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Weight to Volume Relationship of Tart Cherries

By B. R. Tennes, R. L. Anderson and J. H. Levin[1]

CHERRY WEIGHT is difficult to obtain in water. At present there are two accepted methods of obtaining fruit weight delivered in water. These are:

1. Empty the fruit into a water sump (pit) and convey cherries from the pit to a batch conveyor scale for weighing.
2. Drain the water from the pallet tank and then weigh fruit.

Either of these methods may result in further bruising of the fruit. Other methods are:

3. Weigh the total load on a platform scale, then dump pallet tanks into a sump tank with a water "spill-over" tank. The fruit is then conveyed from the sump tank and the overflow of water is pumped back into the grower's pallet tanks. The "spill-over" water is weighed on the platform scales and the weight difference is recorded as the fruit weight.
4. Measure fruit depth in a pallet tank, obtaining a calculated weight from a density factor previously determined. This study attempts to study the variables that are encountered in determining such a density factor.

Cherry processors receive fruit (a) directly from the grower, (b) from company operated receiving stations and (c) from independently operated receiving stations. Most receiving stations do not have conveyor type scales because of the high initial cost. A large percentage of the cherries produced in Michigan reach the processor via the receiving station route. Transfer of ownership takes place at this point, therefore an inexpensive but accurate method of determining the quality and weight of fruit must be available.

According to the Federal State Market Report, Michigan produced 85,676,988 pounds of tart cherries during 1967. It is estimated that 75 percent of this crop was handled in water from grower to processor. Cherry purchasers have expressed a desire to purchase fruit by volume. Little is known of the accuracy of comparing scale weight to the volume of cherries delivered in water. Buyers have indicated an interest in obtaining cherry volume by measuring the depth of the fruit, in a pallet tank and multiplying it by an area factor. A weight equivalent could then be obtained by multiplying this volume by a density factor. The following problems associated with this method of purchasing are listed and used in the experimental design:

a. Securing accurate measurements of the cherry depths in pallet tanks (note Fig. 1 and 2)
b. Variability of pallet tank dimensions
c. Effect of nesting on the accuracy of a density factor
d. Effect of pallet tank water level in relationship to the cherry level
e. Firmness of the fruit
f. Maturity of the fruit based on soluble solid content

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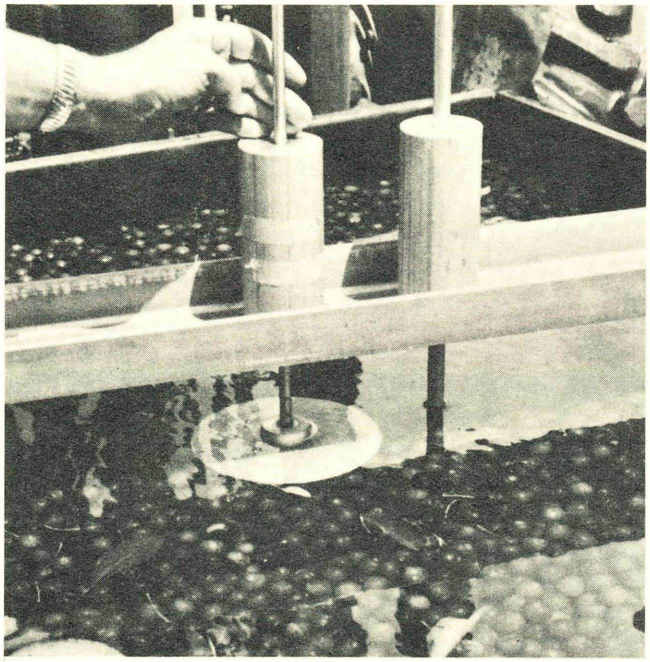

Fig. 1. Measuring the depth of cherries with a differential probe (note rod on right rests on pallet tank bottom —left rod sliding plate rests on cherry surface).

g. Size of the fruit
h. Number of attached stems
i. Time of day
j. Area
k. Season

A study was undertaken during the summer of 1967 at three major cherry producing areas in Michigan to determine the relationship existing between cherry volume and scale weight, and the possible causes of variation in this relationship.

