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# SYMPTOMS AND SENSITIVITY TO CHILLING INJURY OF CANTALOUPE MELONS DURING POSTHARVEST

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## ABSTRACT

The nature and development of specific symptoms of chilling injury (CI) and the variation in sensitivity to the disorder of different cultivars of cantaloupe melons (*Cucumis melo* L. subsp. *melo* var. *cantalupensis* Naudin) was assessed during two seasons. Twenty-three cultivars of the Eastern Shipper (2), Western Shipper (13) and Galia (8) types were grown in a semiarid environment in Curacaví (33º27' S, 70º38' W), Chile, using common cultural practices. Fruits were harvested at the half-slip stage, except Galia (3/5 color), graded ,washed, and stored for 18 days at 0 ºC, with an additional 3 days at 20 ºC. Symptoms of CI appeared with varying intensity in almost all cultivars and were generally similar. Symptoms developed progressively: surface discoloration progressed from light pink to brownish to black, followed by large sunken areas, and eventually, discrete indentations and net whitening. Surface decay was not present in most fruits and should be considered a consequence rather than a symptom of CI. Cultivars had different sensitivities to the disorder; some cultivars were severely injured (Athena, Colima and Revigal) whereas others developed almost no symptoms of CI (Hy-Mark, Gal 96, and Voyager I). The response variability to chilling showed the need for precise temperature recommendations for these cultivars, and signaled a potential for future long-term transport or storage of some cultivars.

**Key words:** cultivars, storage, symptom progression, weight loss, soluble solids.

## INTRODUCTION

Cantaloupe melons are the most important commercially, but contrary to the Inodorus group that stores well, they have a short storage life after harvest (Robinson and Decker-Walters, 1999). Fruits become soft and shriveled after about two weeks because the open, netted epidermis favors high transpiration rates which contribute to the relatively short storage life of the Cantalupensis melon group (Fallik *et al*., 2005, García *et al*., 2005). For maximum conservation, rapid pre-cooling coupled with cantaloupe transport and storage at temperatures between 2 and 7 ºC, and 95% relative humidity (RH) is recommended. Lower temperatures can only be used for short periods because the fruits are susceptible to chilling injury (CI) (Kader, 2002; Shellie and Lester, 2004; Suslow *et al*., 2008). However, storing some cultivars at 0 ºC would be beneficial because it could decrease metabolic and pathogenic activity, thus potentially increasing storage life and quality (Evensen, 1983). It would also facilitate exportation by allowing long distance shipment and common storage with temperate fruits (Combrink *et al*., 1995).

Although symptoms of CI are elusive or hard to define, three general symptoms have been repeatedly reported in cantaloupes: surface discoloration, pitting, and surface decay (Paull, 1990; Hardenburg *et al*., 1990; Combrink *et al*., 1995; 1996; García *et al*., 2005). Symptoms mentioned in most references are quite generic and do not mention the progression which would help to differentiate primary and secondary events. An early identification and accurate description of the symptoms is needed to screen cultivars for sensitivity to the disorder.

It is widely known that genetic variability in chilling sensitivity exists within some species. For melons, pioneering studies cited by Hardenburg *et al*. (1990) already differentiated the Inodorus group as more sensitive to chilling than the Cantalupensis group, and this fact is taken into account in the different storage temperatures recommended for each group (Kader, 2002). In addition, differences in sensitivity have been found among cultivars of cantaloupes (Evensen, 1983). Studies with current cantaloupe cultivars have shown that some, such as Colima, develop severe symptoms, while others, such as

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Hy-Mark, show almost no symptoms of CI after storage at 0 ºC (Krarup *et al*., 2001). Knowledge of the sensitivity of cultivars to CI would permit better maintenance of fruit quality during the marketing process (Combrink *et al*., 1995). It would also facilitate genetic studies on the differences between low and high CI-sensitive genotypes for further improvement.

Breeding new cantaloupe cultivars is an active, ongoing process, but postharvest characteristics or storage behavior of new cultivars, specifically their response to chilling temperatures, are seldom reported. Recently, Galia a cantaloupe hybrid developed in Israel (Karchi, 2000) has captured a considerable share of the world market. Increased breeding efforts have resulted in a whole array of similar cultivars related to the new 'Galia type' (Fallik *et al*., 2005), but there is scant information available on their response to chilling (Combrink *et al*., 1995; 1996).

The objective of this study was to describe the specific symptoms of CI in distinct types of cantaloupes, evaluate the sensitivity to chilling and other postharvest parameters of current cultivars of Eastern Shipper, Galia, and Western Shipper types.

