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Prolonged Storage at Commercially Recommended Temperatures Promotes Chilling Injury in Fresh Georgia Peaches

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ABSTRACT

Peach (*Prunus persica* L.) is a climacteric fruit highly susceptible to chilling injury (CI) during cold storage, a physiological disorder that significantly reduces commercial quality and shelf life. This study evaluated the postharvest quality of fresh-market peaches stored at different temperatures, with a focus on CI development and the critical storage temperature range known as the storage "killing zone." Three commercial cultivars, 'Blazeprince', 'Rich Pride', and 'O'Henry' were stored for up to 28 days (d) at 1.1°C, 5.5°C, or 10°C with 90% relative humidity. Fruit quality was assessed based on visual appearance, respiration rate, weight loss, firmness, decay incidence, CI incidence, flesh color, and total soluble solids (TSS) concentration. Flesh firmness declined in all three cultivars over time, with the most significant losses occurring at 10°C. Weight loss and decay incidence were also higher at 10°C, particularly after 21 days. CI symptoms were most severe in peaches stored at 5.5°C, confirming the elevated risk associated with the "killing zone" temperature range. Importantly, our results showed that 1.1°C, which is usually considered a safe storage temperature, did not prevent CI, with all three cultivars developing CI symptoms after a prolonged storage period. TSS levels increased slightly as fruit ripening progressed, whereas color changes varied by cultivar and were more pronounced under warmer storage conditions. Overall, these results showed that CI can develop during extended storage even under temperatures commonly regarded as safe for peach preservation.

1 | Introduction

Peach (*Prunus persica* L.) is a stone fruit with wide varietal diversity [1]. Originally cultivated in China, it was later introduced into Europe through Persia and Egypt [1, 2]. Currently, peaches and nectarines are cultivated worldwide, in response to strong consumer demand, reaching a global production of 25.3 million metric tons in the 2024/2025 season [3]. Peaches are known for their distinct flavor, aroma, and texture. However, their high perishability presents major challenges and limitations for postharvest handling and market supply [4]. As climacteric fruit, peaches will ripen both on and off the tree, requiring cold storage immediately after harvest to slow down the ripening process and prevent decay [5].

Peaches are cold-sensitive, and storage within the temperature range of 2.2°C–7.7°C, commonly referred to as the "killing zone" is detrimental to their postharvest quality [6]. This range, although above the freezing point, promotes the development of chilling injury (CI), a physiological disorder that typically becomes visible once the fruit is transferred to ambient temperatures [7]. CI is particularly challenging to detect because it does not always manifest externally, making visual assessment unreliable. However, it causes significant flesh

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quality deterioration, including symptoms such as mealiness or wooliness (dry, grainy texture, and reduced juiciness), flesh translucency, browning, internal breakdown, incomplete ripening, and, most importantly, loss of flavor [8–11]. Previous studies have shown that to minimize the CI risk, peaches should be stored within the recommended temperature range of −1°C to 1.6°C, which slows down ripening while avoiding freezing injury [12].

Although low-temperature storage is essential to delay ripening, suppress metabolic activities, and reduce decay in peaches, it does not always prevent the development of CI. Storage near 0°C is generally considered safer than exposure to intermediate "killing zone" temperatures; however, prolonged exposure under these conditions can still lead to CI symptoms, particularly after fruit is transferred to ambient temperature [8, 13].

Low-temperature exposure disrupts normal ripening processes by impairing membrane integrity, altering oxidative balance, and affecting cell wall metabolism, which are key factors associated with CI development. These physiological disturbances interfere with normal softening and juice release, thereby contributing to the textural abnormalities and incomplete ripening commonly observed in peaches after cold storage [12, 14].

Peach cultivars do not respond uniformly to cold storage, and susceptibility to CI is strongly influenced by genotype [11, 15]. Previous studies have shown marked cultivar-dependent variation in the development of mealiness, browning, and other internal breakdown symptoms, even under similar storage conditions [13, 15]. In general, melting-flesh cultivars tend to be more susceptible than firmer nonmelting types, which highlights the importance of evaluating storage responses at the cultivar level rather than assuming a uniform postharvest behavior among peaches [11, 13].

CI-related quality issues are typically noticed by consumers rather than growers or shippers, often after purchase, which can negatively affect market sales [16]. Repeated instances of poor quality due to CI may further discourage consumers and shift preferences toward alternative fruits [17]. Considering the impact of CI symptoms on consumer perception, CI is recognized as a major postharvest disorder and remains one of the primary challenges in the peach industry. In addition to reducing consumer acceptance, CI results in considerable economic losses due to fruit rejection during marketing and processing [18].

Despite previous research on CI and recommended storage conditions for peaches, the duration for which fruit can be held at commercially relevant temperatures before quality deterioration occurs remains unclear. This gap is particularly evident for commercial Georgia peaches stored at industrially-recommended low temperature (0°C–1°C). Defining these thresholds is crucial for postharvest handling, as both storage temperature and duration might directly influence fruit quality and CI development. Therefore, this study is aimed at evaluating the effects of three storage temperatures (1.1°C, 5.5°C, and 10°C) on postharvest quality, CI development, and shelf life in three commercial peach cultivars, in order to define practical storage limits under commercial conditions.

TABLE 1 | Harvest dates for the three peach cultivars used in this study.

Cultivar	Date of harvest
'O'Henry'	July 20, 2023
'Blazeprince'	June 15, 2024
'Rich Pride'	June 15, 2024

2 | Materials and Methods

2.1 | Fruit Material

Three commercial peach cultivars were utilized in this study: 'Blazeprince', an early-season clingstone cultivar released by the University of Arkansas breeding program; 'Rich Pride', a mid-season clingstone peach developed by the USDA-ARS breeding program in Byron, Georgia; and 'O'Henry', a late-season freestone cultivar originating from the Stiles private breeding program in California. Fruit was harvested at commercial optimum maturity from orchards located in central Georgia (Fort Valley, Georgia) (Table 1). Immediately after harvest, peaches were hydrocooled in 1°C–3°C water and sanitized using a chlorine solution containing approximately 60 ppm free chlorine, with pH maintained between 6.5 and 7.5. Peaches were transferred the same day to the postharvest laboratory at the University of Georgia located in Tifton, Georgia, in an air-conditioned vehicle held at 20°C. Upon arrival, the fruit was sorted for uniformity of size and color, and any fruit showing defects, bruises, or decay was discarded.

2.2 | Storage Conditions

Peaches were randomly divided into groups for storage at three different temperatures. The first group was stored at 1.1°C, the second at 5.5°C, and the third at 10°C. Relative humidity (RH) was maintained at 90% to minimize excessive weight loss and shriveling, using the standard airflow conditions of the cold storage system. Each group consisted of three biological replicates per evaluation day, with a minimum of 20 fruits per replicate used as individual observations. All evaluations were conducted after 7, 14, 21, and 28 days of storage plus 3 days simulated retail conditions, rather than immediately after cold storage. After each storage period, fruit was held for three additional days at 20°C and 70% RH to simulate market or home conditions, which also induce the appearance of CI symptoms and other quality defects.

2.3 | Weight Loss

Three boxes (replications) of 25 peaches (experimental units) each were labeled and weighed on arrival (Day 0), and weight loss was calculated with the difference between the initial and

final weights, then divided by the initial weight and multiplied by 100 to express the weight loss as a percentage according to the following Equation (1):

$$Weight\ Loss\ (\%) = \frac{(W_i - W_f)}{W_i * 100} \quad (1)$$

Where Wi is the initial weight in grams (Day 0), and Wf is the final weight in grams.

