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THE EPIDERMAL CHARACTERISTICS OF FRUIT SKIN OF SOME SWEET CHERRY CULTIVARS IN RELATION TO FRUIT CRACKING

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Abstract

The epidermal characteristics of fruit skin of 8 sweet cherry cultivars were determined in terms of susceptibility to cracking. The cultivars 0900 Ziraat and Bella di Pistoia having the thickest cuticle, had the lowest cracking index. There was a negative correlation between the cuticle thickness and fruit cracking. There were no correlations relationship between fruit cracking and thickness of epidermis, thickness of subepidermis and number of subepidermal cell layers.

Introduction

Fruit cracking caused by rainfalls before harvest is a major problem in sweet cherry growing in many parts of the world. In spite of the fact that many researches have been carried out on the phenomenon but the cracking mechanism has not yet been completely understood. The prevailing theories on cracking mechanism have been based on the water penetrating the fruit surface causing an increase in volume of the fruit that itself causes cracking (Sawada, 1931; Verner & Blodget, 1931; Christensen, 1972, 1976, 1994). Some other studies indicated that the water uptake by the fruit from the root system, causing internal turgor pressure buildup, plays an important role in cracking mechanism (Kertesz & Nebel, 1935; Considine & Kriedeman, 1972; Yamamoto *et al*., 1990). Recently according to a new theory, the properties and function of the fruit cuticle and water conducting tissues (xylem and phloem) in the tree, the fruit pedicel and fruit itself are crucial to the sweet cherry cracking mechanism (Sekse, 1995a,b; 1998).

There is a great difference among the sweet cherry cultivars in terms of susceptibility to cracking. Several theories have been put forward by researches as to these differences eg., i. The varieties that take up more water from their fruit surface are likely to be more sensitive to cracking. ii. The varieties that have skins with epidermal cells that are more strongly bound together are likely to resist cracking. The fruit skin, its cuticle and epidermis may be more of a barrier to water uptake into fruit in the resistant varieties (Webster & Cline, 1994).

Sweet cherry fruit cuticle acts as an efficient water barrier against water uptake from the fruit surface, but contains pores that allow some water penetration. Another important property of the sweet cherry fruit cuticle influencing fruit cracking is its rigidity due to its wax-like structure. Irregular water supply to the fruits causes formation of parenchymatous tissue, thereby fruit grows irregularly. Concurrent with this the waxed cuticle does not stretch and fractures develop (Sekse, 1995b). Such cuticular fractures would allow greater water penetration (Glenn & Poovaiah, 1989).

In the literature, a description of the different types of cell and tissue present in the sweet cherry fruit and their relations with fruit cracking are lacking. The skin of the sweet cherry fruit consists of a cuticle and several dermal cell layers (Sekse, 1995a; Kertesz & Nebel, 1935; Glenn & Poovaiah, 1989). Kertesz & Nebel (1935) expressed that sizes of the epidermal cells in sweet cherry differ and while no correlation could be observed between the size of epidermal cells and cracking, a positive correlation could be found between thickness of inner wall of epidermis and cracking. Belmans *et al*., (1990) reported that resistance to fruit cracking was affected by the genetic factors and for this reason, epidermal and cuticular properties of cherry fruits were important.

Sweet cherry cultivars differ in their susceptibility to fruit cracking. The reasons for such differences in cracking susceptibility, however, are not well understood since multiple factors and their interactions influence cracking. Generally, differences in cracking propensity can be attributed to a genetical and an environmental component (Cline & Webster, 1994). Therefore, the study is aimed to determine epidermal characteristics of the fruit skin of some sweet cherry cultivars that differ in cracking susceptibility and investigate a possible relationship between fruit cracking and the epidermal characteristics.