## MATERIALS AND METHODS

### Cultivars, crop production, and fruit material

The cultivars used in the experiments were selected to represent cantaloupe genotypes s that are used commercially in Chile and would likely show differential sensitivity responses and symptoms to chilling. Eastern-type melons are quite perishable and are grown mainly for local consumption in the eastern USA, while Western Shipper melons are grown in the western USA, mainly in Arizona, California, and Texas. They are of special interest because they are less perishable and are well-suited for long distance shipping (Robinson and Decker–Walters, 1999; Shellie and Lester, 2004). Although these melon designations are used to describe melons in the USA, both types, especially the Western Shipper, are also widely grown in other countries, and different local names are used to describe them. Galia-type cultivars represent a new group of cantaloupes developed in Israel which have a characteristic greenish-yellow netted skin and green-fleshed fruit (Karchi, 2000).

The cultivars were grown in three separate field experiments during two seasons in the semiarid environment of Curacaví, (33º27' S, 70º38' W) Chile, to evaluate field production characteristics (data not shown) and postharvest. A randomized complete block design with four replicates was used for each group of cultivars. Replicates were 5 m-long rows with plants separated by 0.33 m within the row and 2 m between rows (population: 1.5 plants $m^{-2}$). The three experiments included the previously mentioned cultivars and the seed company for each type is mentioned between parentheses:

**Experiment 1 (First season)**: Eastern Shipper: 'Athena' (Syngenta-Rogers); Galia: 'Gal 96' (Hazera) and 'Lavigal' (Hazera); Western Shipper: 'Colima' (Seminis), 'Early Tornado' (United Genetics), 'Hy-Mark' (Seminis), 'Málaga' (United Genetics), 'Primo' (Syngenta-Rogers), 'Sol Dorado' (Syngenta-Rogers), and 'Voyager 1' (Nunhems). To evaluate the effect of exposure to sunlight on symptoms of CI developed during postharvest, the area with direct exposure to solar radiation at noontime, that is the top of the fruit, was marked with a small sticker at harvest time of cvs. Athena, Colima, Gal 96, Hy-Mark, and Lavigal.

**Experiment 2 (Second season)**: Eastern: 'CLX 2777' (Clause); Galia: 'Gal 47' (Hazera); Western Shipper: 'Archer' (Harris Moran), 'Colima' (Seminis), 'Cruiser' (Harris Moran), 'Dessert Princess' (Nunhems), 'Hy-Mark' (Seminis), 'Oro Rico' (Harris Moran), 'PS 1039678' (Seminis), and 'Zeus' (Seminis).

**Experiment 3 (Second season)**: Galia: 'CLX 2705' (Clause), 'Elario' (Hazera), 'Gal 47' (Hazera), 'Gal 96' (Hazera), 'H47-37' (Clause), 'Lavigal' (Hazera), 'Revigal' (Hazera), and 'Yupi' (Seminis).

The experimental plantings were direct seeded in mid-spring (October 10-20) and grown using standard cultural practices. Plant growth and development were representative of most growing seasons and fruits were harvested in the summer (mid-January to mid-February) of each season. Fruits of Eastern and Western Shipper cultivars were harvested at the half-slip stage. Galia-type fruits were harvested when ground color changed from green to yellow (color stage 3.5) (Fallik *et al*., 2005). Fruits for the postharvest experiments were taken at the peak of the harvest period (7 to 10 days after the initiation of harvest) and selected according to typical characteristics of each cultivar such as size, shape, and netting. Fruits were brought to the laboratory no more than 4 h after harvest, washed with a sponge in chlorinated water (65 mg $L^{-1}$), dried, and stored the same day.

**Postharvest treatments.** Each cultivar (treatment) had 10 selected fruits (replicates) that were weighed and placed in a cold chamber (NemoEurope Model NK15FE, Valserine, France) at 0 ± 1 ºC and 90 ± 5% RH for a period of 18 d. Immediately upon removal, assessments of CI and fresh weight loss (FWL) were made and fruits were promptly placed in a room at 20 ± 2 ºC and 50 ± 5% RH for 3 d to simulate marketing conditions and stimulate appearance of CI symptoms (Kader, 2002; Kays and Paull, 2004). A final assessment of CI, FWL, and total soluble solids (TSS) content was made at the end of this period.

**Postharvest assessments.** After 18 d at 0 ºC, and again after three additional days at 20 ºC, fruits were examined for visual evidence of CI. The main symptoms observed were pitting, sunken areas of the epidermis, surface discoloration, and other epidermal changes that could be attributed to the disorder. CI was measured as a percentage of the epidermal area affected, and the cultivar response to CI was ranked using the following scale: 1 = non-sensitive (no spots or surface blemishes), 2 = low (< 10% of surface affected), 3 = moderate (11-25% of surface affected), 4 = high (26-50% of surface affected), and 5 = extreme sensitivity (> 50% of surface affected). FWL compared to the initial weight was calculated as a percentage of weight loss after each storage period. TSS was measured in ºBrix with a hand refractometer (Atago, Model Master T, Tokio, Japan) on juice extracted from opposite equatorial areas of the fruit.

