Weight to Volume Relationship of Sweet Cherries in Brine
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Weight to Volume Relationship of Sweet Cherries in Brine

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NATIONALLY ABOUT 45 percent of the sweet cherry crop is brined. In Michigan the amount is about 76 percent. Because of the difficulty in recruiting workers to hand pick and because of potential monetary savings, sweet cherry growers are beginning to use machines for harvesting.

Research shows that the brining of machine harvested sweet cherries should be started within an hour after harvest for best quality (2). Some sweet cherries are now brined at the orchard in the Pacific Northwest and in Michigan. Most sweet cherries are presently transported in brine from receiving stations to processing and brining plants.

Cherry weight is difficult to obtain after cherries have been placed in brine. In Michigan, lined pallet boxes partially filled with brine are weighed before being moved to the orchard, and reweighed after cherries have been added. In some areas of the United States, cherries of individual growers are kept separate during the brining period. Prior to processing, the shrunken cherries are removed from brine and weighed. Neither system of weighing is entirely satisfactory.

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During 1967 and 1968 an improved method of measuring quantities of tart cherries in water was developed in Michigan. Details of the method, which employs volume instead of weight as the unit of measurement, were published recently (1). About 10 million pounds of tart cherries in water were bought and sold on a volume basis in 1968. Costs of measurement were minimal and quality of fruit was maintained. Can sweet cherries suspended in brine also be bought and sold on a volume basis?

It is necessary to know the relationship between weight and volume of the suspended cherries. Specific objectives of the present study were to determine:

1. Accuracy of the probe method for determining the volume of known weights of sweet cherries suspended in brine (Napoleon and Windsor varieties).
2. Effects on suspension density (i.e. weight of cherries per cubic foot of suspension, or "cherry density") from variations in:
   - A. Cherry nesting, or settling
   - B. Level of brine
   - C. Length of soak
   - D. Cherry firmness, or amount of bruising
   - E. Cherry size
   - F. Soluble solids content
   - G. Attached stems

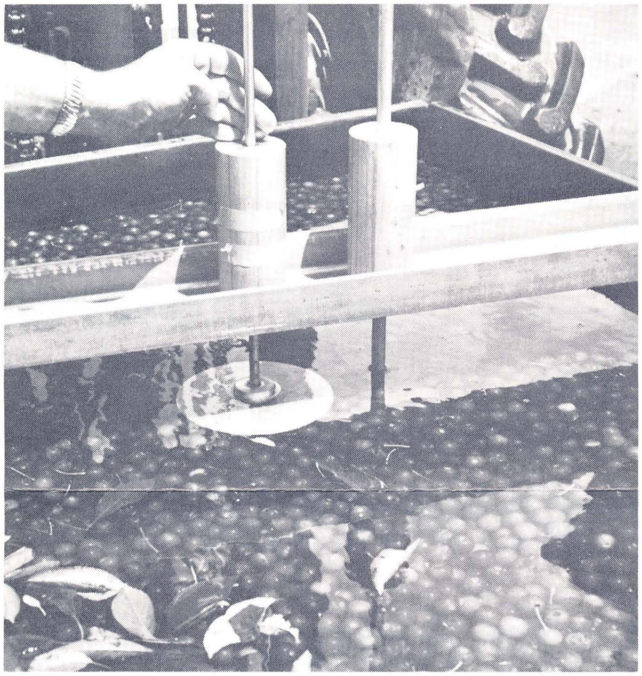

Fig. 1. Measuring the depth of tart cherries with a differential probe (note rod on right rests on pallet tank bottom — left rod sliding plate rests on cherry surface).

3. Average suspension density, or average weight of cherries per cubic foot, of many random lots.
4. Types of bulk containers suitable for volume measurements.

Determining Volume

In any rigid container the accuracy of determining the volume of sweet cherries in brine depends largely on the accuracy of the depth measurement. Usually, depth is measured with a probe similar to the one used with tart cherries in water (see Figs. 1 and 2).

The accuracy of measuring the depth of known weights of cherries in brine is shown in Table 1. Measurements were made with a small probe on samples in 30-pound tins at about 72°F. For each sample, three determinations of depth were made. The average error of measurement was only 0.14 per cent for six samples. This means that depth readings can be duplicated, and that volume and density of the cherries can be determined accurately.