Materials and Methods

This study was carried out in 2001 by using 8 sweet cherry cultivars viz., Turkoglu, Izmit, Honey Heart, Arap, Otabatmaz, Bing, Bella di Pistoia and 0900 Ziraat. For the anatomical study of the skin, 10 fruits of the each cultivar were harvested at full ripeness. A piece of skin, including the epidermis and parenchyma, was sampled in the equatorial region at the opposite side of the suture of each fruit. The material was fixed in Formaldehyde Glacial Acetic Acid-ethyl alcohol, dehydrated by alcohol series and embedded in paraffin by the method as described by Brooks *et al*., (1966). The sections of fruit skin with 8-9 μm were prepared by a rotary microtome. Thickness of cuticle and epidermis, and number of subepidermal cell layers were measured at 20 different points per sample by a micrometer under a light microscope. Cuticle thickness as cuticle + outer epidermal cell wall, epidermis thickness as distance from cuticle to subepidermis, and subepidermis thickness as distance from beginning of subepidermis to parenchyma were measured by the method described by Belmans *et al*., (1990) and Sekse (1995a).

The susceptibility to fruit cracking was assessed in the laboratory by immersion of 50 fruits in distilled water at 20 ± 1°C for 6 h with three replications and numbers of cracked fruits were counted after two hours intervals. The cracking index was calculated by the formula reported by Christensen (1972).

The data was statistically analysed by analysis of variance and means were compared by Duncan Multiple Range Test using MSTAT Programme. The relationship between cracking index and epidermal characteristics was determined by multiple regression analysis using Excel 7.0 programme.

Results and Discussion

In all the cultivars, thickness of cuticle varied from 2.63 to 4.02 μm (Table 1). Cvs., 0900 Ziraat, Bella di Pistoia and Otabatmaz produced the fruits having thicker cuticle than Bing. Cvs., Izmit and Honey Heart produced the fruits having thinner cuticle than Bing. Cvs., Turkoglu and Arap produced the fruits having thickness of cuticle similar to

Table 1. Epidermal characteristics and cracking index of the sweet cherry cultivars.

Cultivars	Thickness of cuticle (µm)	Thickness of epidermis cell (µm)	Thickness of subepidermis cells (µm)	Number of subepidermis cell layers	Cracking index (%)
0900 Ziraat	4.02 a*	20.25	118.35 de	4.4 ab	00.0 e
Bella di Pistoia	3.94 a	17.01	188.49 a	4.8 a	00.0 e
Izmit	2.63 c	21.04	133.26 bcd	3.0 d	10.1 d
Otabatmaz	3.49 ab	18.22	160.69 ab	3.8 bc	19.2 c
Arap	2.89 bc	17.80	153.59 bc	4.4 ab	35.4 b
Turkoglu	2.89 bc	17.70	109.86 de	3.2 d	40.1 b
Bing	2.89 bc	19.80	127.29 cde	3.3 cd	54.5 a
Honey Heart	2.63 c	15.78	96.26 e	3.1 d	56.1 a

*Means followed by different letters within columns differ significantly ($P<0.01$)

Bing. There was a negative correlation between thickness of cuticle and cracking index (Fig. 1). The cultivars having the thickest cuticle, 0900 Ziraat and Bella di Pistoia, had the lowest cracking index (Fig. 2). The cultivars having thinner cuticle such as Honey Heart, Bing, Turkoğlu and Arap had higher cracking index than the others (Table 1). Kramer & Mohamed (1985), Belmans *et al*., (1990) and Wustenberghs *et al*., (1994) indicated that the cultivars having thicker cuticle were more resistant to cracking than those of thinner although Tucker (1934) and Hiratsuka *et al*., (1989) reported that there was no relationship between cracking and thickness of cuticle. Odabaş (1976) also found that undamaged berries of the Karaerik grape cultivar that is susceptible to cracking had thicker cuticle. cv., 0900 Ziraat resistant to cracking, has been reported to have thicker cuticle than Lambert and Van cvs (Demirsoy & Bilgener, 2000).