**Statistical evaluation.** Experiments used a completely randomized design with 10 replicate melons per treatment. Percentage data were transformed before analysis using angular transformation. Data were subjected to analysis of variance and the Tukey test (P = 0.05) was used to separate means.

## RESULTS AND DISCUSSION

### Chilling injury symptoms

Symptoms of CI were analogous and appeared in a similar sequence for all cultivars. A limited number of fruits of some cultivars showed symptoms after 18 d at 0 ºC and these were quite subdued. As was expected, transferring fruit to 20 ºC resulted in a marked increase in symptoms due to the thermal acceleration of all metabolic processes (Kader, 2002; Kays and Paull, 2004). Some common symptoms for all cultivars are shown in Figure 1.

**Surface discoloration.** This was the first common generalized symptom of CI. In large areas of the epidermis, the background color turned first to light pink (Figure 1A), then into a darker shade of red (Figure 1B), and finally dark brown or black (Figure 1C). These blemishes, as reported by Combrink *et al.* (1995) in Galia melons, tended to concentrate in areas of minimal or no netting, in ground and sun spots, as well as in the sutures of those fruit that have them. This symptom is the most striking because it is ubiquitous and, can affect more than 50% of the epidermal area in the most sensitive cultivars (Table 1).

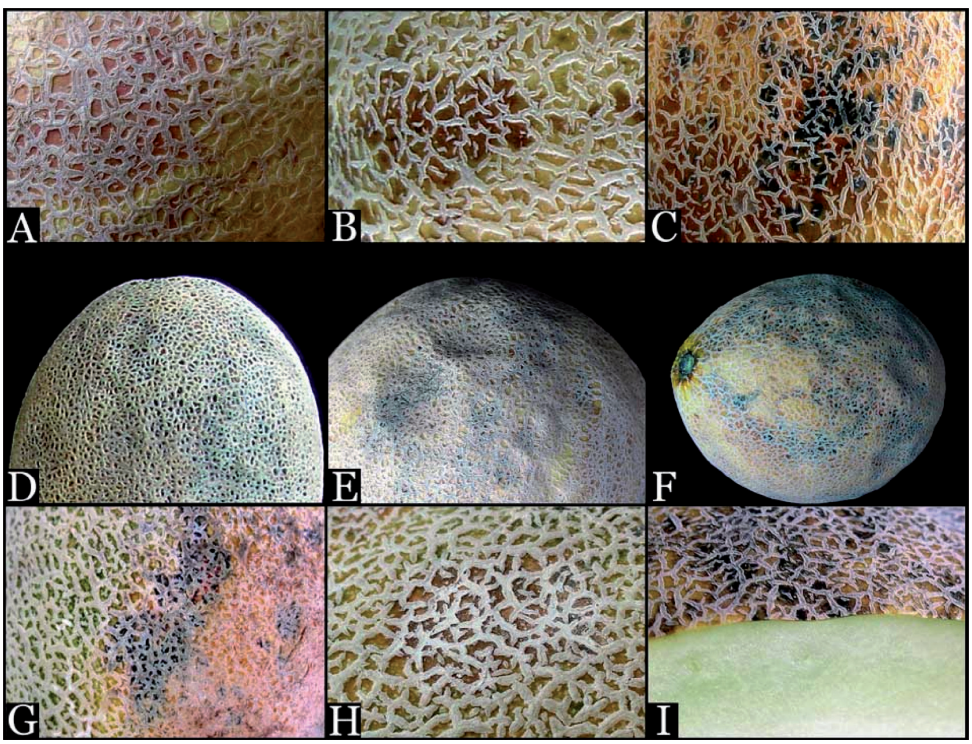


**Figure 1. Symptoms of chilling injury in cantaloupe melons. A) Initial pink discoloration of injured epidermal areas; B) Progressive darkening to red of injured areas; C) Final brown to black color of injured areas; D) Appearance of slight depressions on epidermis; E) Large depressions at the end of the holding period; F) Lattice of depressions following outline of discolored areas; G) Small, sharply defined depressions or pitting of the epidermis; H) Whitening of the corky net on discolored areas; I) Superficial nature of injuries: damaged epidermis above the intact mesocarp.**

**Sunken areas.** After surface discoloration, slight depressions may occur (Figure 1D) which later become progressively more pronounced and deeper (Figure 1E). The sunken areas usually coalesce to form a lattice of depressions which, in most cases, follow the limits of discolored areas. Normal colored zones remain turgid (Figure 1F).

