9. Stamer, J. R., M. H. Dickson, J. B. Bourke, and B. O. Stoyla. 1969. Fermentation patterns of poorly fermenting cabbage hybrids. *Appl. Microbiol.* 18:323–327.
10. Warner, J. N. 1952. A method of estimating heritability. *Crop. Sci.* 44:427–430.
11. Yarnell, S. H. 1953. Five abnormal types of cabbage. *Proc. Amer. Soc. Hort. Sci.* 61:447–450.

Histology of Blemishes of Cherry Fruits, (*Prunus cerasus* L., cv. Montmorency), Resulting from Mechanical Harvesting[1]

C. E. Arnold[2] and A. E. Mitchell
Michigan State University, East Lansing

Abstract. Scald was the major grade lowering defect resulting from mechanical harvesting of sour cherries for processing. Histological sections of scalded tissue showed no crushing or distortion of cells, but the epidermal cells appeared dense and the cell walls appeared to be thicker than those of nonscalded tissue. Since the cells of scalded tissue did not appear distorted, bruising apparently induced a chemical change as a result of membrane disruption bringing about discoloration. Microscopic examination indicated that darkened bruises on the epidermis of the cherries occurred prior to mechanical harvesting. Tannins were located primarily in the epidermal region, but during a 24-hour soak there was a slight movement of tannin into the outer cortical cells. Greater movement occurred in mechanically harvested cherries than in handpicked fruit. The cellular disruption resulting from bruising by mechanical harvesting possibly aided the movement of tannins. Scald was a major grade lowering factor when mechanically harvested cherries were soaked longer than 8 hours before processing.

For economic reasons, the Michigan sour cherry industry is changing from methods involving handpicking and delivery in wooden lugs to mechanical harvesting with the cherries delivered to the processing plant in water. The grade of the processed cherries from the newer method is often lower than would be expected based on their grade upon arrival at the processing plant. Processors feel that during the harvesting operation the cherries are injured internally. However, the injury is not revealed until after processing.

Reduction in quality of processed sour cherries from scald (loss of pigment from epidermal cells) and those factors contributing to scald are well-known (6, 7, 8, 9). However, the internal injury to the fruit during mechanical harvesting and subsequent handling before processing has not been evaluated. This study was initiated to determine possible injury from mechanical harvesting of sour cherries and the significance of such injury to the quality of the processed product.

Materials and Methods

In 1967, approximately 500 g of sour cherries grown under commercial conditions were carefully hand-picked from each of 6 trees. Similar samples were taken immediately after mechanical harvesting from the same trees and again after a 20-hour soak. Commercially, sour cherries are often soaked 12 to 24 hours in water before processing. Immediately after sampling, all the samples mentioned above were placed in commercial SO_2 cherry brine. Even though sour cherries are not usually commercially brined as are sweet cherries to be used as maraschino cherries, the samples were placed in brine to remove the pigments which masked the blemishes.

After approximately 2 months, brined cherries exhibiting different types of injuries were removed from the brine, dehydrated in tertiary butyl alcohol, embedded in Tissuemat (57°C melting point) and sectioned at 20 microns on a rotary microtome, as described by Johansen (5). Sections cleared of paraffin were made into permanent mounts for study of internal cell injury from bruising, using phase-contrast microscopy.

Since the 1967 data suggested that length of soak was critical, in 1968 approximately 25 lb. of cherries were carefully hand-picked from each of 6 mature trees in 3 orchards in southwestern Michigan. Also, approximately 25 lb. of cherries from these same trees were collected immediately after mechanical harvesting. The samples were graded according to USDA standards (1), then placed in cheesecloth bags and suspended in a soak-tank of running water at 54–56°F (Fig. 1).

Following 4-, 8-, 12- and 24-hour soaks, a 500-gram sample of cherries was carefully removed from each bag (1 bag of hand-picked cherries per tree and 1 bag of mechanically harvested cherries per tree) and graded. At the same time another sample of approximately 500 g from each bag was placed in brine. After approximately 2 months, the cherries were removed from the brine and graded. Samples of blemished and non-blemished fruit were prepared as in 1967 (5) for continued study of epidermal and sub-epidermal cells.

