maturity. However, the most important factor is the effect of maturity, and any other effects indicated statistically were only minor.

Percent brine shrink. There was a highly significant decrease in brine shrink as a result of added calcium chloride or added alum (Table 14). Increasing the concentrations caused a progressive decrease in brine shrink (Table 15). None of the other factors had an effect upon brine shrink.

Additions of both calcium chloride and of alum greatly reduced the brine shrink (Table 14). Calcium chloride gave a highly significant decrease from the control at the 1.5% concentration level and higher (Table 15). Alum gave a highly significant decrease from the control at the 0.5% concentration level and higher (Table 15).

Percent pitting loss. Calcium chloride treatment did not have a significant effect upon pitting loss (Table 14) nor did it show much difference at the three maturity levels (Table 16), although pitting loss decreased significantly in the overmature fruit (Table 13).

Table 15. BRINE SHRINK, TOTAL LOSS, AND TEXTURE AS AFFECTED BY CONCENTRATION LEVELS OF CALCIUM CHLORIDE OR ALUM IN BRINE

	Concentration levels of calcium chloride, %						Control versus treatments	Within treatments	Concentration levels of alum, %						Control versus treatments	Within treatments
	0[1]	0.5	1.0	1.5	2.0	3.0	LSD .01[2]	LSD .01[2]	0[1]	0.5	1.0	1.5	2.0	3.0	LSD .01[2]	LSD .01[2]
Brine shrink, %	13.3	13.1	11.5	9.8	9.6	9.8	2.6	2.3	13.3	10.1	7.8	6.4	5.1	4.5	2.6	2.3
Total loss, %	22.8	22.4	20.6	19.2	18.8	18.9	2.7	2.4	22.8	19.3	16.5	15.1	14.4	13.3	2.7	2.4
Texture, gms. comp. force	577	593	615	618	615	614	29.5	28.0								
Calcium, ppm	1,513	2,379	3,177	4,191	4,777	6,431										

[1] Control.
[2] Least significant difference at the 1% level.

Alum treatment resulted in a pitting loss significantly lower than the control (Table 14). With overmature cherries, alum was more effective than calcium chloride in reducing pitting loss (Table 16).

The decrease in pitting loss with increasing maturity (Table 16) can be accounted for by the increase in flesh to pit ratio as the cherry becomes more mature.

Table 16. EFFECT OF ADDED HARDENING AGENTS AND MATURITY ON PITTING LOSS

Hardening agents	Percent pitting loss		
	Immature	Mature	Overmature
	%	%	%
Calcium chloride	9.4	9.5	8.8
Alum	9.3	9.3	7.9

Percent total loss. Additions of calcium chloride or alum to the brines gave a highly significant reduction in the total loss of the brined cherries (Table 14). The total loss was highly significantly decreased with increasing concentration levels of calcium chloride or alum in the brines (Table 15). Total loss decreased in the overmature fruit (Table 13). None of the other factors had an effect upon total loss.

Cherries brined in alum-treated brines had less total loss in all cases than did the cherries in brines treated with calcium chloride (Table 15). Cherries brined in calcium chloride or alum brines had a highly significant decrease in total loss from that of the control (Table 14). Calcium chloride brines effected a highly significant decrease at the 1.5% concentration level, with a progressive decrease at all higher concentrations (Table 15). Alum brine gave a highly significant decrease of total loss at the 0.5% concentration level, with a progressive decrease at all higher concentrations (Table 15). Total loss decreased with maturity (Table 13). This, again, was probably due to the increase in flesh to pit ratio as the fruit ripened.

Texture. The use of calcium chloride resulted in a significant increase in texture when compared to the control, but alum did not change the texture (Table 14). Calcium chloride gave a highly significant increase in texture from the control at the 1% concentration level (Table 15). Increasing the calcium chloride concentration above 1% had no effect upon firmness (Table 15). The calcium content of the fruit at the 1% level of added calcium chloride was approximately 3,200 ppm (Table 15). Although the calcium content increased with higher concentrations of added calcium chloride, apparently the carboxyl groups on the pectin chains were almost completely saturated with calcium at the 3,200 ppm level. Additional calcium did not form additional calcium-pectin bonding and thus did not give increased firming.

Although texture progressively decreased as maturity increased (Table 13), calcium chloride increased the firming effect at all maturities at concentration levels of 0.5 to 3.0% (Table 17).

Table 17. TEXTURE OF BRINED CHERRIES AS AFFECTED BY MATURITY AND ADDITION OF CALCIUM CHLORIDE

	Immature		Mature		Overmature	
	Control	Calcium chloride	Control	Calcium chloride	Control	Calcium chloride
Texture, gms. comp. force	615	643	600	637	515	522

Summary

Solution pockets increased with increasing maturity. None of the treatments with hardening agents produced an important effect upon solution pocket formation.

Brine shrink decreased with additions of calcium chloride or alum, and the decrease in shrink became greater with increasing concentrations. Alum gave the least shrink in all instances. None of the other treatments with hardening agents had an effect upon brine shrink.

Pitting loss decreased with maturity, probably as a result of increasing flesh to pit ratio. Addition of alum decreased the pitting loss.

Total loss decreased with additions of calcium chloride or alum, with increasing concentrations of either salt, and with increasing maturity.

Texture increased with calcium chloride additions up to and including 1% (3,200 ppm of calcium). Further additions of calcium chloride did not increase firming. Alum additions had a negligible effect upon texture during the 1968 season. Texture decreased as the fruit matured.

Addition of Dextrose to Brines

Cherries were hand harvested from two orchards near Salem, Oregon, on July 15 and 19, 1968, and were handled as described previously. Harvesting conditions and fresh fruit analyses are given in Table 18.

