A Method of Testing Crack Resistance in Tomatoes

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In general it may be said that cracking of tomato fruit occurs wherever tomatoes are grown. Many kinds of cracks are seen on tomatoes. Radial, concentric, and side cracks are the most common and destructive. These usually decrease the market value of the fruit. Cracking of tomatoes is one of the most serious problems in processing tomatoes in Japan. It is known that rainfall and variations in soil moisture are the factors most closely associated with cracking. No cultural practices have been found which can consistently reduce the occurrence of cracking. On the other hand, varietal differences in susceptibility to cracking and the inheritance of the crack resistance have been reported by many investigators.

Several methods have been developed for testing the crack resistance. They include the following: (1) the direct methods which induce cracking artificially on the fruit in the field or on detached fruit, (a) the water sprinkling method, which induces cracks in field staked tomatoes by flushing over head irrigation; (b) the complete immersion or water soaking method, in which the fruit is immersed in water; and (c) the vacuum-immersion method, in which the fruit is immersed in water under vacuum: (2) the indirect methods to estimate the cracking tendency of varieties by testing the mechanical properties of the skin and flesh of the fruit, (a) the puncture test, in which a hole is punctured through the skin and flesh and the force required is measured; (b) the bursting test, which apply the pressure of compressed air on tomato epidermis taken from a given part of the fruit; and (c) the tensile test, which stretches a standard-shaped piece of fruit epidermis and recrods the tension needed to break it.

Method of vacuum-immersion

On the basis of the principle of the vacuum-immersion method developed by Hepler[1], the author deviced a modified method adapted to the purpose of testing crack resistance under climatic conditions of Japan. This method of measuring the resistance to fruit cracking consists of placing detached fruits in water, applying a partial vacuum until the air bubbling from the stem end scar (stem attachment point) of the fruit ceases.

Description of vacuum-immersion apparatus

An apparatus of the modified method is shown in Plates 1 and 2. The apparatus consists of four vacuum chambers, four immersion containers, a reservoir tank, and a rotary vacuum pump. Desicators (34 by 34 cm) are used as the vacuum chambers. Battery jars (30 by 15 cm) are used as the immersion containers for the fruit. Another larger desicator is used as the reservoir tank. A non-porous rubber mat is used to tightly close the cover of the vacuum chamber. A round piece of wire-netting is used to hold the fruit completely under water in the immersion container. Vacuum gauges are placed on the

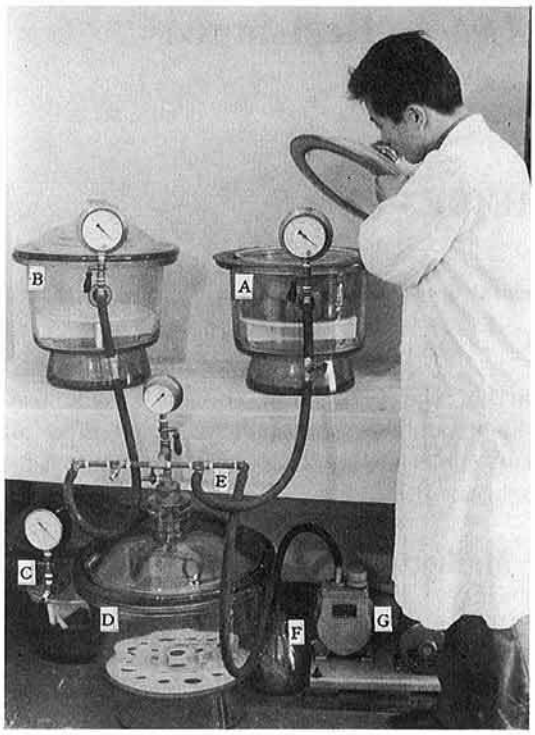

Plate 1. General view of water vacuum-immersion apparatus
(A) and (B) vacuum chamber, (C) spare vacuum chamber (D) reservior tank, (E) valve outlets, (F) filtering flask containing silica, (G) rotary vacuum pump with 1/8 h. p. motor

vacuum chamber and the reservoir tank, to check the degree of vacuum in the chamber. A three-way valve was placed on each of the vacuum chambers, for releasing the vacuum in the vacuum chambers. Four of the five valve outlets of the reservoir tank are to be connected to the vacuum chambers (one to each chamber), and the other one is to be connected to a rotary vacuum pump. A filtering flask is used to protect the vacuum pump against moisture. For a simpler version of this apparatus, a vacuum chamber may be connected directly to a rotary vacuum pump.

Operation

All fruit samples are harvested at the turning stage, and their stem are removed carefully. Harvested fruit is marked with a water-proof felt marking pen, so that a lot of fruit of several varieties can be treated together in the same vacuum chamber. The fruit is immersed in water (maintained at 20°C) in an immersion container inside the vacuum chamber. Usually, a vacuum of 25 to 30 cm of mercury is applied and held until the air bubbling from the fruit ceases (usually about 2 min). After the vacuum in the chamber is released by three-way valve, the immersion container is taken out of the vacuum chamber. The fruit in the immersion container is held under water for a given number of hours (usually 1 to 3 hr). And then, the fruit is taken out of the immersion container. The cracks on the fruit are classified as radial or concentric. The length of a crack may be estimated visually or determined with a map measure as described by White and Whatley[4].