**Pitting.** Small, clear-cut, limited indentations of the epidermal surface are rarely visible, and if present, appear after surface discoloration as a result of the localized collapse of epidermal cells in areas t with color change (Figure 1G). This occasional symptom does not exactly match the definition of pitting given by Abe (1990): formation of circular or irregular-shaped pits that appear as the first evidence of chilling damage on the surface of fruit. Injury in melon is different from the primordial pitting described in cucumber (*Cucumis sativus* L.) and eggplant (*Solanum melongena* L.) resulting in watery and oozing blemishes (Abe, 1990; Paull, 1990). Pitting in melons is more like the sheet pitting present in peppers (*Capsicum annuum* L.) (Paull, 1990) which appears later and is not watery.

**Net whitening.** At the end of the holding period, the usual light grayish to yellowish brown color of the lenticel net s turned white in small discrete patches, mainly in discolored parts of the fruit (Figure 1H). This symptom had not been described before, perhaps because it is infrequent.

Symptoms were all superficial, affecting almost exclusively epidermal and a few hypodermal cells, while the rest of the mesocarp remained largely unaffected (Figure 1I). There were no other discernible symptoms in

**Table 1. Symptoms of chilling injury (%) present in areas of melons exposed to differential solar radiation in the field[1]. Experiment 1.**

| Cultivar | Sun area | Ground area | Lateral area 1 | Lateral area 2 |
|---|---|---|---|---|
| Athena | 95.75 | 91.75 | 54.25 | 41.75 |
| Colima | 45.75 | 70.75 | 12.50 | 20.75 |
| Gal 96 | 12.50 | 16.75 | 0.00 | 0.00 |
| Hy-Mark | 25.00 | 25.00 | 0.00 | 8.25 |
| Lavigal | 16.75 | 20.75 | 0.00 | 0.00 |
| **Mean*** | **39.15a** | **45.00a** | **13.35b** | **14.15b** |

[1] Percentage of epidermal area affected. Mean values followed by different letters in the columns differ statistically according to Tukey test ($P \leq 0.05$).

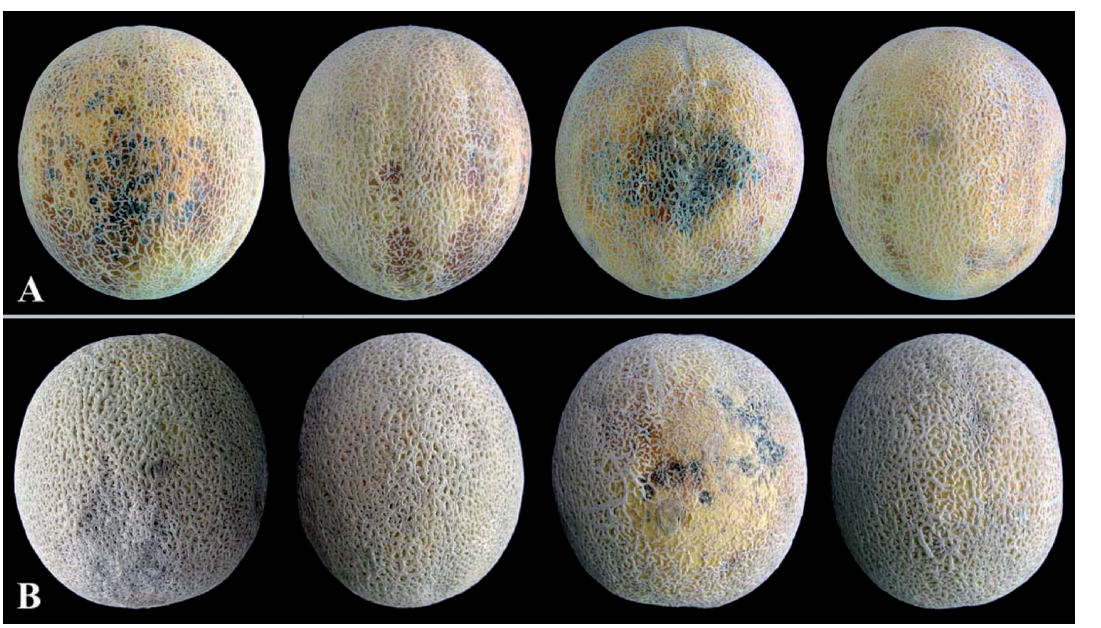


**Figure 2. Solar radiation and appearance of chilling injury in cantaloupe melons. A) Athena cultivar showing (left to right) symptoms of chilling on top, left side, bottom, and right side of fruit; B) Hy-Mark cultivar, with fruit in the same positions. In both cases, symptoms concentrated on the top (sun-exposed) and bottom (shaded area) of the fruits.**