Dextrose in concentrations of 2.0, 4.0, 6.0, 9.0, and 12.0% were added to both calcium carbonate and calcium hydroxide brines which had an SO_2 content of 1.25% and a pH of 2.75. Cherries in these brines were examined subsequently for solution pockets, brine shrink, pitting loss, and total loss. The data were not examined statistically.

Table 18. HARVESTING CONDITIONS, PERCENT SOLUBLE SOLIDS, ACID CONTENT, AND PH OF FRESH CHERRIES

	Harvest dates	
	July 15	July 19
Weather conditions	Cloudy after rain previous day	Raining
Relative humidity, %	75	95
Orchard temperature (°F)	62	55
Picking time	8:30 to 10 a.m.	8:15 to 9:30 a.m.
Soluble solids, %	22.3	19.8
Acid (as malic), %	0.80	0.76
pH	3.60	3.60

Results and discussion

Addition of dextrose to brines increased cherry firmness at all levels of concentration.

When 6 to 12% dextrose was added, the solution pockets decreased by one-half in calcium hydroxide brines (Table 19) and by one-third in calcium carbonate brines (Table 20).

Brine shrink and total loss increased in the calcium carbonate brines but decreased in the calcium hydroxide brines (Tables 19 and 20); however, these effects may not be significant.

Table 19. EFFECT OF ADDITION OF DEXTROSE TO SULFUR DIOXIDE BRINES CONTAINING CALCIUM HYDROXIDE

Added dextrose	Texture (gms. comp. force)	Calcium	Solution pockets	Brine shrink	Pitting loss	Total loss
%		*ppm*	%	%	%	%
0	406	1,852	37.5	14.4	8.6	23.0
2	522	1,953	27.5	13.8	8.1	23.0
4	534	1,885	32.5	14.6	8.2	22.8
6	518	1,864	17.5	13.6	7.9	21.5
9	507	1,804	17.5	13.4	8.0	21.4
12	535	1,801	17.5	13.1	8.0	21.1

Table 20. EFFECT OF ADDITION OF DEXTROSE TO SULFUR DIOXIDE BRINES CONTAINING CALCIUM CARBONATE

Added dextrose	Texture (gms. comp. force)	Calcium	Solution pockets	Brine shrink	Pitting loss	Total loss
%		*ppm*	%	%	%	%
0	510	2,160	27.5	13.2	8.6	21.8
2	545	1,996	25.0	14.4	8.9	23.2
4	534	1,973	17.5	14.7	8.3	23.0
6	558	2,011	12.5	14.8	8.1	22.9
9	559	1,880	17.5	15.0	7.7	22.8
12	579	1,849	17.5	15.0	7.8	22.8

Prebrining Hand Harvested Fruit in the Willamette Valley

As indicated in the experiments on delay prior to brining, swelling of the fruit during the brining operation is believed to be the cause of solution pocket formation. It was determined in the delay prior to brining experiments that dehydration or desiccation prior to brining decreased solution pocket formation. In an attempt to dehydrate the fruit by osmosis (thereby substantially reducing the subsequent swelling), hand-harvested fruit was placed in salt or sugar solutions for several hours prior to brining in regular SO_2 brine. Such brines were termed prebrines.

Fruit was hand harvested on July 10 and 19, 1968, from orchards near Salem and transported to Corvallis. Weather conditions, percent soluble solids, acid content (as percent malic), and pH are listed in Table 21.

Six hours after harvesting, the fruit was placed in prebrining solutions of 1.0, 2.0, 3.0, 4.0, 6.0, and 8.0% calcium chloride, sodium

Table 21. HARVESTING CONDITIONS, PERCENT SOLUBLE SOLIDS, ACID CONTENT, AND pH OF FRESH CHERRIES

	Harvest dates	
	July 10	July 19
Weather conditions	Overcast	Raining
Relative humidity, %	72	95
Orchard temperature (°F)	67	55
Picking time	8:30 to 10:30 a.m.	8:15 to 9:30 a.m.
Soluble solids, %	24.3	19.8
Acid (as malic), %	0.78	0.76
pH	3.65	3.60

chloride, alum, and a mixture of 3.0% calcium chloride and 3.0% sodium chloride. Dextrose concentrations of 2.0, 4.0, 8.0, 12.0, 16.0, and 20.0% also were used. The fruit was immersed in the various solutions for 6, 12, 24, 48, and 72 hours, then removed and placed in a calcium hydroxide-SO_2 brine at pH 2.75 and a concentration of 1.25% SO_2.

Results and discussion

Fermentation occurred in the various brines of 4% and lower salt concentrations during a 40- to 60-hour holding period at room temperature. Cracking of the fruit generally occurred, and solution pocket formation was not decreased; therefore, data regarding these lower salt brines are not reported.

Fruit immersed (prebrined) in calcium chloride prior to conventional SO_2 brining had less solution pockets and was very firm, but the cherries were completely unacceptable due to dark brown discolorations. Apparently the polyphenoloxidase enzyme systems were not inactivated by the calcium chloride.

Cherries prebrined in alum were so badly cracked as to be completely unacceptable, as were the cherries immersed in dextrose sugar solutions. Cherries held 48 hours in 16% dextrose had 55% deep splits, and cherries in 20% dextrose had 25% splits.

Cherries prebrined in 6 and 8% sodium chloride were bright in color and showed a greatly reduced percentage of solution pockets. The fruit was rather soft and flaccid upon removal from the brine, but it firmed up rapidly after being placed in the standard SO_2 brine.

Cherries prebrined in a mixture of 3% sodium chloride plus 3% calcium chloride had as bright a color as the fruit prebrined in sodium chloride, were firmer at all stages of the process, and had fewer solution pockets.

Table 22 lists the data on the 6 and 8% sodium chloride prebrines and the mixture of 3% sodium chloride and 3% calcium chloride prebrine.