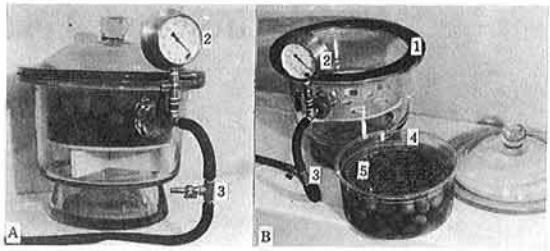

Plate 2. Detailed view of vacuum chamber and immersion container
(A) closed vacuum chamber, with immersion container inside, (B) opened vacuum chamber and immersion container beside it, (1) non-porous rubber mat, (2) vacuum gauge, (3) three-way valve to release vacuum, (4) immersion container, (5) round shaped wire netting

Suggestions and requirements for the testing procedures

The types of cracking induced by the vacuum-immersion method is similar to that occurring under field conditions for a given variety (Plate 3). It has been found that the

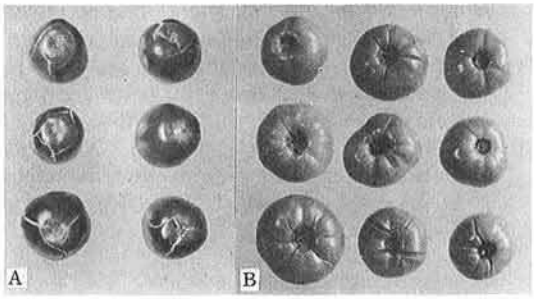

Plate 3. Type of cracks induced by the vacuum immersion treatment
(A) concentric crack on pear-shaped fruit,
(B) radial crack on flattened fruit

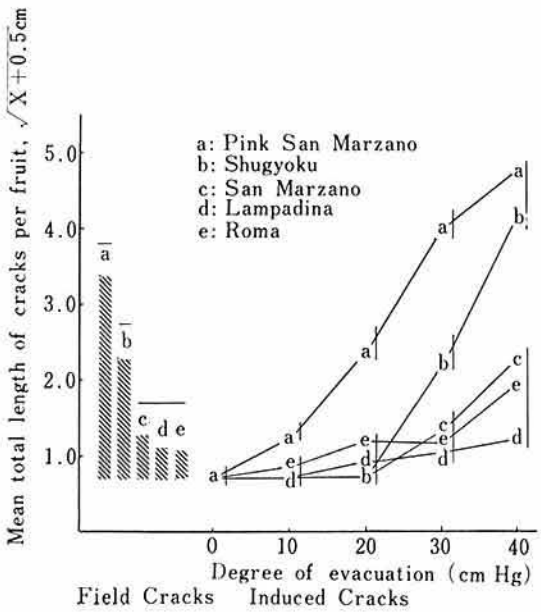

Fig. 1. Effect of the degree of evacuation on the length of cracks induced on fruit at the turning stage
Separate lines (vertical or horizontal) indicate significant diffferences at the 5% level.

cracking induced on vacuum-immersed fruit was correlated with field cracking (Fig. 1). One of the main problems is how to determine the cracking which occurs during the dry season and under greenhouse conditions.

It was proved that the vacuum-immersion method can determine crack resistance of tomatoes grown under such conditions. Thus the method is of considerable value for the determination of the crack resistance of tomato fruit, and also useful for analyzing the mechanism of fruit cracking.

As pointed out by Helper[1], the amount of induced cracks appears to be influenced by the following five factors, 1) the degree of evacuation, 2) the length of time of immersion after evacuation, 3) the temperature of the immersion water, 4) the length of time between harvest and evacuation beyond 12 hr, and 5) maturity of the fruit. Amount of cracking increases with increased evacuation. The longer the period of immersion after evacuation, the more cracking there will be. The amount of cracking increases with an increase in temperature of the immersion water. The most cracking is induced on turning fruits.

Furthermore, in the determination of the cracking resistance, the following cares are required:

1. Care must be taken not to injure the fruit.
2. The fruit already cracked in the field, and the defective fruit with blotchy ripening, sun scald, and blossom-end rot must be eliminated.
3. The fruit must be kept under water completely at all times.
4. The fruit must be evaluated two or three times during a harvest season, because there are differenecs in severity of cracking for a given variety within a season.
5. It may be convenient to compare with a check variety which is known to be crack-resistant and treated in the same way.
6. It may be better to adopt a somewhat higher degree of evacuation than the standard for testing the crack resistance of fruit grown under greenhouse or dry season conditions.
7. A sample of 10 to 30 fruits is considered to be enough for classification of a variety.

References

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