the large number of fruits of the three types of melons studied. Therefore, surface discoloration, large sunken areas, eventual pitting, and whitening of the net should be considered primary symptoms of CI in cantaloupes. Surface decay has been identified as a symptom of CI (Hardenburg *et al*., 1990; Paull, 1990; Shellie and Lester, 2004) and the changes preceding this provide a favorable medium for the growth of pathogens, usually weak parasites (Abe, 1990). The increased sensitivity to pathogens is not a symptom *per se* and can be induced by factors other than chilling temperatures, for example, mechanical injury or low relative humidity which was not visible in most fruits at the end of the experiments of this study. If decay was present, it appeared later and was concentrated in already injured areas. Therefore, surface decay should be considered as a consequence rather than a symptom of CI in cantaloupes.

**Chilling injury symptoms and solar radiation**

The relative exposure of different areas or parts of melons to solar radiation in the field had a clear influence on the location and severity of chilling injury symptoms on the fruits after the holding period. The fruit areas exposed to the sun and the bottom or shaded areas of the fruits were the most affected by CI symptoms, while the lateral areas had a significantly lower incidence of damage (Table 1).

The data and the visual evidence shown in Figure 2 clearly indicate that the degree of solar exposure results in differentiated sensitivity to CI in certain areas of the fruits and that this effect is noticeable. Preharvest exposure of fruits to solar radiation influencing the chilling response after harvest is well documented (Woolf and Ferguson, 2000; Krarup and González, 2004). Previous research comparing shaded and sun-exposed fruits of cv. Galia of the Cantalupensis group found a higher incidence of CI on melons fully exposed to the sun (Combrink *et al*., 1995) with no differences between top and bottom fruit parts (Combrink *et al*., 1996). The clear-cut effect of relative solar exposure found in this study, as well as in a previous study (Krarup and González, 2004), merits further research because responses were significant and may vary according to site, fruiting period, and light-temperature relationships (Woolf and Ferguson, 2000).

**Cultivar response to chilling**

**Experiment 1.** Colima and Hy-Mark cultivars are widely grown in Chile and were used in the first experiment based on their high (Colima) and low (Hy-Mark) sensitivity to CI as seen in previous studies (Krarup *et al*., 2001). All cultivars were susceptible to chilling temperatures although sensitivity was clearly dependent on genotype (Table 2). After 18 d at 0 ºC, the percentage of area affected by CI fluctuated from no variation in some Western Shipper (E. Tornado, Hy-Mark, and Voyager 1) and Galia (Gal 96) cultivars, to slight (8.3%) in the Eastern Shipper (Athena) cultivar.

Symptoms became increasingly apparent during 3 d at 20 ºC and were finally quite distinctive (Table 2) because, as expected, their development accelerated at non-chilling temperatures (Salveit and Morris, 1990). 'Athena', an Eastern-type cantaloupe, had extreme CI (50%), while 'Colima' and 'Primo', Western-type melons, were highly sensitive to CI. Previous studies have identified cvs. Athena and Colima to be highly sensitive (Krarup *et al*., 2001). 'Malaga' had moderate CI symptoms while the rest of the cultivars were slightly affected, including Hy-Mark which confirmed the low sensitivity reported in previous studies (Krarup *et al*., 2001). Galia-type melons have been reported to be severely affected by CI (Combrink

**Table 2. Surface area affected and sensitivity to chilling injury (CI), fresh weight loss (FWL), and total soluble solids (TSS) of 10 cultivars of cantaloupes, after 18 d at 0 ºC, and after three additional days at 20 ºC.**

| Cultivar | CI-18 d | CI-21 d | CI sensitivity | FWL-18 d | FWL-21 d | TSS |
|---|---|---|---|---|---|---|
| | % | | | % | | ºBrix |
| Athena | 8.3a | 53.3a | Extreme | 1.6 NS | 4.8 NS | 9.9ab |
| Colima | 0.8b | 31.6ab | High | 2.1 | 5.4 | 9.2a |
| Primo | 0.8b | 30.1ab | High | 2.9 | 6.1 | 10.8ab |
| Málaga | 1.6b | 15.8bc | Moderate | 2.4 | 5.9 | 10.3ab |
| Sol Dorado | 0.8b | 8.3bc | Low | 1.9 | 5.1 | 11.6ab |
| Voyager | 0.0b | 8.3bc | Low | 1.8 | 4.9 | 12.6b |
| Early Tornado | 0.0b | 6.6bc | Low | 1.9 | 5.2 | 10.6ab |
| Lavigal | 2.5b | 6.6bc | Low | 1.8 | 4.9 | 10.1ab |
| Hy-Mark | 0.0b | 5.0c | Low | 2.2 | 5.8 | 12.6a |
| Gal 96 | 0.0b | 4.1c | Low | 2.8 | 6.0 | 11.8ab |

Values in columns followed by different letters differ statistically according to Tukey test ($P \leq 0.05$). NS: not significant.