In addition, at the end of each soak period, 6 cherries from each of the hand-picked and mechanically harvested samples were placed in a ferrous sulfate, tannin-staining fixative solution consisting of 10% formalin and 2% ferrous sulfate as described by Jensen (4), to study locations of tannin accumulation within the fruit.

Results and Discussion

An anatomical evaluation of hand-picked fresh cherries revealed that splitting of epidermis tissue during final fruit swell (11) was healed by a hardened exudate (Fig. 2a and 2b). Such injury, referred to as wind-whip, was easily mistaken for a surface bruise because the rupture of the epidermis was not easily detected.

Photomicrographs of prepared sections of mechanically

[1]Received for publication March 23, 1970. Published with the approval of the Director of the Michigan Agricultural Experiment Station as Journal No. 5018.
[2]Present address: Department of Fruit Crops, University of Florida, Gainesville.

Fig. 1. Cherries in cheesecloth bags suspended from rods in a grower's soak tank with running water at approximately 55°F.

harvested cherry tissue are shown in Fig. 2c through g. The portion of fruit in cross-section (Fig. 2c) appeared unbruised in surface view; but, cortical cells were sheared approximately 4 cells below the epidermis. A similar type of internal injury was found in cherries hand-picked just before mechanical harvesting (Fig. 2d). Such bruises did not appear to affect the grade of the processed product.

Some sections of hand-picked cherry tissue (Fig. 2e) revealed that the epidermal cells were intact with crushed cells beneath. In surface view, injuries of this nature appeared as dark brown areas.

From microscopic examinations, all darkened bruises on mechanically harvested cherries appeared to have occurred on the tree. Loss of red color or scald associated with soak time was the principal defect of mechanically harvested cherries. There appeared to be a direct relationship between bruising and loss of red color or scald.

Epidermal cells of scalded and non-scalded fruits showed no crushing or distortion. However, cells of the scalded epidermal tissue appeared dense (Fig. 2g), and the cortical cell walls of the mechanically harvested cherries appeared thicker than those of carefully hand-picked non-scalded fruits (Fig. 2f), even though the cells showed no distortion or injury.

Since the cells of scalded tissue did not appear to be distorted, bruising apparently induced a chemical change as a result of membrane disruption bringing about discoloration; or, as Pollack reported (10), the scalding may have resulted from disruption of the normal respiratory process.

Oxidized tannins reported to be primarily responsible for the brown color associated with scald (3, 6 and 12) were observed in both handpicked and mechanically harvested cherries collected before soaking and after a 4-, 8-, 12- and 24-hour soak.

Cross-sections of the sour cherry tissue soaked in ferrous sulfate revealed the presence of tannins localized in the epidermal and sub-epidermal cells (Fig. 3a and 3c). However, during the 24-hour soak period, there appeared to be a slight movement of tannins into the cortex (Fig. 3b and 3d). The movement appeared to be greater for mechanically harvested (Fig. 3d), than for hand-picked cherries (Fig. 3b). Cellular disruption resulting from bruising during mechanical harvesting (Fig. 3c) was apparently responsible for the movement of tannins into sub-epidermal cells.

Length of soak was found to be the critical factor in maintaining high quality of the processed sour cherries. As shown in Table 1, both the hand-picked and the mechanically harvested cherries increased in percent blemishes, primarily scald, as the length of soak increased. However, the increase was much greater for mechanically