2.4 | Respiration Rate (RR)

Ten peaches per replication were randomly selected from each storage temperature and enclosed in two-gallon plastic buckets (United Solutions, Leominster, Massachusetts, United States) for 1 hour. Three biological replicates were set for each group. RR was measured using a CO_2/O_2 modified atmosphere package gas analyzer (Bridge 900141; Bedford Heights, Ohio, United States). The values were determined using the Formula (2) proposed by Fonseca et al. [19] and expressed as the amount of CO_2 released per hour ($mL \cdot kg^{-1} \cdot h^{-1}$).

$$R_{CO_2} = \frac{\left(y_{co_2}^{t_f} - y_{co_2}^{t_i}\right) \cdot V}{100 \cdot M \cdot (t_f - t_i)} \quad (2)$$

Where R = respiration (consumption/production) rate, $mL \cdot kg^{-1} \cdot h^{-1}$. V = free volume, mL. y = volumetric concentration, % v/v. M = mass, kg. t = time, h.

2.5 | Firmness

Fruit firmness was assessed using an AFG 250 N Mecmesin Advanced Force Gauge (Richmond Works, Lake View, Halifax, United Kingdom) attached to a Multitest 2.5-d Mecmesin texture analyzer tower. Nine peaches were randomly selected from each group. A 1-mm slice of peel was removed from the surface of each fruit with a knife, and puncture tests were performed at that site with an 8-mm cylindrical probe. The loading speed was set at 2 mm/s, and the maximum puncture depth was 10 mm [20]. Firmness was expressed as the maximum force in Newtons (N).

2.6 | Visual Flesh Appearance

Flesh visual appearance was evaluated by randomly selecting five peaches from each storage temperature at each evaluation point. Images were collected to document the development of CI symptoms during storage. High-quality photographs were captured on days 0, 7, 14, 21, and 28 using a smartphone camera (iPhone 15 Pro Max, Apple, Cupertino, CA, USA) placed within an enclosed photo booth to ensure uniform lighting and consistent imaging conditions.

2.7 | Flesh Color Evaluation

On each sampling day, three peaches were randomly selected from each replication (nine fruits per storage temperature). Flesh color was assessed on the cut flesh surface by taking three readings at different positions, and the mean was used as the color value for each fruit. Measurements were obtained using a digital colorimeter (Konica Minolta CR-400, Tokyo, Japan) and expressed in the CIE L^* a^* b^* color space, where $L*$ represents lightness (0 = black, 100 = white), a^* the red-green index (+ a = red, − a = green), and b^* the yellow–blue index (+ b = yellow, − b = blue).

2.8 | Decay and CI Incidence

Decay incidence was determined visually by inspecting a minimum of 20 peaches per replicate at each storage temperature. Fruits displaying mold growth or water-soaked lesions on the surface were considered rotten. The decay incidence was calculated as the percentage of affected fruits relative to the total number of peaches evaluated. CI incidence was similarly determined by recording the presence or absence of characteristic CI symptoms on each fruit and expressing the results as the percentage of peaches exhibiting CI relative to the total number of fruits evaluated.

2.9 | Total Soluble Solids (TSS)

Samples were prepared by homogenizing 10 g of fruit with a homogenizer (PowerGen 500, Fisher Scientific, Waltham, Massachusetts, United States). The homogenate was centrifuged in an Allegra 25R unit (Beckman Coulter, Brea, California, United States) at 4800 rpm and 4°C for 35 min. Subsequently, the supernatant was filtered through cheesecloth, and the juice was stored at −20°C until analysis. TSS concentration was measured using a pocket refractometer (PAL-1; Minato-ku City, Tokyo, Japan) by placing a drop of juice on the prism, and the results were expressed as a percentage of TSS.

2.10 | Data Analysis

The study was conducted during the summers of 2023 and 2024 and involved three commercial melting flesh peach cultivars ('Blazeprince', 'Rich Pride', and 'O'Henry') stored at 1.1°C, 5.5°C, or 10°C. Quality attributes were evaluated on days 0, 7, 14, 21, and 28. A subset of three biological replicates per storage temperature was held for three additional days at 20°C and 70% RH to assess CI incidence under simulated market conditions. A completely randomized design was used in this experiment. All statistical analyses were performed in R (R Foundation for Statistical Computing, Vienna, Austria). Data were analyzed separately for each sampling day. For each cultivar and each storage day, a linear model was fitted, followed by a one-way ANOVA to test for differences among storage temperatures. When the significant effects were detected ($p < 0.05$), means were compared using Tukey's HSD test (95% confidence level). Compact letter displays were used to illustrate statistical differences among the groups. The results were expressed as means ± standard errors.

3 | Results

3.1 | Weight Loss

Weight loss in the 'Blazeprince' cultivar increased progressively during storage (Figure 1A (II)). After 7 days, peaches stored at 1.1°C exhibited significantly lower weight loss (5.29% ± 0.28%) when compared with 5.5°C (6.94% ± 0.07%) and 10°C (6.70% ± 0.13%) (Figure 1A (II)). After 21 days, peaches stored at 1.1°C demonstrated significantly lower weight loss (11.04% ± 1.13%) compared with 5.5°C (13.46% ± 0.47%) (Figure 1A (II)). This trend remained consistent throughout the 28 days storage (Figure 1A (II)).

Weight loss in the 'Rich Pride' cultivar increased over time during storage (Figure 1B (II)), following a similar trend to 'Blazeprince.' After 7 days, peaches stored at 1.1°C (4.81% ± 0.23%) and 5.5°C (5.97% ± 0.12%) showed significantly lower weight loss compared with 10°C (7.33% ± 0.45%) (Figure 1B (II)). At 14 and 28 days, peaches stored at 1.1°C exhibited significantly lower weight loss compared with those stored at 10°C (Figure 1B (II)). Weight loss in 'O'Henry' peaches gradually increased during storage across all storage temperatures evaluated (Figure 1C (II)). After 7 days, fruit stored at 1.1°C showed significantly lower weight loss (2.78% ± 0.44%) when compared with 5.5°C (4.84% ± 0.23%) and 10°C (5.10% ± 0.48%) (Figure 1C (II)). From 21 days onward, this pattern remained consistent, with peaches stored at 1.1°C showing the lowest weight loss compared with those held at higher temperatures (Figure 1C (II)). A comparable pattern was observed at 28 days, when peaches stored at 1.1°C showed significantly lower weight loss (19.8% ± 0.48%) than those stored at 5.5°C (22.5% ± 0.80%) or 10°C (27.3% ± 3.03%) (Figure 1C (II)).