*et al*., 1995) which is contrary to the results established in these studies. Lavigal and Gal 96, recently released cultivars included in this evaluation, had very subtle symptoms. Consequently, additional Galia-type cultivars were studied in a separate experiment during the second season to clarify this discrepancy.

External appearance and symptoms of CI for three selected cultivars is shown in Figure 3. Good to excellent visual quality at harvest was pictured for each cultivar (Figure 3, left). Removed after 18 d storage at 0 ºC (Figure 3, center), the visual quality of the cultivar was already impaired in the most sensitive Eastern-type cv. Athena. After three additional days at 20 ºC (Figure 3, right), visual quality diminished in all cultivars, although fruit of the least sensitive cultivar, Gal 96, could still be sellable in most markets.

After 18 d storage at 0 ºC, FWL fluctuated between 1.6% ('Athena') and 2.9% ('Primo'). After three additional days at 20 ºC, FWL varied between 4.8% ('Athena') and 6.1% ('Primo'); there were no differences among types or cultivars in this trial (Table 2). These percentages are comparable to those reported for cantaloupes (Combrink *et al*., 1995). TSS at the end of the storage period varied from 9.2º to 12.6º Brix, with differences among cultivars (Table 2). These characteristics were relevant in selecting cultivars because a high FWL (over 7%) eventually limits sales and minimum TSS contents (9 to 11 ºBrix) are required for some U.S. grades of cantaloupes (Shellie and Lester, 2004).

**Experiment 2.** A second evaluation was conducted to test other cultivars that are presently grown as well as newly-bred cantaloupes. Colima and Hy-Mark cultivars were included to cross-check the response between seasons and cv. Gal 47 to compare response to a concurrent screening of Galia-type melons. Variability to CI was again evident among cultivars (Table 3). After 18 d at 0 ºC, the percentage area affected by CI fluctuated from no variation in Western Shipper ('Cruiser') and Galia ('Gal 47') cultivars, to moderate (12.5%) in 'Colima'. During the additional 3 d at 20 ºC, symptoms increased rapidly as in Experiment 1, and resulted in clear differences among cultivars. It is interesting to note that cvs. Colima and Hy-Mark, included as controls due to their previously established chilling response (Krarup *et al*., 2001),