Maximum benefit for solution pocket control and texture occurred at the 24-hour holding period in the sodium chloride prebrine. Holding the fruit in the sodium chloride prebrine for a period of 48 hours increased the weight pick-up of the fruit and resulted in an increase in the percentage of large solution pockets. Holding the fruit 48 hours in the prebrine mixture of 3% calcium chloride and 3% sodium chloride did *not* give an increase in solution pockets.

Although the total loss was less in the 6% sodium chloride prebrines than in the 3% sodium chloride plus 3% calcium chloride prebrine, the mixture was considered preferable from the standpoint of the increased solution pocket protection at the 48-hour period and from

Table 22. Effect of Various Salt Brines When Used Prior to Standard Sulfur Dioxide Brining

Harvest date	Holding time	Weight gain	Solution pockets: Large	Solution pockets: Small	Small splits and cracks	Brine shrink	Pit loss	Total loss	Texture (gms. comp. force)
	hrs.	%	%	%	%	%	%	%	
Control (standard SO_2 brine) Soluble solids of fresh cherries 24.3%									
7-10	....	....	41	17	3	12.4	10.1	22.5	530
6% sodium chloride (prebrine)									
7-10	6	1.1	25	20	5	10.5	10.0	20.5	555
7-10	12	1.6	15	15	0	9.4	9.3	18.7	554
7-10	24	3.8	5	20	0	10.6	8.9	19.5	561
7-10	48	8.6	20	15	0	6.2	9.3	15.5	587
8% sodium chloride (prebrine)									
7-10	6	0.6	35	10	0	10.8	9.6	20.0	552
7-10	12	1.6	15	30	0	8.8	9.7	18.5	562
7-10	24	2.9	30	10	0	8.4	9.3	17.7	536
7-10	48	4.6	20	25	0	9.3	9.9	19.2	529
Control (standard SO_2 brine) Soluble solids of fresh cherries 19.8%									
7-19	....	....	37	10	20	13.5	9.6	23.1	471
6% sodium chloride (prebrine)									
7-19	6	0.6	30	5	15	11.0	9.0	20.0	488
7-19	24	2.0	5	15	5	10.3	8.3	18.6	549
7-19	48	4.4	15	20	0	8.6	8.2	16.8	535
3% sodium chloride plus 3% calcium chloride (prebrine)									
7-19	6	1.8	15	10	20	12.4	8.3	20.7	516
7-19	24	2.0	5	5	0	11.7	8.4	20.1	590
7-19	48	4.4	5	10	0	10.7	8.6	19.3	572

problems involved in commercial handling. Upon removal from the sodium chloride prebrines, the cherries were soft and flaccid and could easily be mashed and crushed when they were dumped, drained, and pumped. The fruit treated with the 3% sodium chloride plus 3% calcium chloride prebrine was hard and firm and would not be damaged easily during handling. The final increase in texture is also an important factor.

In the Willamette Valley, the 6 and 8% prebrines did not dehydrate the hand-harvested fruit and produced an actual weight loss. The prebrines gave good solution pocket control at the 24-hour period, although there was a slight gain in weight. The weight uptake of the cherries decreased as the brine strength increased, as evidenced by the fact that the 24-hour weight gain in the 1, 2, 3, 4, 6, and 8% prebrines were 12.6, 10.1, 8.0, 6.9, 3.8, and 2.9% respectively (data not shown in Table 22).

Summary

Calcium chloride prebrines reduced solution pocket formation, but the polyphenoloxidase enzymes apparently were not inactivated as the cherries were seriously discolored.

Cherries prebrined in salt concentrations below 4%, alum solutions, or dextrose solutions were severely cracked.

Six and eight percent NaCl reduced solution pockets at the 24-hour period, but solution pockets increased slightly at the 48-hour period. Initially, the fruit was soft, but it firmed up in the standard SO_2 brine.

The prebrine mix of 3% NaCl plus 3% $CaCl_2$ decreased solution pockets at the 24- and 48-hour periods. The fruit was bright colored and firm at all stages of the process.

Prebrining Mechanically Harvested Cherries in the Willamette Valley

Mechanical harvesting of cherries in the Willamette Valley in 1969 progressed from small, primarily experimental lots to the harvesting of considerable acreages with 26 harvesters of various makes. Handling this large volume presented problems of retaining cherry quality. Based upon previous work (Stebbins, Cain, and Watters, 1967; Cain and Smith, 1968), the fruit was brined immediately into bins at the harvester to prevent oxidation and darkening. However, the increase in solution pockets resulting from brining immediately in SO_2 brine prompted an investigation regarding the use of prebrines.

An experiment was set up to compare the quality of Royal Anne cherries brined immediately into sulfur dioxide brine (control) and into two different prebrines. The sulfur dioxide brine consisted of

1.4% sulfur dioxide partially neutralized to pH 2.8 to 3.0 with calcium hydroxide, and the prebrines consisted of 6% sodium chloride and a mix of 3% sodium chloride and 3% calcium chloride. Fruit was selected in the orchard so that each of the experimental brine bins contained fruit of comparable size and maturity.

Due to liquid spilling from the bins in the orchards and during transit, it was impossible to obtain the weight of fresh fruit in each bin. *All* of the bins were held 24 hours after picking and were drained by dumping onto the continuous belt of an automatic scale. The belt consisted of an elongated wire mesh approximately 1/8 to 1/4 inch wide and one inch long and was arranged to give five to six openings per square inch. The draining area was 4 feet wide by 13 feet long. Cherries were drained approximately one minute, or until the continuous read-out on the scale indicated that the drained weight of the fruit was decreasing at a rate of less than two pounds per minute. The fruit was then transferred into a standard 1.4% sulfur dioxide-calcium hydroxide brine at pH 2.8 to 3.0 and was allowed to equilibrate five months before evaluation. Approximately 15 pounds of fruit from each experimental bin were used for evaluation.

