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Studies on Cherry Scald

II. Relationship Between Bruising and Respiration in Air[a]

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Light-colored surface discolorations on cherries, termed scald, is a serious problem of the sour cherry industry. Recent studies by Moyer *(2)*, LaBelle *(1)*, and Whittenberger and Hills *(8)* have shown that the principal cause of scald initiation is bruising, which occurs during both the picking and the post-harvest handling of the fruit.

Previous studies at this Laboratory have been concerned with the effects of bruising on the respiratory activity of cherries *(4)* and the relationship between respiration in water and scald formation *(5)*.

The present study is an investigation of the relationship between bruising and respiration in air as they influence scald formation.

MATERIALS AND METHODS

Cherries for all of the experiments were picked from several trees selected at random from the orchard of the National Agricultural College, Doylestown, Pennsylvania. The areas of the trees to which picking was limited were similar in location and height. The required number of cherries for each experiment was carefully cut by scissors from each tree on the day of the experiment and transported back to the laboratory, the entire process taking no longer than 2 hours.

Two series of experiments were made on these cherries, one to determine their respiration in air when unbruised and bruised, and one to duplicate scald in the laboratory by bruising and subjecting to high air temperatures. The respiration studies were conducted using the Warburg technique employing large, wide-mouthed respiration vessels with ground-glass reduction joints for connection to the manometers. In place of the customary center well, there were 2 hollow stopcock side arms on each flask *(6)*, each containing 0.5 ml. of 5% KOH plus a pleated 35 x 35 mm. piece of filter paper. Supports about 15 mm. from the bottom of each flask held a removable, perforated stainless steel disk for holding the cherries.

The stems were cut from the cherries so that only enough remained to be grasped by tweezers; the cherries were not handled by the fingers during any phase of the experimental procedure. Their weights and volumes were obtained, the latter by water displacement. Two cherries were dried with soft absorbent tissue and placed on the disk inside each vessel. Each vessel containing the fruit was allowed to come to equilibrium with both side stopcocks open to the center chamber. By means of a water bath the vessels were maintained at 2 temperatures, 86° F. (30° C.) and 50° F. (10° C.), the former approximating the average daytime temperature encountered in the orchard, and the latter the temperature of commercial soaking tanks.

Oxygen uptake of each pair of cherries was measured first. Side stopcocks were then carefully closed off from the central chamber with the vessels still in a stationary position in the water bath, and the total gaseous exchange (O_2 plus CO_2) measured. Values for the oxygen and carbon dioxide exchanges were then calculated *(7)*.

Respiratory activities were determined first on the normal fruit and then on the same cherries following bruising. In this manner each set of cherries served as its own control. The cherries were bruised by dropping them from a height of 3 feet onto a hard surface. Care was taken to avoid splitting the skins.

In the second series of experiments, typical lug scald was induced in the cherries in the laboratory by bruising them and storing them at high temperatures comparable to those frequently encountered in the orchard. The cherries were dropped from a height of 3 ft. onto a hard surface 1, 2, 3, or 4 times and then held in a glass container at 90° F. (32° C.) for up to 5 hr. Since the scald spots thus induced did not usually appear immediately, the cherries were soaked overnight in water at 35° F., whereupon the blemishes became quite evident and could be counted easily. (Soaking 6 to 12 hr. before processing is common procedure in the industry.) Each lot treated in this way consisted of 25 to 30 cherries, and the percentage of each lot slightly scalded (partially bleached surface areas) and severely scalded (completely bleached areas at least ¼ in. in diameter) was recorded.

RESULTS AND DISCUSSION

Quantities of oxygen consumed and carbon dioxide evolved by cherries respiring in air at 10° C. (50° F.) are shown in Figure 1. For unbruised fruit the average respiratory quotient (R.Q.) was 0.9. Bruising caused an average increase of 9% in the oxygen consumption and the carbon dioxide output rose by approximately 33% giving an R.Q. of 1.1.

At 30° C. (86° F.) the quantities of oxygen utilized and carbon dioxide evolved (Figure 2) showed an appreciable increase. The oxygen consumption increased from 18.9 μl./g./hr. at 10° C. to 46.6 μl./g./hr. at 30° C., and the carbon dioxide output increased from 17.2 μl./g./hr. to 48.2 μl./g./hr. The ratio of the oxygen consumption of unbruised fruit at 10° and 30° C. was 2.46 corresponding to a calculated Q_{10} value of 1.57, a normal value for enzyme-catalyzed reactions. For unbruised fruit the average R.Q. was 1.0. Bruising caused an average increase of 27% in the oxygen consumption and 63% in the carbon dioxide output, giving an R.Q. of 1.3.

