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Short communication

Oleocellosis incidence in citrus fruit in response to mechanical injuries

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ABSTRACT

Oleocellosis is a physiological disorder set off after the rupture of peel oil glands, releasing their content which is phytotoxic to pericarp cells. The occurrence of the disorder is generally associated to mechanical injuries and causes high postharvest losses. The present work aimed to determine the elements capable of triggering oleocellosis as well as the susceptibility to the disorder in five citrus species submitted to mechanical injuries. Anatomical pericarp differences were evaluated to correlate to higher or lower susceptibility to oleocellosis and occurrence of postharvest decay associated with the disorder. Cv. Ponkan, Michal and Rainha tangerines, cv. Valencia oranges, and cv. Tahiti limes were submitted to compression forces varying between 10 and 250 N applied with the use of an instrumented sphere. The fruits were evaluated 7 days after treatment for oil release, decay, oleocellosis incidence, and anatomical alterations. Oil gland outflow is dependent of force intensity, which is more pronounced in cv. Ponkan tangerines. All the evaluated species presented some degree of oil gland rupture when submitted to compression forces, although only cv. Ponkan presented oleocellosis after oil leakage. Pericarp anatomical differences, such as gland density and location in the peel, are accountable for the incidence of the disorder in Ponkan. Mechanical injuries favor decay development.

1. Introduction

Mechanical injuries are extremely common along the postharvest handling chain of citrus fruit. These injuries are defined as plastic deformations, superficial ruptures, or tissue damages caused by external forces (Sanches et al., 2008). Mechanical injuries favor the development of peel disorders; therefore, along the handling chain, fruits have to be handled carefully to minimize damages to the fruit (Eckert and Eaks, 1989). Danified tissues are susceptible to infections besides resulting in visible scars, which devalue fruit appearance (Golomb et al., 1984). Damaged fruits also present high internal quality losses. Montero et al. (2009) determined reduced flavor and nutritional value in injured tangerines.

One important aspect related to mechanical injuries is the occurrence of oleocellosis. According to Fischer et al. (2007), mechanical injuries cause rupture of peel oil glands with a consequent upsurge of symptoms of oleocellosis. The symptoms increase along the packing line of Valencia oranges and Murcott tangors (Fischer et al., 2009). Despite association of oleocellosis to mechanical injuries in citrus fruit, the disorder occurs more frequently in certain citrus species. According to Santos and Oliveira (2004), oleocellosis has been detected in sweet oranges, lemons, and limes; however, there are only a few studies in which species behavior with regard to oleocellosis has been investigated. Most of the work was performed with only one single species.

Oleocellosis might result from several sorts of injuries including insect attack, hail incidence, bruising, and via contact of damaged fruit with undamaged fruit (Whiteside et al., 1988). However, there are only few reports in which the intensity of mechanical injuries capable of setting off the symptoms of the disorder in citrus fruits is established. The experiments intended as well elucidate why some species are more susceptible to oleocellosis.

2. Material and methods

Oleocellosis incidence in response to static or dynamic forces was determined in the postharvest laboratory and in the plant anatomy laboratory (LAVeg) both at UFRGS (Federal University of Rio Grande do Sul, the southernmost state in Brazil). Citrus fruit were harvested from private groves and separated for similar color, absence of defects and similar size prior to treatment application. There were five harvests at the following

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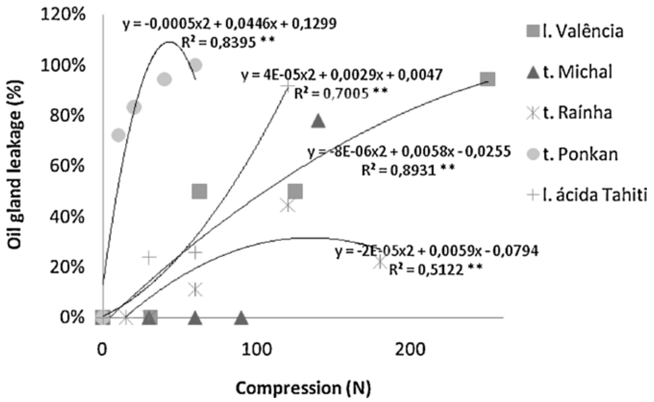

Fig. 1. Oil gland leakage in response to intensity of compression forces in cv. Valencia oranges, cv. Tahiti limes, and cv. Michal, Montenegrina, Rainha, and Ponkan tangerines.

dates: 05/28/08 (‘Ponkan’), 06/18/08 (‘Michal’), 08/26/08 (‘Rainha’), 08/15/08 (‘Valência’), 02/10/09 (‘Tahiti’). Climatic conditions at harvest dates were the following: average temperature of 16.8 °C and precipitation of 53.9 mm for Ponkan tangerine, average temperature of 9.2 °C and precipitation of 1 mm for Michal tangerine, average temperature of 16.1 °C and precipitation of 0 mm for Rainha tangerine, average temperature of 22.5 °C and precipitation of 0 mm for Valencia orange, average temperature of 24.7 °C and precipitation of 10.9 mm for Tahiti lime.

Fruits were submitted to compression forces varying from 10 N to 250 N. Treatments were applied with a hydraulic hauler fixed to a metallic structure. The fruits were placed in line with the instrumented sphere based on strain gauges. The sphere is calibrated to measure static forces (Müller et al., 2008).