3.2 | (RR)

In the 'Blazeprince' cultivar, RR increased gradually during the storage period (Figure 2A (II)). After 7 days, peaches stored at 10°C exhibited significantly higher RR compared with peaches stored at 1.1°C. After 14 days, peaches

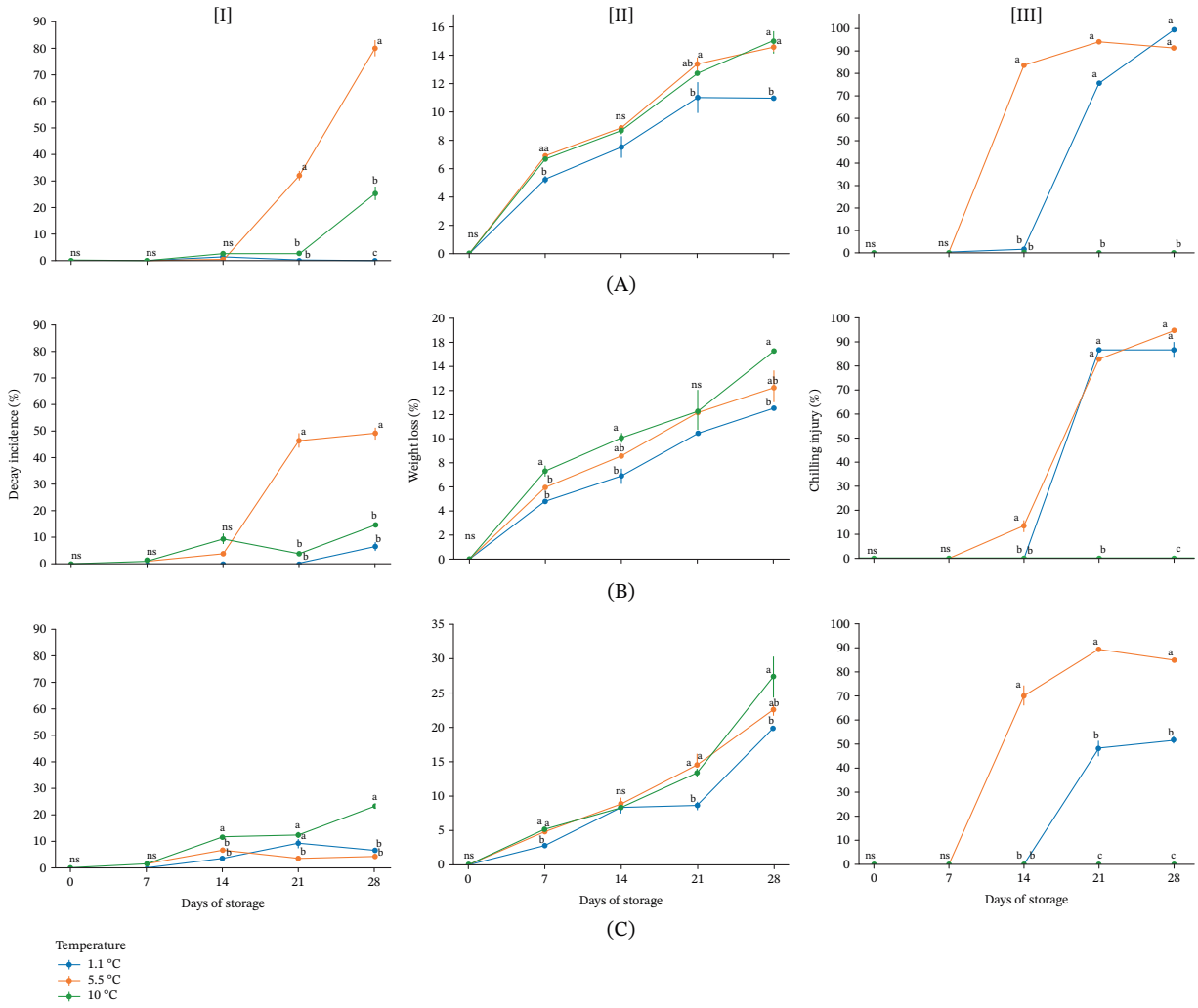


FIGURE 1 | Effects of three different storage temperatures (1.1°C, 5.5°C, and 10°C) on decay incidence (A), weight loss (B), and chilling injury (C) of three peach cultivars (I) 'Blazeprince', (II) 'Rich Pride', and (III) 'O'Henry' during 28 days of storage. Data are shown as means ± standard error ($n = 3$). Different letters above the bars indicate significant differences among the storage temperatures within each storage day (Tukey's HSD, $p < 0.05$). "ns" indicates no significant difference.

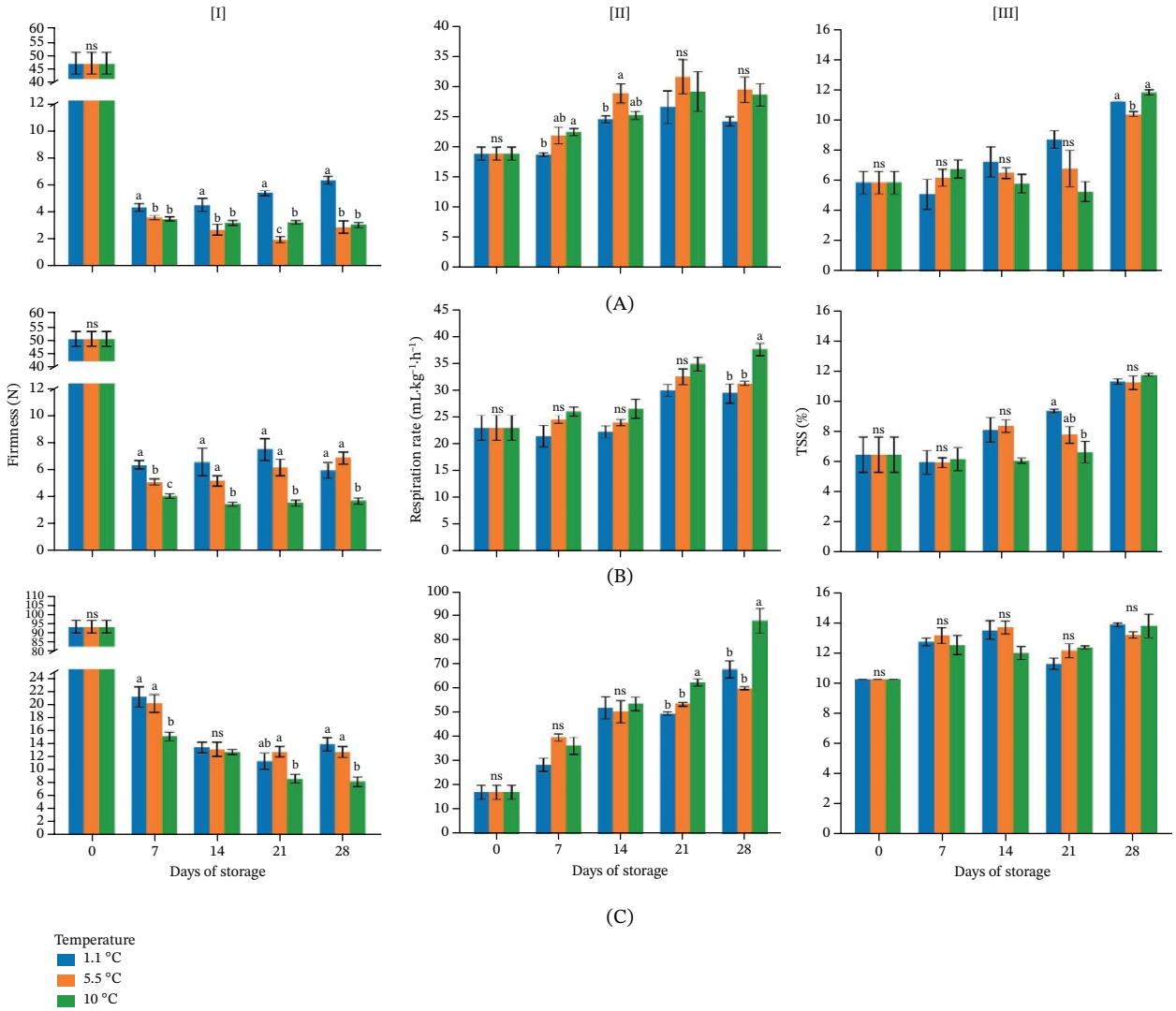


FIGURE 2 | Effects of three different storage temperatures (1.1°C, 5.5°C, and 10°C) on firmness (A), respiration rate (B), and total soluble solids (TSS) (C) of three peach cultivars (I) 'Blazeprince', (II) 'Rich Pride', and (III) 'O'Henry' during 28 days of storage. Data are shown as means ± standard error ($n = 3$). Different letters above the bars indicate significant differences among the storage temperatures within each storage day (Tukey's HSD, $p < 0.05$). "ns" indicates no significant difference.

stored at 5.5°C demonstrated a significantly higher RR ($28.84 \pm 1.60\,mL \cdot kg^{-1} \cdot h^{-1}$) compared with those stored at 1.1°C ($24.54 \pm 0.59\,mL \cdot kg^{-1} \cdot h^{-1}$), whereas fruit stored at 10°C exhibited intermediate values ($25.19 \pm 0.65\,mL \cdot kg^{-1} \cdot h^{-1}$) (Figure 2A (II)).