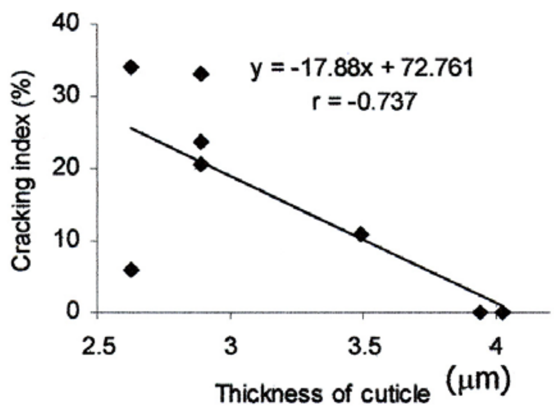

Fig. 1. Correlation between the cuticle thickness of fruits of the sweet cherry cultivars and their cracking index.

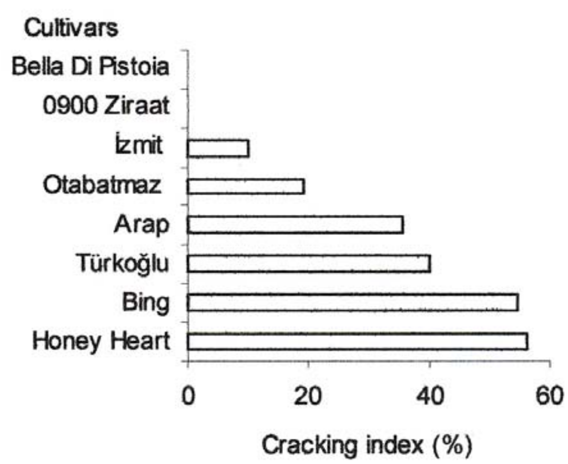

Fig. 2. Cracking index of the sweet cherry cultivars.