Since the purpose of the experiment was to determine if one brining procedure was better than another, the experiment was set up to encompass the wide range of variables which would be encountered in commercial production. Four orchards were harvested in sequence on June 18, 22, 24, and 25, 1969. Two orchards were harvested by a limb shaker and two by a trunk shaker. Experimental samples were harvested in the morning and in the afternoon whenever weather conditions permitted. Aside from an approximately 13% decrease of attached stems and a 7% decrease in solution pockets in the afternoon samples (Appendix Table 1), no appreciable difference could be observed between morning and afternoon harvesting. In the statistical analysis, the effects of different orchards, dates of harvest, type of shaker, and hour of harvest were combined; thus, the effects to be presented comprise those due to prebrine irrespective of other variables.

Results and discussion

In order to compare treatments, the means of the experimental results and their statistical significance are listed in Table 23.

Since it was impossible to obtain the fresh fruit weight, percentages were calculated on the basis of the drained weight which was obtained after five months in brine. The "brine shrink" (Table 23) is the difference in drained weights of the fruit after 24 hours in the prebrines or control SO_2 brines and after five months in the SO_2 brines. The least significant difference (LSD) was calculated at the 5 and 1% levels.

Table 23. EFFECT OF STANDARD SULFUR DIOXIDE BRINE AND PREBRINES UPON GRADE AND QUALITY OF MECHANICALLY HARVESTED BRINED CHERRIES

Brine and prebrine treatments	Brine pH	Soluble solids	Brine shrink	Pitting loss	Pits	Texture (gms. comp. force)	Soft fruit	Pitter holes No. 2 grade	Pitter holes No. 3 grade	Unpitted
		%	%	%	%		%	%	%	%
SO_2 (control)	3.25	16.33	24.65	13.88	8.83	346.3	14.25	3.30	2.58	1.30
6% NaCl (salt)	3.38	15.27	18.10	14.53	8.68	396.7	20.33	4.33	3.42	2.87
3% NaCl plus 3% $CaCl_2$ (mix)	3.34	15.43	19.27	13.22	8.61	421.5	10.47	2.38	2.63	0.93
LSD (.05)	0.12	2.04	5.14	1.60	0.69	55.3	5.15	1.65	1.41	1.68
LSD (.01)	0.17	2.91	7.31	2.28	0.98	78.6	7.32	2.35	2.00	2.39
Control versus salt	*	NS	*	NS	NS	NS	*	NS	NS	NS
Control versus mix	NS	NS	*	NS	NS	*	NS	NS	NS	NS
Salt versus mix	NS	NS	NS	NS	NS	NS	**	*	NS	*

	Attached stems	Solution pockets	Brine cracks	Mechanical damage	Rain cracks	Grades No. 1	Grades No. 2	Grades No. 3	Grades No. 4
	%	%	%	%	%	%	%	%	%
SO_2 (control)	53.25	20.42	7.67	6.33	19.75	60.5	7.7	22.3	9.5
6% NaCl (salt)	53.67	14.58	2.92	6.58	15.42	68.0	8.5	13.2	10.3
3% NaCl plus 3% $CaCl_2$ (mix)	54.92	10.25	0.83	3.50	23.75	71.1	8.8	12.8	7.3
LSD (.05)	12.17	5.55	8.87	4.62	8.57	7.95	2.61	8.51	5.58
LSD (.01)	17.31	7.9	12.61	6.57	12.19	11.31	3.71	12.11	7.93
Control versus salt	NS	*	NS	NS	NS	NS	NS	*	NS
Control versus mix	NS	**	NS	NS	NS	*	NS	*	NS
Salt versus mix	NS	NS	NS	NS	NS	NS	NS	NS	NS

LSD (.05) = least significant difference at the 5% level.
LSD (.01) = least significant difference at the 1% level.
* = significant at the 5% level.
** = significant at the 1% level.
NS = no significance.

Statistically, the pH of the SO_2 (control) is lower than that of the 6% salt solution, but from an operational standpoint all of the pH's can be considered to be identical. The "brine shrink" was significantly less than the control in both the 6% sodium chloride prebrine and in the mixture of 3% sodium chloride and 3% calcium chloride. The texture of the fruit in the 3% NaCl plus 3% $CaCl_2$ mix was more firm than in either the SO_2 control or the 6% NaCl. The percentage of soft fruit was significantly greater in the NaCl than in the control. The percentage of soft fruit in the mix was slightly (but not significantly) less than in the SO_2 control, so these two treatments must be considered to be identical in this respect.

The percentage of No. 2 grade pitter holes and of unpitted fruit was significantly greater in the 6% NaCl than in the 3% NaCl plus 3% calcium chloride mix, but none of the treatments were different from the SO_2 control. Cherries prebrined with 6% NaCl had significantly less solution pockets than those in the SO_2 control, and cherries prebrined with the 3% NaCl plus 3% $CaCl_2$ mix gave a highly significant decrease in solution pockets when compared to the SO_2 control. Treatment with the 3% NaCl plus 3% $CaCl_2$ mix significantly increased the percentage of No. 1 grade fruit and significantly decreased the percentage of No. 3 grade fruit when compared to the SO_2 control. The 6% NaCl treatment decreased the percentage of No. 3 grade fruit but had no significant effect upon the other grades. There was no difference in any of the other quality attributes as a result of treatment with the standard SO_2 brine (control) or with the prebrines (6% NaCl or the 3% NaCl plus 3% $CaCl_2$ mix) (Table 23).

Two prebrine samples of 3% calcium chloride plus 6% sodium chloride (Appendix Table 1) were compared to the other treatments. This 9% mix gave almost the same fruit quality as the 6% mix in all respects, indicating that additional sodium chloride was not beneficial. Perhaps additional calcium chloride in the mix would be helpful.