In a series of studies being carried out in this Laboratory (unpublished data) it has been noted that

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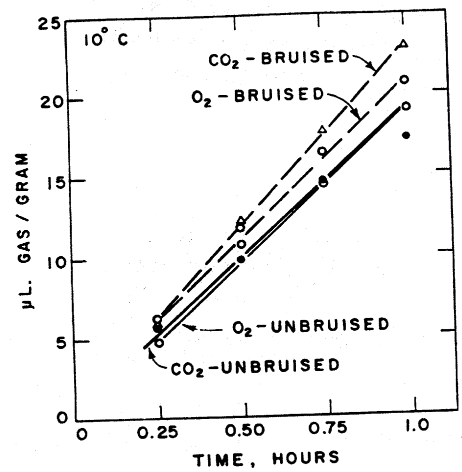

Figure 1. Respiratory activity of unbruised and bruised red tart cherries in air at 10° C.

the respiratory activities of red tart cherries from one orchard has been similar so far for the seasons of 1956 and 1957. The probability that geographical location may exert a notable effect on the respiratory effect as well as on the response to bruising is suggested in a report on cherries grown in the Biglerville, Pa., area *(4)* which showed an increase in oxygen consumption and carbon dioxide evolution of 50% and 126%, respectively, after bruising. These cherries also had higher R.Q. values, both bruised and unbruised, than the cherries reported in this study.

In order to provide more information on scald development, experiments were carried out relating scald to the extent of bruising and to the time and method of holding cherries in air at a higher temperature following bruising.

Table 1 shows that the incidence and severity of scald in cherries held at a high temperature were related to the amount of bruising.

Table 2 shows that after the bruised cherries were held in air at 90° F. for 2 hours scald was evident on all the cherries but most of it was slight, and that severe scald appeared in half of the bruised cherries held for 5 hr. To determine the possible effect of the conditions under which cherries are held after bruising, a further experiment was performed in which the cherries, instead of being placed on top of each other in a container, were placed on a wire screen in a single layer. As Table 2 shows, with this procedure scald was completely eliminated in more than half of the cherries, while the rest were for the most part only slightly scalded. Examination of the cherries held in the container and those held on the screen showed that in each case scald occurred only at points of contact. The scald was much more extensive in the cherries held in the container where there were many points of contact between the cherries and the container. Similarly, the scald was restricted greatly where each cherry had only minute points of contact with the meshes of the screen.

TABLE 1

Effect of the extent of bruising on the formation of scald in bruised cherries
(Cherries held in container 5 hr. at 90° F.)

No. of 3-ft. drops	% of cherries: No scald	Slight scald	Severe scald
0	100	0	0
1	68	32	0
2	36	60	4
3	0	52	48
4	4	48	48

Thus, the similarity between lug scald and tank scald, as described in a separate publication *(5)* can be established. In the present case it appears that points of contact between cherries and the container or other cherries would have little or no oxygen supply. At these points of contact, or in the wet environment, gas exchange was curtailed sharply, oxygen supply was limited, and a shift in respiration took place. Scald formation therefore appears to be due to a lack of oxygen, or to the liberation or accumulation of toxic substances *(3)* that may occur as a result of an inadequate oxygen supply.

TABLE 2

Effect of time and conditions of holding on the formation of scald in bruised cherries
(Cherries dropped 3 times from 3-ft. height)

Held at 90° F. (hr.)		% of cherries		
In glass container	On wire screen	No scald	Slight scald	Severe scald
0	..	100	0	0
2	..	0	65	35
5	..	0	50	50
..	5	56	38	8

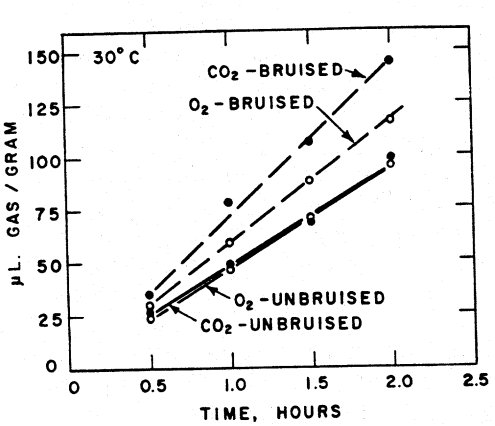

Figure 2. Respiratory activity of unbruised and bruised red tart cherries in air at 30° C.

SUMMARY

Unbruised red tart cherries respiring in air gave a respiratory quotient of 0.9 at 10° C. and of 1.0 at 30° C. Raising the temperature from 10° to 30° C caused nearly a three-fold increase in the oxygen consumption of unbruised fruit. Under conditions of stress such as bruising, the oxygen consumption and carbon dioxide evolution rose at either temperature.

Bruised cherries stored in air at 90° F. for only 2 hours scalded at the points of contact between cherries, and between cherries and container. Scald development was correlated with the extent of bruising and with the length of the delay period after bruising.

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