In 'Rich Pride', RR remained relatively stable during the early storage period across all evaluated storage temperatures, with a clearer increase observed after prolonged storage, particularly by 28 days, when peaches stored at 10°C exhibited the highest RR ($37.31 \pm 1.15\,mL \cdot kg^{-1} \cdot h^{-1}$) (Figure 2B (II)).

In the 'O'Henry' cultivar, RR increased on a larger scale compared with 'Blazeprince' and 'Rich Pride' throughout the 28 days of storage for all three storage temperatures (Figure 2C (II)). After 21 days of storage, peaches stored at 10°C showed significantly higher RR ($62.83 \pm 1.45\,mL \cdot kg^{-1} \cdot h^{-1}$) compared with those at 1.1°C ($50.04 \pm 0.60\,mL \cdot kg^{-1} \cdot h^{-1}$) and 5.5°C ($53.89 \pm 0.77\,mL \cdot kg^{-1} \cdot h^{-1}$) (Figure 2C (II)). This trend continued after 28 days of storage, where fruit held at 10°C showed the highest RR ($88.12 \pm 5.06\,mL \cdot kg^{-1} \cdot h^{-1}$) (Figure 2C (II)).

3.3 | Firmness

In the 'Blazeprince' cultivar (Figure 2A (I)), fruit firmness declined from 0 to 7 days of storage. By 7 days, peaches stored at 1.1°C maintained significantly higher firmness ($4.29 \pm 0.28\,N$) compared with those stored at 5.5°C ($3.54 \pm 0.14\,N$) or 10°C ($3.44 \pm 0.14\,N$), a trend that persisted up to the 14-days mark. From 21 days onward, firmness increased in fruit stored at 1.1°C and remained higher than at the other storage temperatures through the 28-days storage period.

Similarly, for the 'Rich Pride' cultivar, firmness declined from 0 to 7 days of storage (Figure 2A (I)). After 7 days, fruit stored at 1.1°C exhibited the highest firmness ($6.21 \pm 0.30\,N$), whereas those stored at 10°C exhibited the lowest readings ($4.00 \pm 0.15\,N$)

(Figure 2B (I)). From 14 days onward, peaches stored at 1.1°C and 5.5°C consistently maintained higher firmness compared with those stored at 10°C (Figure 2B (I)).

In the 'O'Henry' cultivar, flesh firmness decreased during storage across all evaluated temperatures, although the decline was less pronounced than in 'Blazeprince' and 'Rich Pride' (Figure 2C (I)). After 7 days, peaches stored at 1.1°C and 5.5°C maintained higher firmness compared with those stored at 10°C (Figure 2C (I)). After 21 days, peaches stored at 5.5°C were firmer than those at 10°C, whereas storage at 1.1°C showed intermediate firmness values (Figure 2C (I)). This pattern persisted until 28 days of storage, with the lowest firmness observed in fruit stored at 10°C ($8.10 \pm 0.75\,N$)(Figure 2C (I)).

3.4 | Flesh Visual Appearance

During the first 7 days of storage, all cultivars retained their visual quality, with no signs of CI across storage temperatures (Figures 3, 4, and 5). By 14 days of storage, CI symptoms appeared in fruit stored at 5.5°C, whereas peaches at 1.1°C and 10°C remained unaffected (Figures 3, 4, and 5). At 21 days, CI was observed on peaches stored at both 1.1°C and 5.5°C, whereas fruit stored at 10°C remained free of symptoms. This trend persisted through 28 days, at 1.1°C and 5.5°C, and no symptoms were observed at 10°C (Figures 3, 4, and 5).

3.5 | Flesh Color Evaluation

The L* value, representing lightness, showed no significant differences among storage temperatures in the 'Blazeprince' cultivar through 14 days. However, on 21 days, peaches stored at 10°C exhibited significantly higher L* values (66.8 ± 0.41) compared with 5.5°C (62.9 ± 1.46) (Table 2). For the 'O'Henry' cultivar, significant differences were observed at 21 days, with peaches at 5.5°C showing significantly lower L* values (69.0 ± 1.62) compared with fruit stored at 1.1°C.

The a* values, representing red-green color tones, remained stable throughout storage in the 'Blazeprince' cultivar, with no significant differences among storage temperatures (Table 2). In the 'Rich Pride' cultivar, differences emerged after 21 days of storage, when peaches stored at 1.1°C showed lower a* values (6.2 ± 1.56) compared with 10°C (11.3 ± 1.15) (Table 2). By 28 days, peaches stored at 10°C retained higher redness (9.3 ± 0.73) (Table 2). For the 'O'Henry' cultivar, significant differences appeared earlier, at 14 days, with peaches stored at 10°C showing significantly lower a* values (1.29 ± 0.29) compared with 1.1°C (3.12 ± 0.64), and 5.5°C (5.45 ± 0.45) (Table 2). On 28 days, peaches stored at 10°C expressed significantly higher a* values (10.9 ± 1.58) compared with 1.1°C (6.2 ± 0.88) (Table 2).

The b* values indicate yellow-blue tones. For the 'Blazeprince' cultivar, fruit stored at 10°C expressed significantly higher b* values at 14 days (49.1 ± 0.99) compared with fruit stored at 5.5°C (43.5 ± 1.71). A similar trend was observed at 21 days, when peaches stored at 10°C expressed significantly higher b* values (53.8 ± 0.99) compared with both 5.5 and 1.1°C storage temperatures (Table 2). For the 'Rich Pride' cultivar, b* values remained stable throughout storage, with no significant differences among storage temperatures. In the 'O'Henry' cultivar, significant differences were detected at later stages, with fruit stored at 10°C presenting higher b* values after 21 and 28 days of storage compared with 5.5°C.