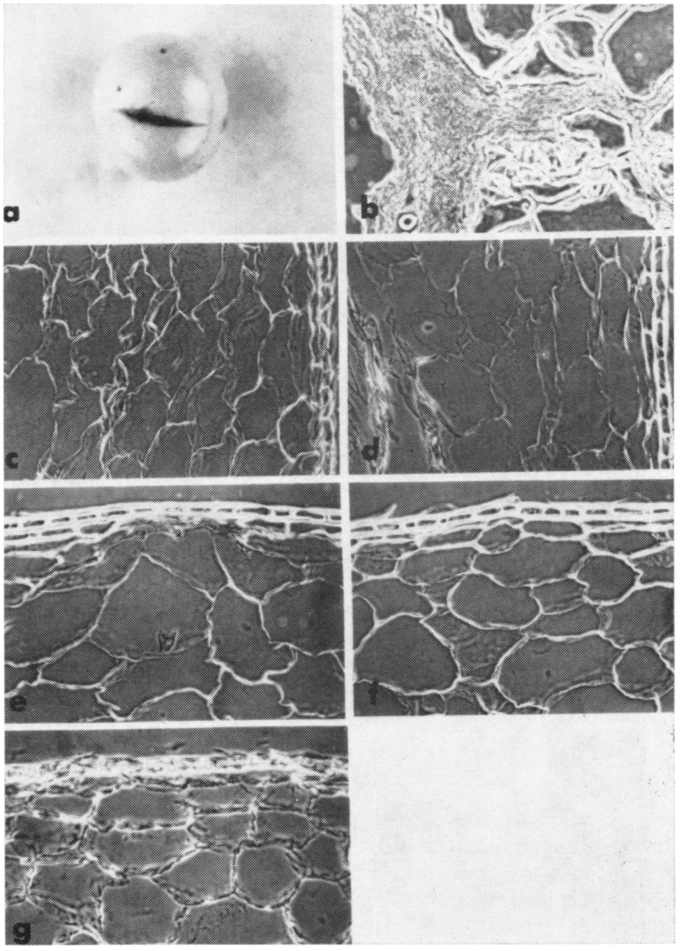

Fig. 2. External and internal injury of cherry fruits on the tree and during mechanical harvesting, handling, and processing. Southwestern Michigan, 1967.

a. Wind-whip scar occurring on the tree (SO_2 bleached cherry).
b. Cross-section of wind-whip scar shown in Fig. 2a. Phase contrast, 125×.
c. Shearing of cortical cells. Cherry collected after mechanical harvesting. Phase contrast, 125×.
d. Internal injury. Cherry hand-picked from tree. Phase contrast, 125×.
e. Sub-epidermal injury. Cherry hand-picked from tree. Phase contrast, 125×.
f. Tissue of non-scalded cherry hand-picked from the tree. Phase contrast, 125×.
g. Tissue of scalded cherry collected after processor soak. Phase contrast, 125×.

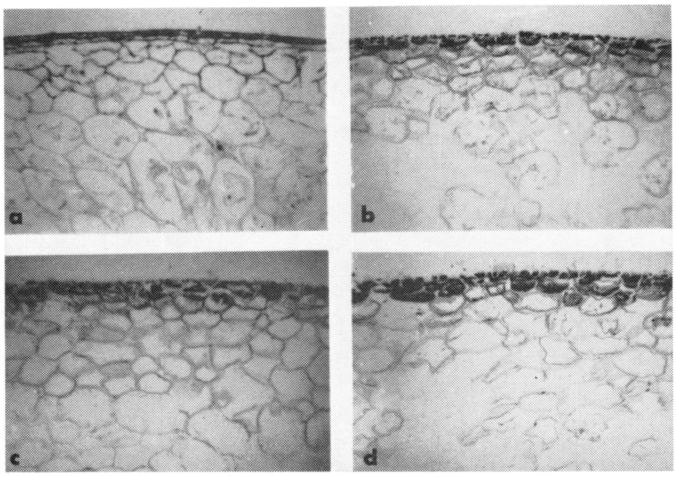

Fig. 3. Cross-sections of hand-picked and mechanically harvested cherries before soaking and after soaking for 24-hours, stained with ferrous sulfate to show tannin content. Bright field 50×.
a. Hand-picked cherry before soaking.
b. Hand-picked cherry after 24-hour soak.
c. Mechanically harvested cherry before soaking.
d. Mechanically harvested cherry after 24-hour soak.

harvested cherries than for hand-picked cherries. Removing the anthocyanin pigments by bleaching in brine for 2 months vividly revealed the scald which was present only in the mechanically harvested cherries. Bruising from mechanical harvesting apparently resulted in an increase of leaching of anthocyanin pigments from the epidermal cells of the fruit revealing the oxidized tannins which gave the fruits a brownish appearance.