Summary and conclusions

The 6% NaCl prebrine decreased the brine shrink, caused an increase in soft fruit, slightly increased No. 2 grade pitter holes and unpitted fruit, decreased solution pockets, and decreased No. 3 grade fruit.

The 3% NaCl plus 3% $CaCl_2$ prebrine decreased brine shrink, increased texture, decreased the soft fruit slightly but not significantly, slightly decreased No. 2 grade pitter holes and unpitted fruit, increased No. 1 grade fruit, and decreased No. 3 grade fruit.

Although the 6% NaCl prebrine produced some desirable changes in quality, the fact that it significantly increased the percentage of soft fruit indicates that it is inferior to the SO_2 control. The 3% NaCl plus

3% $CaCl_2$ prebrine increased texture, slightly decreased soft fruit, and was either better than or equal to the standard SO_2 control brine in all of the other quality attributes, indicating that it is a superior treatment. The most important attribute of the 3% NaCl plus 3% calcium chloride mix is the immediate hardening effect it produces, whereas the other two treatments produced an initial softening effect. This initial hardening effect is desirable in commercial handling, as the fruit is less likely to be damaged by dumping, draining, weighing, and pumping to large storage tanks. It is suggested that the prebrine concentration be increased from 6% to possibly 8 or 10% and that the calcium chloride (in the mixture) be increased to 60% of the total.

These prebrines will mold or ferment, and it would be a dangerous policy to re-use the prebrines without pasteurization. However, if the salt concentration were adjusted to the original level and the prebrine flash pasteurized to 190° F and flash cooled, the brine could be re-used several times before it picked up sufficient polyphenols and anthocyanins to present a color problem. Pasteurization also would eliminate any danger of enzymatic softening which might be carried over from one lot to another (Beavers and others, 1970).

The experimental data from which the means were taken for statistical analyses in Table 23 are included in Appendix Table 1.

Prebrining Mechanically Harvested Cherries in The Dalles

Arrangements were made to mechanically harvest Royal Anne cherries from three orchards in The Dalles area and test the effectiveness of two prebrine solutions upon the quality of the fruit. The cherries were harvested on a Roberts machine (a limb shaker) on June 19, 24, and 30, 1969, at 5:30 to 10:30 a.m. At each date, a different orchard was used. The cherries harvested on June 19 and 24 were slightly to full colored and approaching full maturity, whereas those harvested June 30 at a higher elevation were immature.

Pre-weighed drums containing weighed brine or prebrine solutions were taken to the orchard the day before the cherries were harvested. The drum was mounted on the harvester, and the fruit was brined immediately after harvest. Fruit from one to three trees were required to fill a drum, depending upon the fruit load and the percent of fruit harvested. At each date two drums of each of the following solutions were filled randomly with fruit:

- ✓ Control—1.25% SO_2 calcium carbonate brine at pH 2.7;
- ✓ 7% by weight of sodium chloride solution; and
- ✓ 3.5% by weight each of sodium chloride and calcium chloride.

The filled drums were transported to the brining plant, where the control brine drums were placed directly into storage. The prebrine drums were held 24 hours prior to final SO_2 calcium brining and then placed in storage. The filled drums, as received from the orchard, were weighed and the weight of the fresh fruit was calculated. This varied between 210 to 270 pounds fruit per drum. After 24 hours, those cherries in the prebrine solutions were drained by dumping them into a gate-sided half tote ($42\frac{1}{2}'' \times 42\frac{1}{2}'' \times 12''$), tipping the tote 6 inches on one side and allowing the cherries to drain five minutes. Then the cherries were dumped into a second pre-weighed drum containing SO_2 solution (same as the control brine) and re-weighed to determine the change in weight due to prebrining. Those cherries initially harvested into the SO_2 brine were not drained and weighed.

Following a storage period of six months, all drums were drained and weighed, as explained above. The cherries from each drum were separately pitted and graded (Oregon Brined Grade Standards) into combination grade, No. 3, unclassified, and pieces. Weights of these classifications and the recoverable pits and trash were determined. The cherries were pitted on Dunkley pitters with 23 mm cups. The grading was done by six women graders employed by a cherry brining plant.

Results and discussion

Brine shrink. The cherries in the 7% salt brine and in the mixture ($3\frac{1}{2}$% each of NaCl and $CaCl_2$) gained from 3 to 9% in weight during the 24-hour holding period (Table 24). Subsequently, after six months the drained weight was higher for the cherries in the prebrines than those in the control brine by about the same amount as the gain in weight during the 24-hour exposure to the prebrines.

Comparisons of the effects of the brines on the shrinkage after a six-month curing period (Table 25) indicate a statistically significant ($P < .05$) reduction in shrink due to the two prebrines. The reduction is clearly evident under all three orchard situations. Differences between the effects of the two prebrines are small.

Table 24. EFFECT OF PREBRINING ON THE BRINE SHRINK OF CHERRIES[1]

	Control		7% NaCl		3.5% NaCl plus 3.5% $CaCl_2$	
	24 hrs.	6 mos.	24 hrs.	6 mos.	24 hrs.	6 mos.
Orchard 1	....	−10.4	+5.4	− 6.0	+8.9[2]	− 4.1[2]
2	....	−18.7	+4.5	−14.2	+5.5	−12.5
3	....	−18.6	+3.0	−13.0	+4.7	−11.5
Mean, all orchards	....	−15.9	+4.3	−11.1	+6.4	− 9.4

[1] Expressed as a percent of the fresh weight.
[2] Only one drum sample.