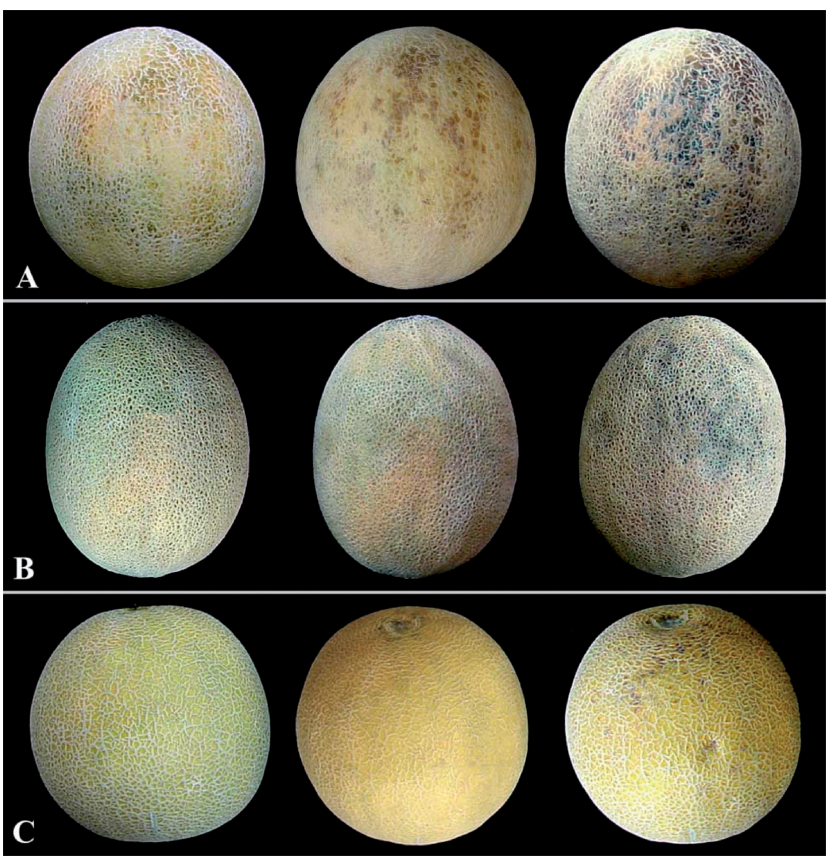


**Figure 3. Chilling injury sensitivity in cantaloupe melons. A) Athena, an extremely sensitive Eastern-type cultivar; B) Primo, a moderately sensitive Western-type cultivar; C) Gal 96, a Galia-type cultivar slightly sensitive to chilling. Same individual fruits pictured at harvest (left), after 18 d at 0 ºC (middle) and after three additional days at 20 ºC (right).**

**Table 3. Surface area affected and sensitivity to chilling injury (CI), fresh weight loss (FWL), and total soluble solids (TSS) of 10 cultivars of cantaloupes, after 18 d at 0 ºC, and after three additional d at 20 ºC. Experiment 2.**

| Cultivar | CI-18 d | CI-21 d | CI sensitivity | FWL-18 d | FWL-21 d | TSS |
|---|---|---|---|---|---|---|
| | % | | | % | | ºBrix |
| Colima | 12.5c | 35.0c | High | 1.3a | 6.3ab | 10.0 |
| CLX 2777 | 7.5bc | 22.5bc | Moderate | 1.7ab | 6.6ab | 10.6 |
| Zeus | 4.2ab | 15.8ab | Moderate | 1.8abc | 6.0ab | 10.4 |
| Archer | 0.8a | 15.8ab | Moderate | 2.3cd | 6.3ab | 10.6 |
| Oro Rico | 2.5ab | 14.2ab | Moderate | 2.9d | 7.2b | 11.2 |
| Gal 47 | 0.0a | 12.5ab | Moderate | 1.5ab | 5.2a | 11.9 |
| D. Princess | 2.5ab | 10.8ab | Moderate | 1.9bc | 5.3a | 9.6 |
| Hy-Mark | 0.8a | 8.3ab | Low | 1.9bc | 6.3ab | 11.8 |
| PS 1039678 | 3.3ab | 7.5a | Low | 1.4ab | 5.1a | 11.3 |
| Cruiser | 0.0a | 7.5a | Low | 1.8abc | 6.0ab | 10.2 |

Values in columns followed by different letters differ statistically according to Tukey test ($P \leq 0.05$).

behaved as expected. 'Colima' and 'Hy-Mark' showed high and low CI sensitivity, respectively, and percentage area affected by symptoms was similar to those in the previous season. The genetic influence on the expression of CI was consistent even though different seed lots were used for cultivars each season.

After 18 d storage at 0 ºC, FWL fluctuated between 1.3% ('Colima') and 2.9% ('Oro Rico'). After three additional days at 20 ºC, FWL loss varied between 5.1% ('PS 1039768'') and 7.2% ('Oro Rico'). In contrast to Experiment 1, there were differences among types or cultivars because the FWL of 'Oro Rico' (7.2%) was much higher than that of 'Dessert Prince' (5.3%), 'Gal 47' (5.2%), and 'PS10309678' (5.1%) (Table 3). However, the percentages were similar to those reported earlier in Experiment 1. TSS at the end of the storage period varied between 9.6º and 11.9º Brix, with differences among cultivars (Table 3). Values for CI, FWL, and TSS of cvs. Colima and Hy-Mark showed only slight variations between seasons (Tables 1 and 2) and were consistent with the results.

**Experiment 3.** The scant information about temperature response of the original Galia cv. indicated a high sensitivity to CI (Combrink *et al*., 1995; 1996). The results of Experiment 1 indicated that cvs. Lavigal and Gal 96 had low sensitivity to CI; this probable variation in cultivar response to CI justified adding several currently grown cultivars listed in Table 4. 'Lavigal' and 'Gal 96' were included as Galia-type controls because their response to CI was known from Experiment 1. After 18 d at 0 ºC, the percentage of area affected by CI was small, varying from 0% ('Gal 47') to 5.8% ('Lavigal'). During the additional 3 d at 20 ºC, symptoms increased and resulted in a clear differentiation of cultivars, with low (Gal 47 and Elario), moderate (H47-37, CLX 2705, Lavigal, and Gal 96), and high (Revigal and Yupi) sensitivity to CI (Table 4).