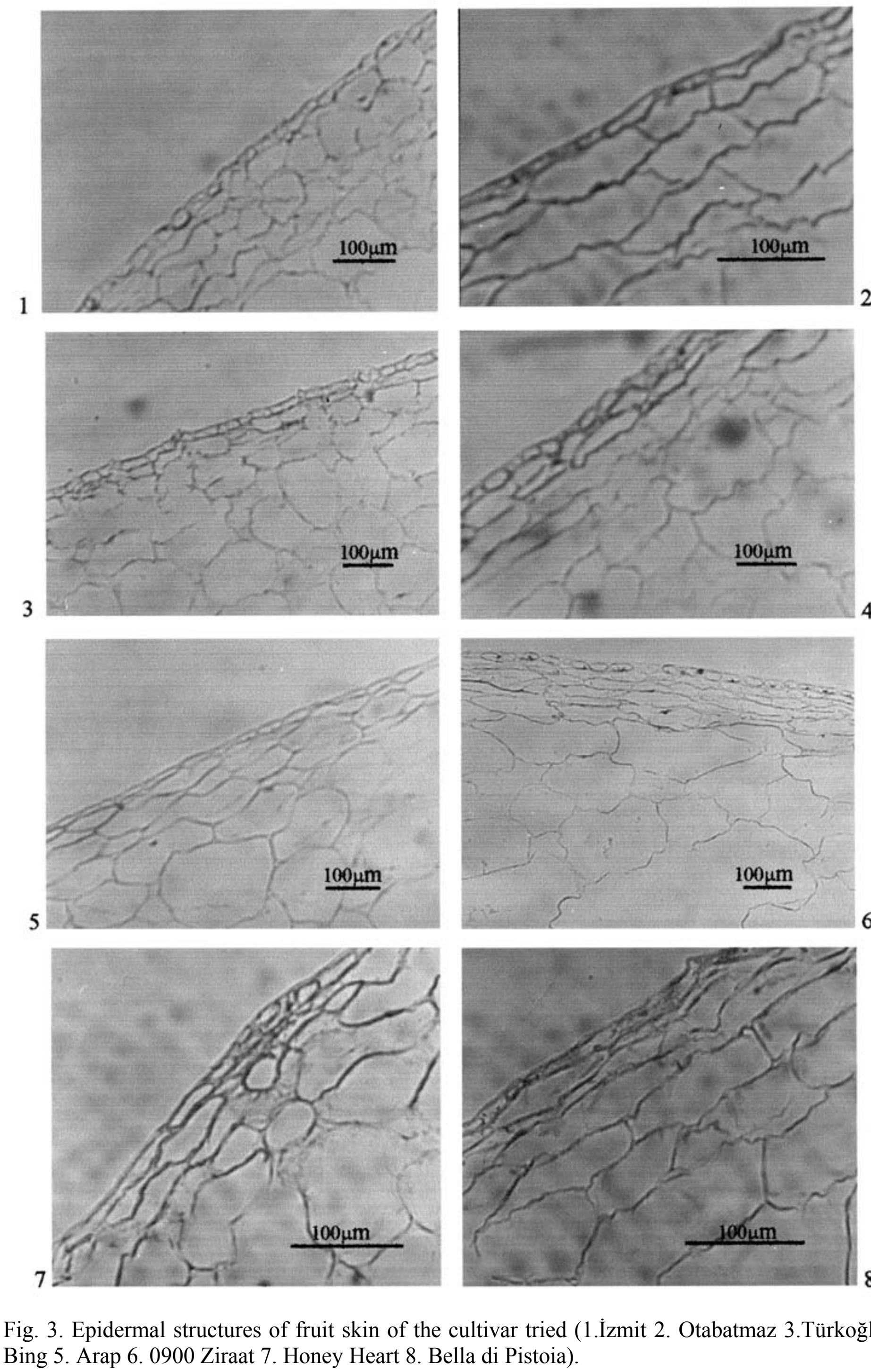

Fig. 3. Epidermal structures of fruit skin of the cultivar tried (1.İzmit 2. Otabatmaz 3.Türkoğlu 4. Bing 5. Arap 6. 0900 Ziraat 7. Honey Heart 8. Bella di Pistoia).

There was no difference among the cultivars in terms of thickness of epidermis although there was a significant difference among the cultivars in terms of thickness of subepidermal cells and number of subepidermal cell layers (Table 1). In this study, it was found that there was no correlation between the epidermal characteristics except for cuticle thickness and cracking index. Kertesz & Nebel (1935) reported that thickness of subepidermal cells of the cultivars which are resistant to cracking was lower. Contrary to Kertesz & Nebel (1935), Hiratsuka *et al*., (1989) revealed that there was a significant relationship between cracking and thickness of subepidermis, and that thickness of subepidermis increased under susceptible conditions. However, Hiratsuka *et al.* (1989) suggested that there was no relationship between thickness of upper epidermis and fruit cracking. Meynhardth (1964) and Odabaş (1976) reported that having lower number of subepidermal cell layers in grapes increased susceptibility to cracking. Cracking resistance of cv., 0900 Ziraat can be explained by its thicker epidermis and subepidermis and a higher number of subepidermal cells layers (Demirsoy & Bilgener, 2000).

In addition, the present results showed that the cultivars where subepidermal cells were flatter and regularly ordered such as in 0900 Ziraat and Bella di Pistoia had the lowest cracking index while cvs., Honey Heart, Bing and Turkoglu having more round and irregularly arranged subepidermis cells, had higher fruit cracking than the other cultivars (Fig. 3). Cracking resistance mechanism of 0900 Ziraat cv was also explained by its larger subepidermis cells, especially longer cells (Demirsoy & Bilgener, 2000). Demirsoy & Bilgener (2000) also suggested that longer cells might bind subepidermal cells together more strongly thus increasing touching surface area of cells, which might create larger space against the tensile forces acting on the fruit surface from inside the fruit. We also think that longer and regular subepidermal cells may have some role in the mechanism of resistance to cracking..

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