Solution pockets. Within an individual orchard there was no difference in the percent solution pockets between the three brines. There was a significant difference between orchards, as could be expected. Cherries from orchard 1 had significantly more solution pockets than those from orchards 2 and 3 (Table 25). Despite this variability, the use of the prebrines did not significantly affect the means of this quality variable.

Soft fruit. The percentage of soft fruit was determined subjectively by classification of a sample of 200 cherries from each of the drums. The data indicate extreme variability in the manner in which the three solutions affected this factor (Table 25). In orchard No. 1 there was an increase in the percent of soft fruit when packed in the prebrines, but it was not significant. In orchard No. 2, the prebrines decreased the percent of soft fruit but not significantly. In orchard No. 3, with small fruit, the cherries brined in the prebrines were softer than those in the control, but there was no significant difference between them. On the average, however, despite the indicated orchard variability, there was no significant difference in the means of the percent of soft fruit due to the brines used.

Grading classification. The average percent combination grade, No. 3 grade, and unclassified fruit, together with the percentage of recoverable pieces and pits, are shown in Table 25. The raw data in terms of weights recoverable are shown in Appendix Table 2; these data represent the base from which Table 25 was prepared.

Inspection of the data in Table 25 for the combination grade, No. 3 grade, and the unclassified fruit show that there was no difference in the performance of the three brines within a single orchard. These data also reveal that there is a difference between orchards within a single brine. Specifically, in the case of No. 3 grades, the data show a very real difference between the orchards within each of the brines. This is a natural orchard-to-orchard variation, and the fruit of orchard 3 was generally small, only lightly blushed, and immature. There were few limb scars, bird pecks, and other defects in this fruit, which account for the low figure. In orchards 1 and 2 there was a considerable percentage of fruit in the No. 3 grade. With respect to the percentage of pits and pieces of fruit, the data indicate the orchard-maturity variability factor. There were more pieces of fruit in orchard 3, indicating some degree of tearing of the flesh when pitted. These data also show that fruit from orchard 3 had a higher percentage of pits. This is due, in part, to the relative proportion of flesh to pit in the fruit as it matures. The ratio of pit to flesh would decrease with increase of size of fruit and therefore reduce the percentage of recoverable pits.

Table 25. EFFECT OF STANDARD SULFUR DIOXIDE AND PREBRINES UPON GRADE AND QUALITY OF BRINED CHERRIES

	Orchard	SO_2 (control)	Prebrine 7% NaCl	Prebrine 3½% mix	Orchard mean	LSD .05[1] Within orchards or brines	LSD .05[1] Orchard or brine means
Brine shrink, %	1	10.4	6.0	4.1	6.8	4.2 (5.2)	2.4 (2.6)
	2	18.7	14.2	12.5	15.1		
	3	18.6	13.0	11.5	14.4		
Brine mean, %		15.9	11.1	9.4			
Solution pockets, %	1	19.5	20.5	15.0	18.3	6.2	3.5
	2	4.5	11.5	8.5	8.2		
	3	4.5	6.0	5.0	5.2		
Brine mean, %		9.5	12.7	9.5			
Soft fruit, %	1	6.5	11.0	14.5	10.7	11.1	6.4
	2	9.5	6.5	4.5	6.8		
	3	3.0	13.0	14.0	10.0		
Brine mean, %		6.3	10.2	11.0			
Combination grade, %	1	66.2	71.8	67.9	68.6	13.7 (16.8)	7.9 (8.3)
	2	55.5	62.9	61.2	59.9		
	3	69.0	76.1	75.9	73.7		
Brine mean, %		63.6	70.3	68.3			
No. 3 grade, %	1	10.4	11.3	16.2	12.6	13.3 (16.3)	7.7 (8.1)
	2	15.7	11.1	14.4	13.7		
	3	2.7	1.0	1.1	1.3		
Brine mean, %		9.6	7.8	10.6			
Unclassified, %	1	3.1	2.3	3.6	3.0	2.9 (3.5)	1.7 (1.7)
	2	2.2	3.8	3.4	3.1		
	3	1.2	0.3	0.4	0.6		
Brine mean, %		2.2	1.8	2.5			
Pits, %	1	6.5	6.6	7.1	6.7	1.0 (1.3)	0.6 (0.6)
	2	6.4	6.5	6.3	6.4		
	3	7.6	7.9	7.9	7.8		
Brine mean, %		6.8	7.3	7.1			
Pieces, %	1	0.8	0.8	0.4	0.6	0.9 (1.1)	0.5 (0.5)
	2	0.8	0.6	0.5	0.6		
	3	1.0	1.4	1.7	1.4		
Brine mean, %		0.9	0.9	0.9			
Marketable recovery, %	1	76.7	83.3	84.2	81.4	4.1 (5.1)	2.4 (2.5)
	2	71.3	74.2	75.2	73.8		
	3	71.8	77.2	77.7	75.6		
Brine mean, %		73.3	78.2	79.2			

[1] Least significant difference at the 5% level. Values included in parentheses are exact for comparisons involving missing data.

Summary

In the appraisal of the brine or orchard means of Table 25, perhaps a more generalized analysis may be made. We are simply asking the question, "Even though a variation will exist in orchards and fruit maturity, how do the three brines perform?" For this information, inspection of the "brine means" shows that there is no significant difference between the general performance of the brines in the combination, No. 3, and unclassified grades and the brines in the "pieces and pits" classification.

The effect of the prebrine is shown clearly under present marketable recovery (Table 25). These data represent the combination grade plus the No. 3 grade expressed as a percent and show a statistically significant increase in percent marketable fruit of 4.9% and 5.9% for the 7% salt and the 3½% mix prebrines, respectively, when compared to the SO_2 control.

The percent brine shrink is 4.5 less in the 7% salt prebrine solution and 6.5 less in the 3½% mix than in the control (Table 25).