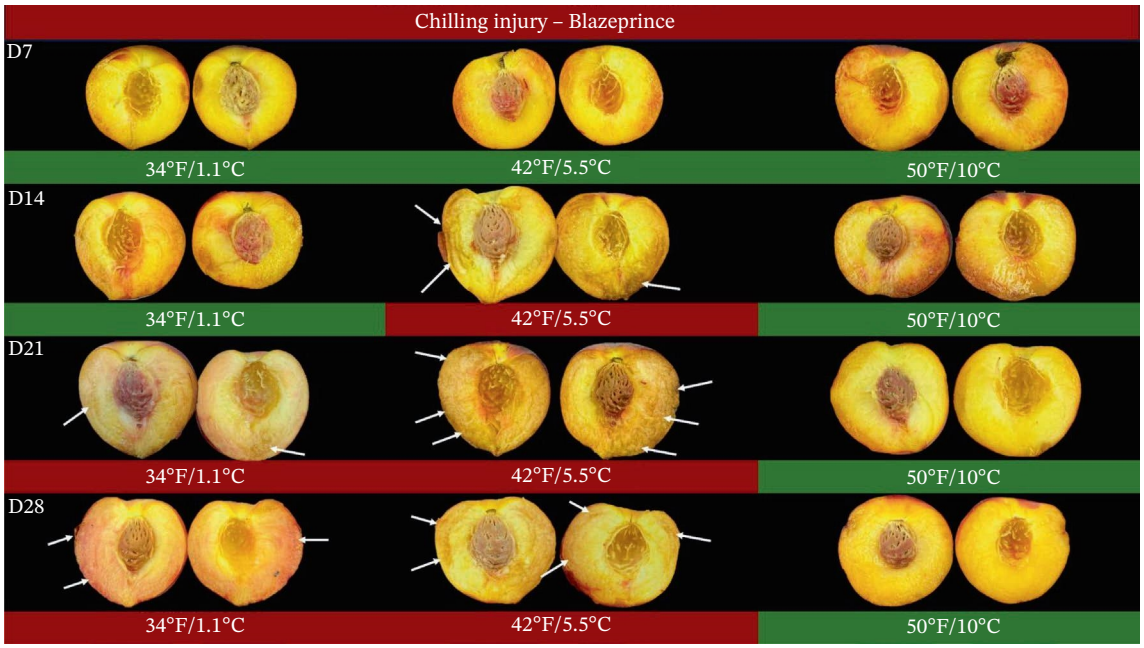


FIGURE 3 | Visual appearance of cut peaches for 'Blazeprince' stored at three different storage temperatures (1.1°C, 5.5°C, and 10°C) over four storage evaluation points (7, 14, 21, and 28 days). Representative fruits were selected to be shown for each temperature and day. White arrows highlight the areas that have been affected by chilling injury symptoms, including internal breakdown, mealiness or wooliness, lack of juiciness, and bleeding.

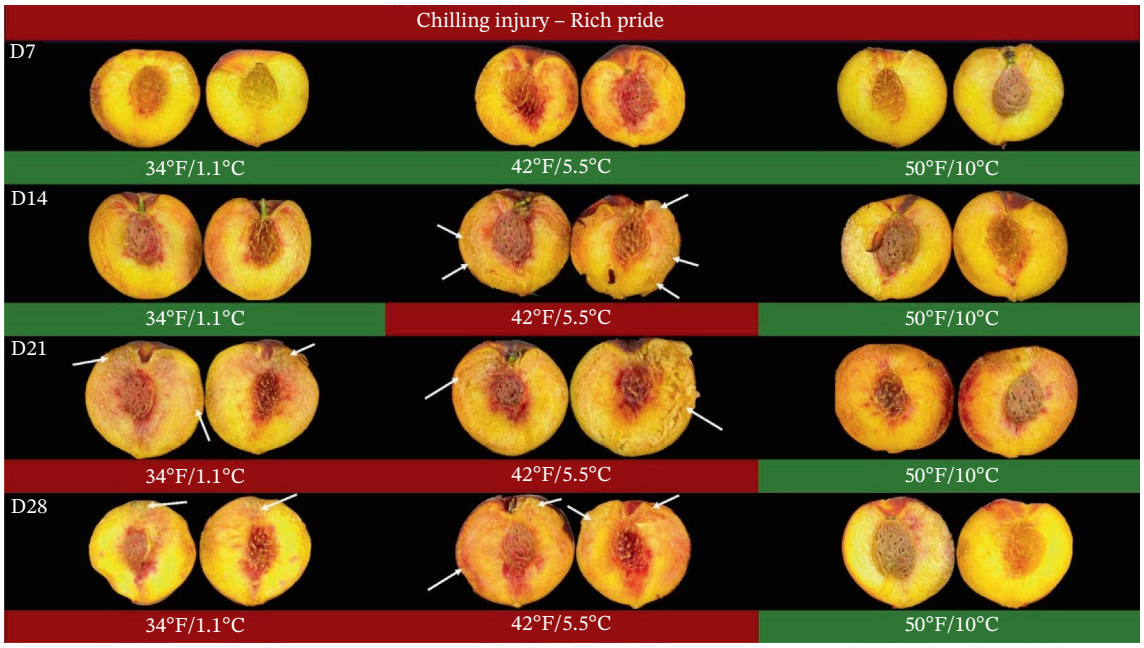


FIGURE 4 | Visual appearance of cut peaches for 'Rich Pride' stored at three different storage temperatures (1.1°C, 5.5°C, and 10°C) over four storage evaluation points (7, 14, 21, and 28 days). Representative fruits were selected to be shown for each temperature and day. White arrows highlight the areas that have been affected by chilling injury symptoms, including internal breakdown, mealiness or wooliness, lack of juiciness, and bleeding.

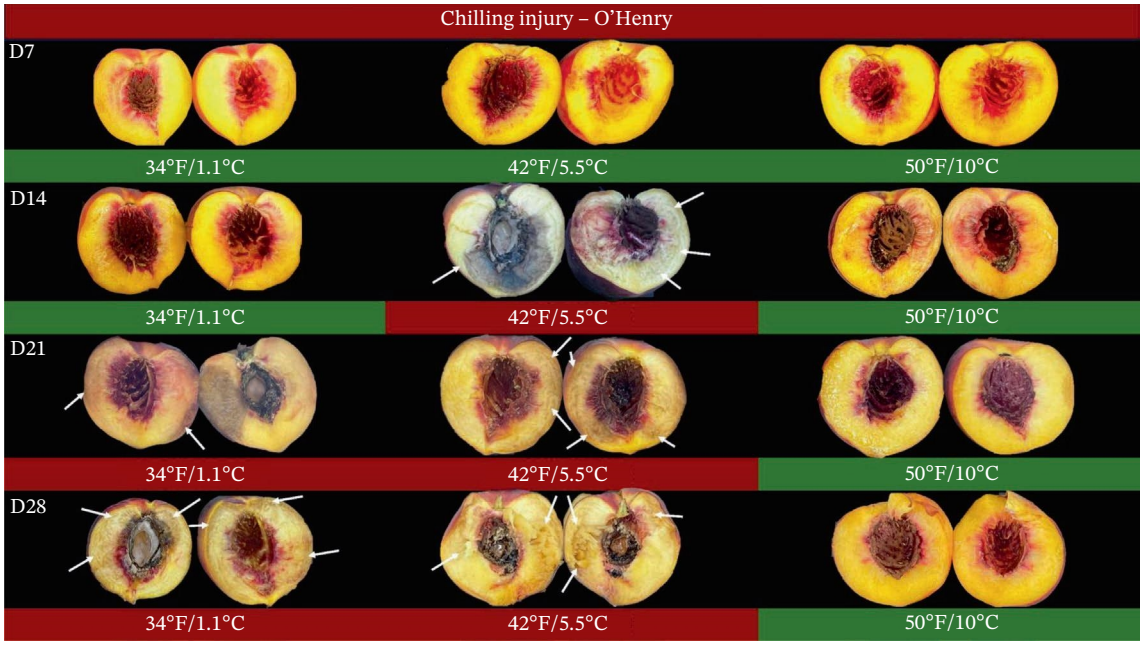


FIGURE 5 | Visual appearance of cut peaches for 'O'Henry' stored at three different storage temperatures (1.1°C, 5.5°C, and 10°C) over four storage evaluation points (7, 14, 21, and 28 days). Representative fruits were selected to be shown for each temperature and day. White arrows highlight the areas that have been affected by chilling injury symptoms, including internal breakdown, mealiness or wooliness, lack of juiciness, and bleeding.