OBTAINING DATA

Measurement of Cherry Depth

A depth variation of ½ inch can result in a 2-3 percent variation in volume and calculated weight in the average pallet tank. This depth variation could result from unevenness of cherry depth in the pallet tank or from an inaccurate perpendicular probe of depth with the measuring probe.

The instrument used to measure depth was placed at the approximate center of and at right angles to the long axis of the pallet tank in an attempt to secure an average cherry depth (Fig. 1). A probing rod (Fig. 2) can be placed by judgment into the approximate center of the tank, nearly parallel, so as to be within a ± .05 percent tolerance when using a level to determine the true vertical axis.

A perforated sliding plate 8 inches in diameter was fitted onto the probe and slid down until it rested on the cherries. It was later determined that the perforated plate should have a diameter of at least 10 inches to maximize the average cherry level.

Calibration of Tank

Pallet tanks from the same manufacturer can vary in size as well as those from different manufacturers. The cross-sectional area of pallet tanks could vary 3-5 percent. Fig. 4 shows the pallet tank design recommended by Michigan Canner and Freezer Association. Several commerial tanks were calibrated by averaging three measurements on the short, long and vertical axes, and by weighing increased depths of water in the tank then plotting water weight vs. height (Fig. 3). The length, width and height of over 200 pallet tanks were measured and data were plotted on graph paper to give the calibration of the individual tanks.

The pallet tanks possessed a uniform vertical measurement with a ± .5 percent tolerance, but the cross-sectional dimensions (length, width) varied from 0-5 percent among those made by the same manufacturer. Only one manufacturer's tanks were found to be consistent. Therefore each tank must be separately calibrated if a volume method is to be accurate.

Nesting of Cherries

Nesting is the degree of "compacting together" of cherries in a water pallet tank. The number (per a given volume) and therefore weight of cherries in a given volume depends on the amount of nesting. This could be influenced by:

1. Vibrations in transportation
2. Water level in relation to cherry level
3. By the initial degree of bruising

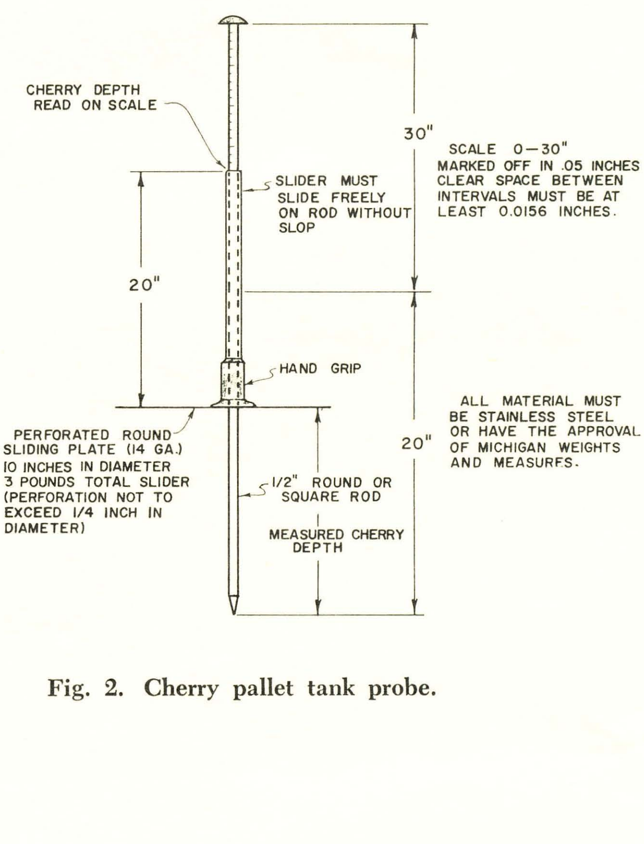

Fig. 2. Cherry pallet tank probe.

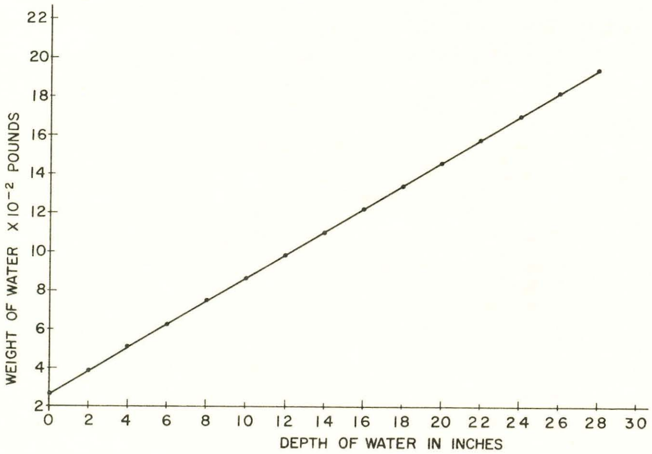

Fig. 3. Weight of water vs. depth of water.