Nesting of Cherries

Nesting is the degree of "compacting together" or "settling" of sweet cherries in brine in a container. The number and weight of cherries in a given volume depend partly on the amount of nesting.

Table 1. Accuracy of measuring depth of sweet cherries in brine in 30 lb tins

Cherry Sample	Depth of 15.43 lb. cherries, inches[1]	Error of depth measurement, per cent	Calculated density, lbs. of cherries per cu. ft.	Standard deviation, lbs.
1 (most stems)	9.88	0.29	35.91	0.181
2	9.75	0.04	36.40	0.047
3	9.74	0.05	36.44	0.069
4	9.02	0.14	39.32	0.095
5	8.93	0.12	39.74	0.081
6 (no stems)	8.36	0.22	42.41	0.161
Average	9.28	0.14	38.37	0.106

[1] Ave. of three determinations, five measurements each.

Nesting is influenced by vibration during transportation. For example, when cherries in brine in 30-pound tins were transported by car, they nested rapidly during the first mile, and then reached a relatively constant level (see Table 2). Additional travel or vibration had no significant effect on cherry level.

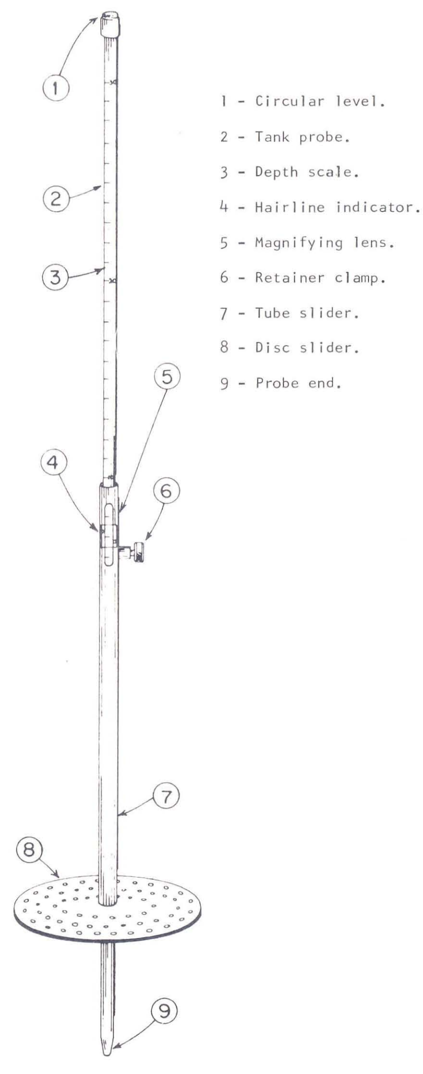

Fig. 2. Cherry pallet tank probe.

Table 2 shows also that cherries reached an equilibrium level of nesting after about 25 vibrations (mechanical) of one inch amplitude. Additional studies with pallet boxes each containing about 835 pounds of cherries in brine showed similar results. Nesting due to vibration can be disregarded as a factor affecting suspension density, provided the suspension has been transported for about one mile over roads of normal roughness.

Table 2. Effect of vibration on nesting, or settling, of sweet cherries in brine in 30 lb tins

Method of Vibration					
Transported in car (cherries A)			Mechanical vibration, one-inch amplitude (cherries B)		
Distance traveled, miles	Cherry density, lbs./cu. ft.	Diff., per cent	No. of Vibrations	Cherry density, lbs./cu. ft.	Diff., per cent
0	36.83	0	0	37.38	0
0.3	37.82	2.7	5	38.95	1.5
1	38.20	3.7	10	39.28	5.1
3	38.47	4.4	25	39.64	6.0
6	38.32	4.0	50	39.70	6.2
12	38.26	3.9			

Level of Brine

In a container, brine level in relation to cherry level can affect suspension density (see Table 3). When the brine level was 2 inches below the cherry level, the cherries became somewhat compacted and had a relatively high density. In contrast, when the brine level was 2 inches above the cherries, cherry density was relatively low. For consistent results in making probe readings on cherry depth, it is recommended that the cherries be completely covered with brine.