3.6 | Decay Incidence

In the 'Blazeprince' cultivar, no significant differences in decay incidence were observed among storage temperatures up until 21 days, when peaches stored at 5.5°C showed higher decay (32.0% ± 1.63%) than the other conditions (Figure 1A (I)). At 28 days, decay incidence increased sharply in peaches stored at 5.5°C (80.0% ± 2.94%) and was also higher at 10°C reaching approximately 25.3% ± 2.62%, whereas fruit stored at 1.1°C remained free of decay throughout the entire storage period (Figure 1A (I)).

In 'Rich Pride', decay incidence was not significantly different among storage temperatures until 21 days, when fruit stored at 5.5°C showed significantly higher decay incidence (46.7% ± 2.87%) compared with other conditions (Figure 1B (I)).

TABLE 2 | Color values $L_{002A;}$, $a_{002A;}$, and $b_{002A;}$ for 'Blazeprince', 'Rich Pride', and 'O'Henry' peaches stored for 7, 14, 21, and 28 days at 1.1°C, 5.5°C, and 10°C at 90% RH.

Day	Color value	Storage temperature	'Blazeprince'	'Rich Pride'	'O'Henry'
7	L002*A*;	1.1°C	63.4 ± 1.56^{a}	61.1 ± 1.23^{a}	74.7 ± 1.05^{a}
		5.5°C	68.6 ± 1.46^{a}	60.1 ± 1.26^{a}	77.4 ± 0.49^{a}
		10°C	62.6 ± 2.30^{a}	62.7 ± 1.52^{a}	77.2 ± 0.74^{a}
14		1.1°C	65.9 ± 1.78^{a}	63.9 ± 2.08^{a}	74.9 ± 0.84^{a}
		5.5°C	60.9 ± 1.85^{a}	60.6 ± 1.96^{a}	73.1 ± 0.65^{a}
		10°C	63.9 ± 0.89^{a}	61.3 ± 1.60^{a}	74.9 ± 0.73^{a}
21		1.1°C	63.9 ± 0.80^{ab}	67.4 ± 1.86^{a}	74.1 ± 1.32^{a}
		5.5°C	62.9 ± 1.46^{b}	66.2 ± 1.30^{a}	69.0 ± 1.62^{b}
		10°C	66.8 ± 0.41^{a}	61.5 ± 1.86^{a}	71.4 ± 0.85^{ab}
28		1.1°C	64.6 ± 1.33^{a}	65.3 ± 1.52^{a}	70.2 ± 1.38^{a}
		5.5°C	64.6 ± 1.33^{a}	68.9 ± 1.17^{a}	67.7 ± 1.89^{a}
		10°C	65.4 ± 1.48^{a}	61.2 ± 0.74^{b}	65.4 ± 1.07^{a}
7	a002*A*;	1.1 °C	5.23 ± 1.26^{a}	11.4 ± 1.38^{a}	1.00 ± 0.77^{a}
		5.5°C	4.66 ± 0.74^{a}	11.5 ± 1.23^{a}	0.58 ± 0.29^{a}
		10°C	5.65 ± 0.95^{a}	10.7 ± 1.16^{a}	-0.43 ± 0.59^{a}
14		1.1 °C	4.92 ± 0.98^{a}	10.2 ± 1.76^{a}	3.12 ± 0.64^{b}
		5.5°C	6.72 ± 1.03^{a}	13.5 ± 1.35^{a}	5.45 ± 0.45^{a}
		10°C	5.72 ± 0.63^{a}	10.5 ± 1.18^{a}	1.29 ± 0.29^{c}
21		1.1°C	7.42 ± 1.18^{a}	6.2 ± 1.56^{b}	6.96 ± 2.15^{a}
		5.5°C	6.04 ± 0.63^{a}	9.3 ± 1.02^{ab}	7.34 ± 0.99^{a}
		10°C	5.13 ± 0.57^{a}	11.3 ± 1.15^{a}	5.70 ± 0.84^{b}
28		1.1°C	5.81 ± 0.61^{a}	7.1 ± 1.29^{ab}	6.28 ± 0.88^{b}
		5.5°C	5.81 ± 0.61^{a}	5.7 ± 0.55^{b}	7.34 ± 0.99^{ab}
		10°C	4.72 ± 0.53^{a}	9.3 ± 0.73^{a}	10.9 ± 1.58^{a}
7	b002*A*;	1.1°C	51.1 ± 1.68^{a}	49.5 ± 2.39^{a}	54.8 ± 1.35^{a}
		5.5°C	54.4 ± 1.29^{a}	50.1 ± 2.03^{a}	54.9 ± 0.63^{a}
		10°C	50.7 ± 2.96^{a}	55.8 ± 2.47^{a}	54.7 ± 1.38^{a}
14		1.1°C	47.1 ± 1.72^{ab}	51.9 ± 2.16^{a}	52.5 ± 1.35^{a}
		5.5°C	43.5 ± 1.71^{b}	48.4 ± 2.10^{a}	51.8 ± 1.12^{a}
		10°C	49.1 ± 0.99^{a}	52.2 ± 1.89^{a}	51.6 ± 0.96^{a}
21		1.1°C	45.3 ± 1.95^{b}	52.1 ± 1.32^{a}	55.1 ± 2.87^{ab}
		5.5°C	45.8 ± 1.44^{b}	52.6 ± 1.14^{a}	48.1 ± 3.29^{b}
		10°C	53.8 ± 0.99^{a}	52.9 ± 2.21^{a}	62.7 ± 1.46^{a}
28		1.1°C	42.7 ± 1.25^{a}	50.7 ± 1.69^{a}	51.9 ± 2.59^{ab}
		5.5°C	42.7 ± 1.25^{a}	51.5 ± 1.81^{a}	48.1 ± 3.29^{b}
		10°C	47.0 ± 1.20^{a}	48.7 ± 1.02^{a}	60.3 ± 1.43^{a}

Note: Different letters are assigned where storage temperatures significantly affected the measured parameters (p value < 0.05).

By 28 days, decay incidence remained highest in peaches stored at 5.5°C (49.3% ± 2.36%), followed by 10°C (14.7% ± 1.25%) and 1.1°C (6.7% ± 1.70%) (Figure 1B (I)).

In 'O'Henry', no decay was observed until 7 days. By 14 days, peaches stored at 10°C exhibited significantly higher decay incidence (11.7 ± 0.47%) compared with 5.5°C (6.7 ± 0.47%) and 1.1°C (3.7 ± 0.47%) (Figure 1C (I)). At 21 days, decay incidence was higher in fruit stored at 10°C (12.3% ± 1.25%) and 1.1°C (9.3% ± 1.89%) than at 5.5°C (3.5% ± 0.47%) (Figure 1C (I)). By 28 days, fruit stored at 10°C exhibited the highest decay incidence (23.3% ± 0.47%) compared with 5.5°C (4.3% ± 0.47%) and 1.1°C (6.7% ± 0.47%) (Figure 1C (I)).

3.7 | CI

CI in 'Blazeprince' peaches was absent across all three storage temperatures up to 7 days (Figure 1A (III)). At 14 days, peaches stored at 5.5°C exhibited significantly higher CI incidence (84.0% ± 1.41%), whereas those at 1.1°C or 10°C remained symptom-free (Figure 1A (III)). However, by 21 days, CI was observed in fruit stored at 1.1°C and 5.5°C, whereas fruit at 10°C remained unaffected (Figure 1A (III)). This pattern persisted through 28 days of storage, with high CI incidence at 1.1°C and 5.5°C and no symptoms at 10°C (Figure 1A (III)).