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Appendix Table 1. PREBRINING MECHANICALLY HARVESTED CHERRIES IN THE WILLAMETTE VALLEY

Treatment[1]	Date	Orchard	Brine pH	Soluble solids	Drained weight	Pitting loss	Pits	Texture (gms. comp. force)	Soft
				%	%	%	%		%
SO_2 (control)	6-17 a.m.	1	3.15	17.4	79.8	13.95	9.77	476	0
6% mix	6-17 a.m.	1	......	17.0	85.8	12.60	9.77	557	0
6% mix	6-17 a.m.	1	3.25	16.4	87.1	12.80	9.41	563	0
SO_2 (control)[2]	6-18 a.m.	2	3.38	15.4	79.7	16.20	9.20	304	13.5
Salt[1]	6-18 a.m.	2	3.50	15.0	83.2	15.10	9.00	376	22.5
6% mix[2]	6-18 a.m.	2	3.52	15.5	87.8	15.05	10.00	410	14.0
Salt	6-18 p.m.	2	3.40	16.0	83.5	13.10	8.85	507	6.0
6% mix	6-18 p.m.	2	3.45	15.2	86.9	13.55	9.80	463	11.5
SO_2 (control)[2]	6-22 a.m.	3	3.50	20.0	73.3	13.70	9.60	302	3.0
Salt[2]	6-22 a.m.	3	3.50	18.3	81.3	13.70	8.40	458	8.0
6% mix[2]	6-22 a.m.	3	3.50	17.0	83.1	12.90	8.00	460	2.0
SO_2 (control)[2]	6-24 a.m.	4	3.40	12.0	72.4	13.35	9.07	267	13.3
Salt[2]	6-24 a.m.	4	3.57	14.8	78.6	15.80	8.67	328	20.5
6% mix[2]	6-24 a.m.	4	3.30	16.3	71.2	12.35	8.47	420	11.3
9% mix	6-24 a.m.	4	3.50	14.5	79.4	12.45	8.80	372	8.0
SO_2 (control)[2]	6-24 p.m.	4	3.10	15.5	68.9	12.60	7.78	419	8.7
Salt[2]	6-24 p.m.	4	3.40	13.8	85.1	15.60	8.55	423	22.0
6% mix[2]	6-24 p.m.	4	3.40	13.8	78.2	13.00	8.53	435	7.5
9% mix	6-24 p.m.	4	3.30	16.0	75.9	12.20	7.77	437	2.0
SO_2 (control)[2]	6-25 a.m.	5	3.00	15.0	77.9	15.75	8.58	408	26.0
Salt[2]	6-25 a.m.	5	3.20	13.7	76.3	14.20	8.72	386	27.0
6% mix[2]	6-25 a.m.	5	3.20	15.0	83.2	12.35	7.81	431	9.0
SO_2 (control)[2]	6-25 p.m.	5	3.10	19.5	79.9	11.70	8.73	378	21.0
Salt[2]	6-25 p.m.	5	3.10	16.0	86.9	12.75	8.72	409	22.0
6% mix[2]	6-25 p.m.	5	3.10	15.0	80.9	13.65	8.86	373	19.0
9% mix	6-25 p.m.	5	3.20	14.0	85.2	13.55	8.55	442	21.0
SO_2 (control)	6-24 a.m.	6	3.20	17.0	75.3	13.75	8.06	421	19.0
6% mix	6-24 a.m.	6	3.20	19.3	79.7	10.65	7.67	451	4.5

[1] SO_2 (control) = standard 1.4% sulfur dioxide-calcium hydroxide brine at pH 2.8 to 3.0.

[2] Data selected for statistical analysis in Table 23.

Salt = prebrine of 6% sodium chloride;

6% mix = prebrine of 3% sodium chloride plus 3% calcium chloride;

9% mix = prebrine of 6% sodium chloride plus 3% calcium chloride.

Appendix Table 1 (Continued)

Pitter holes											
No. 2 grade	No. 3 grade	Un-pitted	Stems	Solu-tion pockets	Brine cracks	Me-chan-ical damage	Rain cracks	No. 1 grade	No. 2 grade	No. 3 grade	No. 4 grade
%	%	%	%	%	%	%	%	%	%	%	%
2.0	0.3	1.3	79.5	6.5	1.5	9.0	4.0	83	10	6	1
0.3	0.7	0.3	70.0	2.0	0.0	6.0	3.5	90	5	5	0
1.0	0.5	0.3	61.0	3.0	1.0	12.0	3.5	81	11	6	2
6.5	5.7	2.0	72.0	14.0	0.5	3.0	1.0	82	2	1	15
4.5	4.0	2.0	59.0	18.0	0.0	13.0	0.5	80	2	3	15
2.5	4.5	1.5	76.0	10.0	0.0	3.0	0.5	78	2	1	19
7.0	4.0	0.5	44.0	6.0	0.5	2.5	1.0	89	1	1	9
2.7	3.0	0.5	58.0	4.5	0.0	10.0	0.5	86	3	9	2
1.3	1.3	0.3	30.0	23.0	29.0	10.0	5.0	55	14	25	6
1.5	2.0	0.0	53.0	8.5	1.5	2.0	6.0	71	14	14	1
0.5	1.0	0.3	49.0	12.0	1.5	0.0	6.0	71	17	9	3
4.5	3.0	1.5	79.0	33.0	7.5	4.5	12.0	61	2	29	8
8.5	5.0	1.7	65.5	17.0	0.5	10.5	13.5	76	8	6	10
3.3	3.3	1.0	69.5	14.5	0.5	4.5	24.5	80	6	7	7
3.0	2.5	1.5	59.0	19.0	0.5	8.0	11.0	83	7	7	3
2.5	2.0	1.0	43.5	11.0	3.0	8.0	41.5	64	7	25	4
4.7	6.0	3.0	58.5	9.0	0.5	4.0	16.0	72	7	9	12
3.5	2.5	0.5	44.0	4.5	0.5	3.5	34.5	65	10	20	5
1.0	1.0	0.5	42.0	7.0	0.5	3.0	37.0	61	8	26	5
3.0	2.0	0.5	50.0	19.0	2.5	4.5	32.0	56	11	22	11
3.5	1.5	6.5	39.0	19.0	13.0	5.0	21.5	57	7	17	19
2.0	2.0	1.3	55.0	11.5	2.0	4.5	36.0	64	8	24	4
2.0	1.5	2.5	45.0	22.5	3.5	8.0	27.0	45	10	32	13
3.3	2.0	4.0	47.0	16.0	2.0	5.0	35.0	52	13	30	5
2.5	2.5	1.0	36.0	9.0	0.5	5.5	41.0	68	10	16	6
2.0	1.0	1.5	55.0	13.0	0.0	5.0	45.5	59	10	22	9
2.5	3.0	0.5	58.0	11.5	10.0	18.0	27.0	62	4	20	14
0.5	0.7	1.0	50.0	13.0	4.0	4.0	27.0	65	15	19	1