Table 3. Effect of brine level on density of sweet cherries suspended in brine

Level of brine	Cherry density lbs./cu. ft.	Difference, per cent
2 inches above cherries	36.74	0
almost even with cherries	37.63	2.4
2 inches below cherries	37.82	2.9

Length of Soak

Sweet cherries shrink considerably when held for the conventional 2 months or more in brine. The rate of shrink, however, is not well known. Rate of shrink is of major significance in establishing payment for cherries that are brined in an orchard and then delivered to a processor.

Tests showed that shrinkage of sweet cherries in brine occurred at a relatively slow rate (see Table 4). During the first 12 hours that cherries were in brine, cherry volume decreased only 0.53 per cent. Even after 24 hours the decrease was less than 1 per cent. In fact, shrinkage in brine was much less than corresponding shrinkage of cherries held in lugs (about 4 per cent in 24 hours). Since most growers deliver cherries to a processing plant within 12 to 18 hours after harvest, shrinkage in brine would not have a significant effect on cherry volume or density at delivery time.

Table 4. Rate of shrink of sweet cherries in brine (Ave. of four tests)

Time in brine, hours	Cherry density, lbs./cu. ft.	Cherry shrinkage, per cent
0	37.78	0
6	37.79	0.03
12	37.98	0.53
24	38.14	0.95
48	38.33	1.46

Firmness and Bruising

With tart cherries in water, the amount of bruising had a major effect on suspension density (1). Sweet cherries, however, are firmer than tart cherries, and a lesser effect of bruising on density was observed.

Moderate bruising (sweet cherries dropped 3 times from 3 feet, a bruise approximating that of mechanical harvest) increased suspension density by 1.3 per cent (see Table 5). The value for severe bruising (cherries dropped 6 times) was 2.6 per cent. A slightly greater weight of bruised cherries than unbruised cherries was required to fill a given volume. Growers will be rewarded appropriately for unbruised fruit and penalized for bruised fruit when the fruit is purchased by volume.

Table 5. Effect of firmness and bruise level on density of sweet cherry-brine suspensions (ave. of 2 tests)

Bruise level (no. of 3 ft. drops)	Cherry density, lbs./cu. ft.	Difference, per cent
0	40.83	0
3 X	41.36	1.3
6 X	41.88	2.6

Soluble Solids Content and Cherry Size

Sweet cherries vary widely in soluble solids content (an index of maturity) and size. Since sugar, the major constituent of the soluble solids fraction, has a density of 1.59, it might be expected that cherries of high soluble solids content would form cherry-brine suspensions of relatively high density. Cherries of large size should form suspensions of relatively low density. Generally, large particles resist tight packing.

Many tests with samples (stem-free) taken at random during commercial operations showed little correlation between soluble solids content and suspension density (see Table 6). No significant correlation between cherry size and suspension density was observed.

The soluble solids and size factors varied simultaneously in a manner that cancelled out their separate effects on density. The largest cherries (5.87 grams) were the highest in soluble solids content (17.2 per cent), and the smallest cherries (3.89 grams) had the lowest soluble solids content (14.0 per cent). In commercial practice where large amounts of fruit are handled, the combined effects of soluble solids content and cherry size on suspension density can be disregarded.

Table 6. Effect of soluble solids content (maturity) and cherry size on density of sweet cherry-brine suspensions

Cherry sample (no stems)	Ave. soluble solids content, per cent	Ave. cherry weight, grams	Cherry density, lbs./cu. ft.	Difference, per cent
3 lots of lowest soluble solids	14.0	3.89	41.77	0
4 lots of average soluble solids	15.9	4.35	42.25	1.1
3 lots of highest soluble solids	17.2	5.87	42.18	1.0

Attached Stems

The proportion of attached stems on cherries was the most important single factor that affected density of sweet cherries in brine (see Table 7). When cherries having 100 per cent of stems attached were placed in brine, their bulk density was 35.08 pounds per cubic foot. Removing the stems increased bulk density to 42.47 pounds per cubic foot (17.4 per cent increase). Intermediate quantities of attached stems gave intermediate values for bulk density.