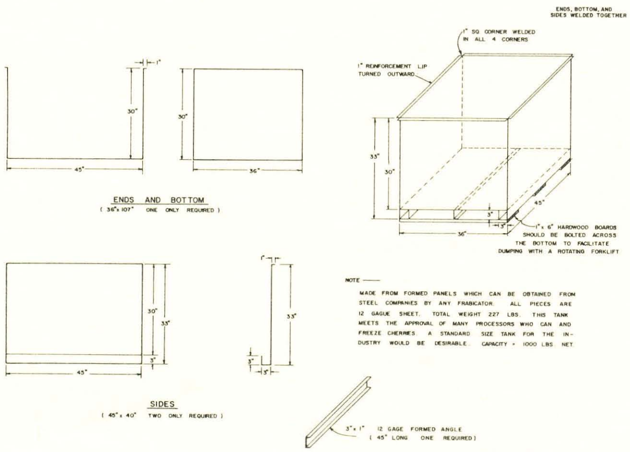

Fig. 4. Suggested tank for transporting red tart cherries in water.

To determine if nesting occurred in transit, pallet tanks were measured (water level and cherry level) at the orchard cooling pads. The depth of water and cherries were then recorded every mile for 5 miles with a final water and cherry depth recorded at the processing plant. Weights from the processor were recorded and the nested density calculated. Soluble solid content was measured with a hand refractometer.

RESULTS

In tanks where the water level was below the cherry level, the density was greater than in those tanks where the water level was higher than the cherry level. The amount of water lost by splash out from the tank filled to a depth of 23 inches increased as the distance traveled increased. It was concluded that:

1. Cherries nest during the first ½ mile, then reach a constant level; therefore, increased distance has no effect on density due to nesting.
2. When the water level is equal to or above the cherry level, nesting was not significant—even at various cherry height levels. Nesting does become a density factor when the water level is below the cherry level in the pallet tanks.

Firmness (bruising effect)

The more the cherries are bruised, the less turgid they become; therefore, the weight of fruit will increase in a given volume. A cubic foot of badly bruised fruit will weigh more than fruit that contains few or no bruises.

A given volume (0.725 cu. ft.) of unbruised (hand picked) fruit was weighed. The fruit was then subjected to bruising by dropping each cherry one time (1-X) 36 inches onto a wooden surface. This was repeated a second time (2-X bruise) and a third time (3-X bruise). After each treatment, the fruit was drained for 2 minutes, and then a volume measurement taken and weight recorded.

These results indicate that the level of bruising does affect the density of the fruit in two distinct ways. As shown in Table 1, the first level of bruising reduces the density because the ruptured skin allows cherry juice to drain away. After losing their initial turgidity, cherry density increased with each succeeding bruise level. Severely bruised fruit is penalized approximately 3 percent when the density of unbruised fruit is used to obtain the weight.

TABLE 1—Effect of bruised cherries on pallet tank weight

Bruise Level	Bulk Density	Wgt. Calculated for Standard Pallet Tank (16.8 ft.^{3}), lb.	% Difference in Wgt. Caused by Brusing
0-X	49.3	838	0
1-X	48.6	816	−1.5
2-X	49.5	831	+0.3
3-X	50.3	845	+2.8

Maturity and Fruit Size

Within a given volume mature fruit with a high solids content could weigh more than immature fruit, so the differentiation within a given volume as to weight was studied among different sizes.

The cherry samples were mechanically sorted into three groups: (1) 16mm and smaller, (2) 16-19 mm, and (3) 20 mm and larger. A sample of 9.725 cu. ft. was taken of each size group and the weights recorded. Each sample size was subjected to the average soluble solids test to indicate maturity. Average values for density and soluble solids for each sample were then calculated.