In summary, the reduction in grade of processed sour cherries below that of the fresh grade was due mainly to scald resulting from bruises followed by a soak of more than 8 hours. When graded according to USDA standards (1), the scald on fresh cherries was masked by anthocyanin pigments even following 24 hours of soak. After soaking fruits more than 8 hours and bleaching them with brine, the scald or brownish appearance became very obvious. Bruises resulting from wind-whip and severe bruises resulting from impact with non-padded surfaces were not masked by anthocyanin pigment. These cherries were thrown out by the electric-eye sorter and were not present in the processed product.

Table 1. Percentage blemished fresh and bleached fruits, hand-picked and mechanically harvested, as influenced by length of soak. Average of 3 harvests. Southwestern Michigan, 1968.

Length of soak[x]	Percent blemished fruits[y]			
	Fresh		Bleached[z]	
	Hand picked	Mechanically harvested	Hand picked	Mechanically harvested
Before soak.....	3.2 a	8.6 a	7.8 a	18.3 a
After 4-hour soak....	4.1 a	18.8 b	8.7 a	22.3 ab
After 8-hour soak....	4.7 a	27.1 c	9.1 a	26.4 b
After 12-hour soak...	7.1 ab	33.8 d	9.8 a	33.7 c
After 24-hour soak...	11.6 b	49.6 e	11.9 a	90.4 d

[x]Water temperature ranged from 54 to 56° F.
[y]Numbers in the same column followed by the same letter are not significantly different (5% level).
[z]Held in commercial cherry SO_2 brine.

Literature Cited

1. Anon. 1960. Red sour cherries for processing: inspection instructions. Agricultural Marketing Services, USDA.
2. Esau, Katherine. 1965. Plant Anatomy (2nd ed.). John Wiley and Sons, Inc., New York, pp. 586–606.
3. Hawkins, L. A. and C. E. Sando. 1920. Effect of temperature on the resistance to wounding of certain small fruits and cherries. *USDA Bul.* 830:1–6.
4. Jensen, W. A. 1962. Botanical Histochemistry. W. H. Freeman and Co., San Francisco.
5. Johansen, D. A. 1940. Plant Microtechnique. McGraw-Hill Book Co., New York.
6. LaBelle, R. L. 1965. Controlling cherry scald. *Proc. N. Y. State Hort. Soc.*, p. 117.
7. ———, J. C. Moyer, W. B. Robinson, and D. B. Hand. 1958. Causes of scald in red tart cherries. *Food Tech.* 12:94–98.
8. Marshall, R. E., W. F. Robertson, C. L. Bedford, and W. H. Case. 1951. The effect of the length of soak on the quality of canned and frozen Montmorency cherries. *Food Tech.* 5:116–118.
9. Moyer, J. C. 1952. Factors causing scald. *Canner and Freezer* 115:10.
10. Pollack, R. L., C. Ricciuti, C. F. Woodward, and C. H. Hills. 1958. Studies on cherry scald. I. Relationship between bruising and respiration in water. *Food Tech.* 12:102–105.
11. Tukey, H. B. 1934. Growth of the embryo, seed and pericarp of the sour cherry (*Prunus cerasus*, L.) in relation to season of fruit ripening. *Proc. Amer. Soc. Hort. Sci.* 31:125–144.
12. Yeatman, J., G. Birth, J. Ernest, R. Bender, and A. Sidwell. 1961. Spectrophotometric evaluation of anthocyanin pigment development and scald damage in intact red tart cherries. *Food Tech.* 15:521–525.