After 18 d storage at 0 ºC, FWL fluctuated between 2.5% ('CLX 2705') and 3.1% ('Elario'). After three additional days at 20 ºC, FWL varied between 4.7% ('Gal 96') and 6.9% ('Yupi'), with measured differences among cultivars after this period (Table 4). The range of final FWL for the cultivars in this experiment was quite restricted. Values were similar to those obtained for 'Lavigal', 'Gal 47', and 'Gal 96' in the previous experiments; they were almost the same as those reported for the original cv. Galia (Combrink *et al*., 1965) and cv. Malika (Fallik *et al*., 2005). TSS at the end of the storage period varied from 9.0º to 11.7º Brix, with significant differences among cultivars (Table 4). The values were consistent with those obtained from the Galia-type cultivars in Experiments 1 and 2, as well as those reported in the literature (Combrink *et al*., 1996; Fallik *et al*., 2005).

## CONCLUSIONS

All tested cantaloupe cultivars were susceptible to chilling injury and had a similar sequence of symptoms, starting with surface discoloration, followed by large depressed areas, and eventually, pitting and net whitening. Surface decay was only occasional and should be not be considered as a symptom but rather as a consequence of CI. The differences in cultivar sensitivity, the lack of symptoms in some cultivars after storage at 0 ºC, and the slight development of the problem at 20 ºC in two cultivars all point out the relevance of studying genotypic response for temperature recommendations. Temperatures close to 0 °C could prolong storage potential of certain commercial cultivars, especially if melons are used immediately after storage.

**Table 4. Surface area affected and sensitivity to chilling injury (CI), fresh weight loss (FWL), and total soluble solids (TSS) of eight cultivars of Galia cantaloupes, after 18 d at 0 ºC, and after three additional days at 20 ºC.**

| Cultivar | CI-18 d | CI-21 d | CI sensitivity | FWL-18 d | FWL-21 d | TSS |
|---|---|---|---|---|---|---|
| | % | | | % | | ºBrix |
| Revigal | 1.7 | 27.5c | High | 3.0 | 6.6ab | 9.0a |
| Yupi | 3.3 | 25.8bc | High | 2.8 | 6.9b | 11.2ab |
| H47-37 | 4.2 | 20.8abc | Moderate | 2.7 | 5.8ab | 9.7ab |
| CLX 2705 | 3.3 | 14.2abc | Moderate | 2.5 | 5.5ab | 10.7ab |
| Lavigal | 5.8 | 12.5abc | Moderate | 2.8 | 5.5ab | 9.7ab |
| Gal 96 | 2.5 | 12.5abc | Moderate | 2.8 | 4.7a | 11.5ab |
| Elario | 2.5 | 8.3ab | Low | 3.1 | 6.6ab | 11.5ab |
| Gal 47 | 0.0 | 3.3a | Low | 3.0 | 5.2ab | 11.7b |

Values in columns followed by different letters differ statistically according to Tukey test ($P \leq 0.05$).


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## RESUMEN

**Síntomas y sensibilidad a daño por enfriamiento de melones reticulados durante poscosecha.** La naturaleza y el desarrollo de los síntomas de daño por enfriamiento (CI) y la variación en sensibilidad de diversos cultivares de melones reticulados (*Cucumis melo* L. subsp. *melo* var. *cantalupensis* Naudin) a este desorden fisiológico se evaluaron durante dos temporadas. Veintitrés cultivares de los tipos Eastern (1), Western (15) y Galia (8) se cultivaron en un ambiente semi-árido en Curacaví (33º27' S, 70º38' O), Chile, en cultivos realizados de manera convencional, y los frutos se cosecharon al estado de madurez de medio desprendimiento, excepto el tipo Galia (3/5 de color). Después de la selección y lavado, los frutos se almacenaron por 18 días a 0 ºC, más 3 días adicionales a 20 ºC. Los síntomas de CI se desarrollaron de manera progresiva: primero aparecieron manchas en la superficie del fruto, las que evolucionaron de un color rosado pálido a pardo y eventualmente negro, seguidas de la aparición de vastas concavidades de la superficie y, ocasionalmente, de depresiones discretas y blanqueado del reticulado corchoso. La presencia de enfermedades fue esporádica y secundaria, debiendo considerarse una consecuencia y no un síntoma de CI. Los cultivares presentaron una sensibilidad variable a CI; algunos como Athena, Colima y Revigal fueron severamente afectados, mientras que otros como Hy-Mark, Gal 96, y Voyager I presentaron escasos síntomas. La variabilidad en la respuesta al enfriamiento mostró la necesidad de recomendaciones precisas de temperaturas para estos cultivares y señaló un potencial para usar temperaturas más bajas que las usualmente recomendadas para una mayor conservación de algunos cultivares.



**Palabras clave:** cultivares, almacenamiento, síntomas, pérdida de peso, sólidos solubles.


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