After treatment application, the fruits were maintained at room temperature (20 °C ± 2 °C) for seven days and then analyzed for oleocellosis and decay incidence. Oil gland leakage was determined at treatment application by using a paper towel to absorb the oil and expressed as percentage of fruit showing oil outflow. Oleocellosis and decay were as well expressed as percentage of fruit presenting visual signs of pathogen attack and of the peel disorder.

Three tangerine cultivars (Ponkan, Michal, and Rainha), one orange cultivar (Valencia), and one lime cultivar (Tahiti) were evaluated in experiments conducted in a completely randomized design. Data were submitted to regression and correlation analysis. The fruit weight when harvested was: 175 g for Ponkan tangerine, 180 g Michal tangerines, 120 g for Rainha tangerine, 174 g for Valencia oranges, and 97 g Tahiti limes.

In the second part of the present work, pericarp samples were extracted from equatorial area of the fruit and fixed in 1% glutaraldehyde and 4% formaldehyde 0.1 M phosphate buffer at pH 7.2. The samples were dehydrated in an ethyl alcohol series and embedded in 2-hydroxyethyl-methacrylate (GMA) resin (Technovit 7100; Gerrits and Smid, 1983) from which 3-μm thick slices were excised with a Leitz microtome and mounted onto glass slides.

Longitudinal and tangential sections of the pericarp were stained with a combination of 0.5% Astra Blue and 0.5% Basic Fuchsin (Kraus and Arduin, 1997). The slides were observed under a Leica DM bright field light microscope, equipped with a Leica DFC500 digital camera. Subsequently, the photomicrographs were subjected to analysis for area and distances in the Corel Draw and Image J softwares.

3. Results

Compression forces applied to the citrus fruits resulted in oil leakage in all evaluated species (Fig. 1), although oil leakage was dependent on treatment intensity. The tangerines cv. Michal and Rainha, although showing oil leakage, do not respond significantly to the intensity of the applied force.

Cv. Ponkan tangerines presented high oil leakage in comparison to all other citrus fruit cultivars and species tested in the experiment (Fig. 1). Forces as low as 10 N caused oil gland ruptures in 72% of the fruit, whereas forces at the same range or even higher did not cause oil leakage in the other evaluated cultivars.

However, even with oil leakage observed in the citrus species of the present experiment, oleocellosis symptoms did not occur in all of them. Cv. Ponkan was the only citrus species in which the highest incidence of oil leakage was determined followed by high oleocellosis symptoms after the compression test (Fig. 1).

Decay occurrence (*Penicillium digitatum*) was highly correlated to the incidence of oleocellosis (0.9175, $p < 0.001$). In the treatment in which 60 N was applied, all the ‘Ponkan’ fruits showed symptoms of oleocellosis, and all of them also developed decay symptoms. That same treatment did not set off the same effects in any of the other species or cultivars under evaluation.

Anatomical examinations of the peel of the citrus species and cultivars were able to identify variations in oil gland distribution, density, and size (Figs. 2 and 3 and Tables 1 and 2). The total area of oil gland cavities by section varied among species and cultivars in the longitudinal and tangential sections which is an indication of oil gland size.

In the longitudinal sections, the average area of Tahiti limes presented the smallest area. Biggest oil gland total areas were determined in cv. Ponkan tangerines. In the tangential sections, the biggest oil gland areas were determined in cv. Ponkan tangerines, and the smallest areas were determined in cv. Tahiti limes and cv. Michal. The number of oil glands per area was highest in cv. Ponkan tangerines in both transversal and longitudinal sections. That cultivar presented almost doubled the number of oil glands in tangential sections in comparison to all other species and cultivars.

The shortest distance of oil glands to the outer epidermal layer was found in cv. Ponkan tangerines (Fig. 3 and Table 1). Another characteristic of ‘Ponkan’ is the proximity between oil glands boosting simultaneous rupture of a higher number of glands leading to higher amounts of leaked oil to the surrounding tissues (Fig. 3i and j).

Table 1
Total area, minimal distance to outer epidermal layer, average density of oil glands of ‘Valencia’orange, ‘Michal’, ‘Rainha’ and ‘Ponkan’ tangerine and ‘Tahiti’ lime evaluated in longitudinal sections.

Species/cultivar	Total oil gland area (mm^2)	Density ($gland/cm^2$)	Average minimal distance to the outer layer (mm)
Tahiti lime	0.05	19.23	0.23[a]
Valência orange	0.08	15.72	0.39
Michal tangerine	0.08	18.35	0.29
Rainha tangerine	0.08	57.31	0.37
Ponkan tangerine	0.30	59.70	0.09

[a] Average values after seven sections.

Table 2
Average density and total area of oil gland of ‘Valencia’orange, ‘Michal’, ‘Rainha’ and ‘Ponkan’ tangerine and ‘Tahiti’lime evaluated in tangential sections.

Species/cultivar	Total oil gland area (mm^2)	Density ($gland/cm^2$)
Tahiti lime	0.01	78.84[a]
Michal tangerine	0.07	122.34
Raínha tangerine	0.18	100.70
Valência orange oranfgeoragn	0.26	74.67
Ponkan tangerine	0.34	210.97

[a] Average values after seven sections.