The smallest cherry size sample in Table 2 had a significantly lower density than did the two larger sized samples. The soluble solid content was highest for the largest cherries. The density of the two larger sizes shows no significant variation, but the smaller

TABLE 2—The effect of cherry size on density and soluble solids

Cherry Size	Density lb. per ft.^{3}	Soluble Solids Percent
16 mm and smaller	45.40	10.2
16 mm - 19 mm	48.50	12.2
20 mm and larger	48.40	13.7

cherry group shows a significant weight differentiation from the other two. Even though small cherries weigh less, in the majority of loads average size remains constant and this factor can be ignored. Therefore the combination of fruit size and soluble solids content should have no significant effect on computing the weight by volume for an average field sample.

Stem Effect

Mechanically harvested cherries may retain a large percentage of stems. Stems weigh less than fruit; therefore, a given volume of cherries with stems would weigh less than destemmed cherries.

A 0.1 cu. ft. sample of orchard run cherries were used to evaluate the significance of stem influence on density. Cherries with 100 percent of the stems attached were weighed and counted, as were percentages of 15, 10, 5 and 0.

Table 3 shows a significant difference in volume weight at the 100 percent level as compared to slight significance at the 15 percent stem level and no significance with 10 percent or less. Most mechanically harvested cherries have less than 10 percent stem, therefore stem effect can also be ignored in making calulations.

TABLE 3—The effect of stemmed cherries on volume weight

Percent Stems Attached to Fruit	Weight lbs.	Number of Cherries per Weight[a]
100	3.86	337
15	3.94	374
10	4.11	379
5	4.16	379
0	4.18	379

[a]Average soluble solid content for the measured cherries was 13.2.

VOLUME VS. WEIGHT

During the 1967 cherry harvest season, over 200 pallet tanks containing approximately 150 tons of cherries were measured. The cherry depth, tank dimensions and conveyor scale weight were recorded. A sample was taken and weighed from each measured pallet tank.

Effect of load size, day and area on density

Density variation exists among delivered loads, not only between different growers, but also between different loads delivered by an individual grower (Table 4). The 4 percent variation can be compared to the 3 percent variation which 3-X bruised cherries posses over 0-X bruised cherries (Table 1). The variation that exists among loads must be related, in part, to the condition in which each grower delivers fruit to the receiving station. When a sample was taken from each load, variation in density was greater than when the sample was taken from the first load tested. The low variation of density among early morning delivered pallet tanks may be due to the fruit having soaked during the night.

TABLE 4—Cherry density measured by load, day and area (0.725 cu. ft. sample)

	Actual wgt. obtained by scale		Measured wgt. obtained by vol.	
	Mean Density	Standard Deviation	Mean Density	Standard Deviation
Average Load Density	48.32	2.02	46.80	4.16
Average Day Density (1st load tested)	47.93	.62	44.67	.37
Average Area Density (1st load tested)	48.09	.55	44.62	.30

The measured weight of cherries in a pallet tank were calculated by using a corrected density factor obtained from a 0.725 cu. ft. sample taken from each load. The computed weight could be expected to fall within ± 4 percent of the scaled weight 95 percent of the time. If the density factor was computed for each day in an area and this factor used to compute the weight of cherries received for the remainder of that day in that particular area, then the total computed volume weight could be expected to fall within ± 1 percent of the scale weight.

Possible Advantages of Volume Weighing

The most important variable affecting the accuracy of volume weighing is the degree of bruising, which is an advantage to those growers who deliver quality fruit. Non-bruised fruit will have a density lower than the predetermined density factor, consequently a grower will be paid a premium. Those growers delivering badly bruised fruit will be penalized because the density will be greater than the factor used in determining the delivered weight of cherries.

CONCLUSIONS

1. The combination of fruit size and soluble solids content has no significant effect on density for an average load of cherries.
2. Nesting does not occur when water level is maintained above fruit level.
3. Firmness of cherries has the most significant effect on density. Variation in firmness can cause the density to fluctuate by 3 percent from 0-X to 3-X bruising.
4. The weight of a load of cherries, calculated by a volume method, can be expected to be within ± 4 percent of the scale weight 95 percent of the time (Table 4).
5. The total weight, calculated by a volume method for a day or an area, can be expected to be within ± 1 percent of the accumulative weight for that day or area 95 percent of the time (Table 4).

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