For the 'Rich Pride' cultivar, no CI symptoms were observed until 14 days, when peaches stored at 5.5°C showed a slight increase in CI incidence (13.3% ± 2.49%) (Figure 1B (III)). By 21 days, fruit stored at 1.1°C and 5.5°C exhibited significantly higher CI incidence (86.6% ± 1.25% and 82.6% ± 0.94%, respectively), compared with fruit stored at 10°C, which remained free of CI symptoms (Figure 1B (III)). This pattern persisted at 28 days, with the highest CI at 5.5°C (94.6% ± 1.25%), followed by 1.1°C (70.6% ± 3.40%), whereas no CI symptoms were detected at 10°C throughout the storage period (Figure 1B (III)).

In 'O'Henry' cultivar, CI was absent during the first 7 days of storage across all three storage temperatures evaluated (Figure 1, III, C). On 14 days, CI was observed only in peaches stored at 5.5°C (Figure 1C (III)). On 21 days, fruit stored at 5.5°C presented the highest CI (89.47% ± 0.82%), followed by 1.1°C (48.1% ± 3.30%), whereas fruit stored at 10°C remained symptom-free (Figure 1C (III)). This trend persisted through 28 days, with CI present at 5.5°C (85.0% ± 1.41%) and 1.1°C (51.6% ± 0.47%), with no symptoms detected at the storage temperature of 10°C (Figure 1C (III)).

3.8 | TSS

For the 'Blazeprince' cultivar, TSS remained relatively stable during most of the storage period, with differences among storage temperatures becoming evident only after 28 days of storage (Figure 2A (III)). At that time, peaches stored at 5.5°C had significantly lower TSS (10.37° C ± 0.17° C), compared with the ones stored at 1.1°C and 10°C (Figure 2A (III)).

In the 'Rich Pride' cultivar, TSS also remained relatively stable during storage, with only minor variations among the temperatures (Figure 2B (III)). After 21 days, peaches stored at 1.1°C showed statistically significantly higher TSS values (9.40% ± 0.10%) when compared with 10°C (6.67% ± 0.72%) (Figure 2B (III)). By 28 days, TSS values did not differ significantly among storage temperatures.

In the 'O'Henry' cultivar, TSS values showed only slight variation throughout the storage period, and no significant differences were detected among storage temperatures at any evaluated time point (Figure 2C (III)).

4 | Discussion

Postharvest temperature management plays a key role in maintaining peach quality during storage and distribution. Peaches, as a climacteric fruit, continue to show increased metabolic activity after harvest, which can lead to rapid softening, increased susceptibility to decay, shortened shelf life, and declined marketability value [10]. Refrigeration is crucial to slow down respiration and ethylene production, both of which contribute to the fruit ripening and senescence [21]. Consequently, for producers, packing house owners, distributors, and even consumers, the storage temperature must be carefully controlled. Peach storage is particularly challenging due to the "killing zone," defined in the literature as the temperature range between 2.2°C and 7.7°C, where the risk of CI symptoms such as mealiness, browning, and internal breakdown is elevated [10, 13]. In this study, 'Blazeprince', 'Rich Pride', and 'O'Henry' peaches were stored at 1.1°C (industrially recommended temperature), 5.5°C (within the "killing zone"), and 10°C (elevated storage temperature, above the "killing zone") for up to 28 days. CI developed during extended storage even at 1.1°C (putative safe storage temperature), with higher incidence observed at 5.5°C. The presence of CI symptoms at 1.1°C across all evaluated cultivars indicates that the effectiveness of these putative safe storage conditions in preventing CI may depend not only on temperature but also on storage duration. It is important to note that the responses observed in this study are based on three commercial cultivars, and variability among genotypes may influence tolerance to storage conditions. On the other hand, storage of peaches at 10°C did not trigger any CI symptoms in any of the three cultivars. Nevertheless, fruit stored at the elevated temperature softened faster and showed greater weight loss, whereas decay incidence was cultivar-dependent, with higher decay at 10°C in 'O'Henry' and more pronounced decay at 5.5°C in 'Blazeprince' and 'Rich Pride'. The complete absence of CI under 10°C storage suggests that this storage temperature could be an acceptable solution for short storage periods or rapid distribution when the main concern is the avoidance of CI. However, this storage temperature is unsuitable for long-term storage due to the rapid softening occurring under these conditions. These results indicate that peach postharvest performance was shaped by an interaction among CI development, ripening-related softening, weight loss, decay incidence, and cultivar-specific tolerance to storage temperature, rather than by any single quality parameter alone.

Weight loss steadily increased during storage in all three cultivars, with the highest values consistently observed at 10°C and the lowest at 1.1°C, which agrees with the expected reduction in weight loss at lower storage temperatures [22–24]. Weight

loss was exacerbated during the additional 3-days shelf-life period at room temperature, particularly after extended storage. Therefore, the relatively high losses observed in this study were likely driven by the combined effects of storage duration, the additional shelf-life period at room temperature, and temperature-dependent transpiration. Storage at 5.5°C resulted in intermediate weight loss values with a more pronounced increase after 21 days, especially in 'Blazeprince' and 'Rich Pride'. These results showed that, beyond RH, storage temperature plays a key role in regulating weight loss, with 1.1°C being the most effective in reducing dehydration. This temperature-dependent pattern in weight loss, which was observed at higher temperatures, is consistent with the faster softening and increased decay incidence reported under such conditions, likely associated with accelerated ripening and tissue deterioration [25].

Peach RRs increased overall during storage for all cultivars evaluated, and the highest values were usually linked with the highest storage temperature (10°C). This is an expected outcome because the warmer temperatures increase metabolic activities and lead to faster CO_2 production. Several studies have shown that peaches stored at higher temperatures respire more rapidly, which accelerates softening and reduces shelf life [13, 17]. However, 'Blazeprince' showed higher RRs at 5.5°C compared with 10°C after 14 days of storage, which suggests a possible stress response in the "killing zone" temperature range for this specific cultivar. The different patterns show that cultivars can react differently when exposed to cold stress or warmer storage conditions. In our study, the increase in respiration at 10°C was accompanied by accelerated softening, greater weight loss, and in some cultivars, higher decay incidence, whereas the lower RRs at 1.1°C reflected reduced metabolic activity under cold storage conditions.

TSS values increased slightly during storage across all evaluated cultivars, consistent with the normal ripening process involving the conversion of starches and complex carbohydrates into simpler sugars [26, 27]. The differences among temperatures were not consistent, and the changes were small compared with the other quality traits. This agrees with previous work showing that storage temperature has a limited direct influence on TSS in peaches, since sugar accumulation mainly depends on ripening stage and cultivar characteristics rather than temperature alone [21]. In contrast, storage temperature had a more pronounced impact on weight loss, RR, firmness, and decay incidence, highlighting the lower sensitivity of TSS under the evaluated conditions. In our study, the minor increase in TSS reflected normal ripening during cold storage and was not associated with CI. Flesh color responses were cultivar dependent. Lower L^* values observed at 5.5°C in some cultivars may indicate darker flesh associated with CI-related browning. This interpretation is supported by previous reports linking internal browning in peaches with changes in CIELAB parameters, particularly L^*, and is recognized as a common symptom of CI after cold storage [10, 28].