Table 7. Effect of attached stems on the density of sweet cherries in brine (ave. of tests with 6 lots of cherries)

Attached stems, per cent	Cherry density, lbs./cu. ft.	Difference, per cent
0	42.47	0
25	40.34	5.0
50	38.46	9.4
75	36.67	13.7
100	35.08	17.4

A correction factor that will adjust for the proportion of cherries with attached stems should be used when sweet cherries in brine are purchased on a volume basis. The decrease in bulk density is almost 1 per cent for every 5 per cent increase in cherries with stems. Normally, mechanically harvested sweet cherries have from 5 to 90 per cent of attached stems.

Attached stems lowered bulk density primarily through their interference with close packing of fruit, much as excelsior might do. The weight effect of the stems was relatively small, comprising less than 2 per cent of the combined cherry-stem weight (see Table 8). Thus the amount of money paid by processors to growers for the stem material mixed with cherries, on a weight basis, is relatively small.

Table 8. Relative weight of stems attached to harvested sweet cherries

Cherry sample	Weight of 100 cherries with attached stems grams	Weight of 100 stems only, grams	Fraction of total weight due to stems per cent
A	377	7.0	1.86
B	564	9.5	1.69
C	665	10.0	1.50

Average Density of Sweet Cherries in Brine

The sweet cherry industry needs to know the average density of sweet cherries suspended in brine to initiate buying of fruit on a volume basis. The present study provided preliminary answers from two sources: (a) many tests with small samples, and (b) limited tests with large samples.

Results of the small scale tests (samples in 30-pound tins) showed that the average density of stem-free cherries in brine was 42.5 pounds per cubic foot. The effects of various factors in cherry density have been discussed previously in this paper.

For large scale tests, dry cherries were weighed carefully and placed in brine in pallet boxes lined with plastic sheeting. The depth of cherries was measured in 8 pallet boxes, each containing about 835 pounds of cherries. Average density of the cherries was 43.3 pounds per cubic foot.

It is recommended, therefore, that a cherry density value of about 43 pounds per cubic foot be used as an original base for the purchase by volume of sweet cherries in brine.

Type of Container

Processors have on hand large numbers of pallet boxes with plastic liners for bulk handling sweet cherries in brine. Tests with 12 of the plywood boxes indicated that the boxes can be made rigid enough to maintain constant cross sectional areas at various depths. However, the plastic liners were difficult to insert without producing folds and pockets that affected container volume.

For best results in volume measurement of sweet cherries in brine, bulk containers should be made of plastic, stainless steel, or steel having a suitable coating. Containers should resist corrosion by sulfur dioxide and be rigid.

CONCLUSIONS

1. The volume of sweet cherries (Napoleon and Windsor) in brine in bulk containers can be determined accurately, quickly, and inexpensively.
2. Cherries in brine should be transported over roads of normal roughness for about one mile before volume readings are made. Vibration is required for equilibrium settling.
3. Brine level should be above cherry level when volume readings are taken.
4. Sweet cherries shrink slowly in brine (less than 1 per cent in 24 hours). If the cherries have been in brine for no longer than 18 hours, no correction factor for shrinkage is necessary during volume determinations at a processing plant.
5. No correction for variations in firmness and bruising should be made. The effect of bruising on bulk density is small, but will penalize a grower for severely bruised fruit.
6. The effect of cherry size on bulk volume is offset by the effect of soluble solids content. The largest cherries have the highest soluble solids content. Thus, no correction factor is needed for the combined effects of size and soluble solids on the bulk volume of an average load of cherries.
7. Attached stems have a strong effect on the bulk volume of sweet cherries in brine. Cherry density decreases as stem counts increase. A correction factor of about 1 per cent for every 5 per cent of attached stems is recommended.
8. The average bulk density of stemless sweet cherries in brine is about 43 pounds per cubic foot. This value can be used during the first commercial trials in buying sweet cherries by volume.
9. Rigid and corrosion resistant containers that permit accurate measurement of bulk volume should be used.

This study led to the conclusion that sweet cherries in brine can successfully be bought and sold by volume.

LITERATURE CITED

1. Tennes, B. R., R. L. Anderson and J. H. Levin (1968). Weight to volume relationship of tart cherries. Mich. State Univ., Research Report 70.
2. Whittenberger, R. T., J. H. Levin, and H. P. Gaston (1968). Maintaining quality by brining sweet cherries immediately after harvest. Mich. State Univ., Research Report 73.

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