Appendix Table 2. PREBRINING MECHANICALLY HARVESTED CHERRIES IN THE DALLES (1969)

		Drum No.	Initial fruit weight	Drained weight (24 hrs.)	Percent of fresh weight	Trash weight	Soft fruit[1]	Solution pockets[1]	Mechanical damage[1]	Drained weight (6 mos.)
			lbs.	*lbs.*	%	*lbs.*	%	%	%	*lbs.*
Orchard 1	SO_2	1	265	......	......	0.2	1	20	2	237
(6-19-69)	SO_2	2	257	......	......	0.2	12	19	4	230
	7% NaCl	3	272	285	104.7	1.1	6	22	3	259
	7% NaCl	4	273	290	106.2	0.2	16	16	2	254
	3½% mix	5	256	279	108.9	0.1	10	18	2	246
	3½% mix	6[2]	......	......	......	0.4	19	12	1	289
Orchard 2	SO_2	7	260	......	......	1.6	7	7	9	218
(6-24-69)	SO_2	8	246	......	......	2.0	12	2	16	194
	7% NaCl	9	240	250	103.9	1.5	8	11	5	210
	7% NaCl	10	254	267	105.1	1.5	5	12	4	214
	3½% mix	11	240	255	106.0	0.7	4	10	5	212
	3½% mix	12	256	269	105.1	0.6	5	7	6	222
Orchard 3	SO_2	13	254	......	......	0.9	3	3	5	206
(6-30-69)	SO_2	14	256	......	......	0.9	3	6	6	209
	7% NaCl	15	210	217	103.1	1.8	17	8	2	182
	7% NaCl	16	212	218	103.1	1.4	9	4	1	185
	3½% mix	17	230	243	105.7	2.1	11	5	3	208
	3½% mix	18	232	241	103.9	3.2	17	5	5	201

		Drum no.	Brine shrink	Combination grade		No. 3 grade		Culls		Pits		Pieces		Marketable fruit comb. and no. 3 grade
			%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	%
Orchard 1	SO_2	1	10.2	195	73.7	13.3	5.0	8.3	3.1	17.8	6.7	2.0	0.8	78.7
(6-19-69)	SO_2	2	10.5	151	58.8	41.0	16.0	8.3	3.2	16.3	6.3	2.1	0.8	74.7
	7% NaCl	3	5.0	187	68.8	41.0	15.1	9.0	3.3	16.8	6.2	2.2	0.8	83.8
	7% NaCl	4	7.1	205	75.1	21.3	7.8	3.6	1.3	19.3	7.1	2.4	0.9	82.9
	3½% mix	5	4.1	174	68.0	41.5	16.2	9.3	3.6	18.3	7.1	1.1	0.4	84.2
	3½% mix	6	......	235	......	23.3	......	3.5	......	......	......	......	......	......
Orchard 2	SO_2	7	16.4	128	49.2	59.5	22.9	8.8	3.4	17.3	6.6	1.8	0.7	72.1
(6-24-69)	SO_2	8	21.0	152	61.9	21.3	8.7	3.0	1.2	15.3	6.2	2.5	1.0	70.6
	7% NaCl	9	12.5	154	64.2	29.8	12.4	6.8	2.8	16.3	6.8	1.5	0.6	76.6
	7% NaCl	10	15.9	157	61.8	25.3	9.9	12.3	4.8	16.3	6.4	1.5	0.6	71.8
	3½% mix	11	11.7	134	55.8	45.5	18.9	12.3	5.1	15.3	6.4	1.3	0.6	74.8
	3½% mix	12	13.3	131	66.8	25.8	10.1	4.8	1.9	16.2	6.4	1.0	0.4	76.9
Orchard 3	SO_2	13	18.9	180	70.7	2.9	1.1	1.3	0.5	19.3	7.6	3.2	1.3	71.8
(6-30-69)	SO_2	14	18.4	173	67.4	11.5	4.5	5.0	1.9	19.3	7.6	2.0	0.8	71.9
	7% NaCl	15	13.3	158	75.0	2.3	1.1	0.8	0.4	16.8	7.9	2.8	1.3	76.1
	7% NaCl	16	12.7	164	77.4	2.0	0.9	0.7	0.3	16.8	7.9	3.1	1.5	78.3
	3½% mix	17	9.8	174	75.7	3.1	1.4	0.9	0.4	19.8	8.6	4.0	1.7	77.0
	3½% mix	18	13.3	177	76.3	1.9	0.8	0.9	0.4	17.3	7.4	3.9	1.7	77.1

[1] Percent based on 200 fruit. All other percent data based on initial fruit weight.
[2] Brine spilled in orchard; no exact weight known.