Firmness is an important quality attribute for peaches because it is associated with textural integrity and postharvest shelf life. However, peach marketability also depends on other factors, including CI symptoms and decay incidence [26]. Our results showed that firmness declined over time in all three cultivars, reflecting normal ripening driven by the enzymatic degradation of key cell wall components, such as pectin, cellulose, and hemicellulose. Enzymes, including polygalacturonase (PG), pectin methylesterase (PME), and β-galactosidase, play a central role in modifying pectic substances and in weakening cell wall structure, ultimately leading to fruit softening [8, 27]. In this study, firmness increased at later storage stages in all cultivars stored at 1.1°C, a response associated with the development of CI. This disorder is linked to an incomplete cell wall disassembly in the mesocarp, resulting in a dry and rubbery texture, commonly referred to as mealiness or wooliness [8, 10, 29]. However, this response was cultivar-dependent, with 'Blazeprince' showing the most pronounced firmness increase after 21 days at 1.1°C, whereas 'O'Henry' showed a more moderate decline and a less dramatic response to low temperatures, suggesting differences in CI susceptibility among cultivars. In contrast, peaches stored at 10°C softened more rapidly, which may be related to accelerated activity of cell wall-degrading enzymes and, possibly, to the greater weight loss observed under this storage condition [25, 30].

Decay incidence is a serious postharvest concern that can negatively affect peach marketability, especially under conditions that compromise fruit integrity. In our study, decay incidence increased notably after prolonged storage (21 days), with the highest rates observed in fruit stored at the higher storage temperatures of 5.5°C and 10°C. A similar study by Sun et al. [31] found that peaches stored at 5°C and 8°C developed decay earlier and at higher percentages than fruit stored at 0°C and 2°C, with decay increasing steadily as storage duration progressed. In our study, decay incidence was cultivar dependent. 'Rich Pride' and 'Blazeprince' exhibited higher decay at 5.5°C, whereas 'O'Henry' showed greater decay at 10°C. The elevated decay observed at 5.5°C in the first two cultivars may be associated with increased CI incidence. This pattern suggests that decay is influenced not only by storage temperature but also by the extent of chilling-related tissue damage, which may have increased fruit susceptibility to deterioration in more sensitive cultivars.

It is worth noting that our findings showed that CI symptoms developed at 1.1°C in all three cultivars evaluated, challenging the common assumptions that this temperature is completely safe for long-term peach storage. Franzoni et al. [12] reviewed the biochemical and molecular responses of peaches to low temperature stress and described how cold storage led to damage of membrane integrity, reactive oxygen species (ROS) accumulation, and altered cell wall structure, all of which contribute to CI development. Our results are aligned with these findings, highlighting that extended storage durations play a critical role in the manifestation of CI, even at temperatures considered as safe (1.1°C). This suggests that the presence and severity of CI are not solely dependent on storage temperature but are also significantly influenced by storage duration and cultivar variability.

5 | Conclusion

This study demonstrated that storage temperature and duration play a crucial role in the postharvest quality attributes and the CI development of three commonly grown Georgia peach cultivars. Among the three temperatures evaluated, fruit stored at 1.1°C exhibited the lowest weight loss and decay incidence during the 28-days storage period. However, our results showed

that prolonged storage (≥21 days) at this temperature (1.1°C), previously considered as safe and outside the "killing zone", led to a gradual increase in firmness due to the onset of CI, indicating that 1.1°C is suitable only for short-term storage and should not be recommended for periods exceeding 3 weeks. The low temperature might slow the fruit metabolism, but it does not fully prevent the internal stress that leads to CI. On the other hand, peaches stored at 10°C did not develop any CI symptoms, suggesting potential use for short-term storage or quick local distribution. Responses to cold storage were cultivar-dependent, highlighting the need for targeted postharvest handling protocols. Although this study focused on postharvest quality attributes and the appearance of visual CI symptoms, other factors such as aroma volatiles, consumer flavor perception, or different harvest maturity stages may further influence CI susceptibility and warrant future investigation. Due to the nature of CI symptoms, which manifest only when the fruit is exposed to room temperatures (20°C), the quality decline is usually noticed by end-of-market consumers rather than producers, packers, or shippers. Overall, these findings provide practical postharvest information for optimizing cold chain management by balancing storage temperature and duration, directly relevant to commercial peach postharvest handling protocols.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon request.

References

1. D. Bassi, and R. Monet, "Botany and taxonomy," in *The Peach: Botany, Production and Uses* (Cabi, 2008), 1–36.

2. A. Weisskopf, and D. Q. Fuller, "Peach: Origins and Development," in *Encyclopedia of Global Archaeology* (Springer International Publishing, 2020), 8459–8461.

3. USDA FAS, "Peaches & Nectarines: Production – Peaches & Nectarines," in *United States Department of Agriculture* (Foreign Agricultural Service, 2025).

4. G. Zhang, Y. Zhang, T. Yang, et al., "Physiological and Transcriptomic Analysis of Salicylic Acid on Membrane Lipid Metabolism and Cell Wall Metabolism in Postharvest Peach Fruit," *Postharvest Biology and Technology* 229 (2025): 113683, https://doi.org/10.1016/j.postharvbio.2025.113683.

5. C. Crisosto, and D. Valero, "Harvesting and Postharvest Handling of Peaches for the Fresh Market," in *The Peach: Botany, Production and Uses* (CABI, 2008), 575–596.

6. C. Rodrigues, P. D. Gaspar, M. P. Simões, P. D. Silva, and L. P. Andrade, "Review on Techniques and Treatments Toward the Mitigation of the Chilling Injury of Peaches," *Journal of Food Processing and Preservation* 46 (2022): e14358, https://doi.org/10.1111/jfpp.14358.

7. H. Zhou, X. Zhang, M. Su, et al., "Controlled Atmosphere Storage Alleviates Internal Browning in flat Peach Fruit by Regulating Energy and Sugar Metabolisms," *Plant Physiology and Biochemistry* 186 (2022): 107–120, https://doi.org/10.1016/j.plaphy.2022.07.003.

8. D. A. Brummell, V. Dal Cin, S. Lurie, C. H. Crisosto, and J. M. Labavitch, "Cell Wall Metabolism During the Development of Chilling Injury in Cold-Stored Peach Fruit: Association of Mealiness With Arrested Disassembly of Cell Wall Pectins," *Journal of Experimental Botany* 55 (2004): 2041–2052, https://doi.org/10.1093/jxb/erh228.

9. C. H. Crisosto, D. Garner, G. M. Crisosto, and E. Bowerman, "Increasing 'Blackamber' plum (Prunus salicina Lindell) Consumer Acceptance," *Postharvest Biology and Technology* 34, no. 3 (2004): 237–244, https://doi.org/10.1016/j.postharvbio.2004.06.003.

10. S. Lurie, and C. H. Crisosto, "Chilling Injury in Peach and Nectarine," *Postharvest Biology and Technology* 37 (2005): 195–208, https://doi.org/10.1016/j.postharvbio.2005.04.012.

11. P. J. Martínez-García, C. P. Peace, D. E. Parfitt, et al., "Influence of Year and Genetic Factors on Chilling Injury Susceptibility in Peach (Prunus persica (L.) Batsch)," *Euphytica* 185, no. 2 (2012): 267–280, https://doi.org/10.1007/s10681-011-0572-1.

12. G. Franzoni, N. D. Spadafora, T. M. Sirangelo, A. Ferrante, and H. J. Rogers, "Biochemical and Molecular Changes in Peach Fruit Exposed to Cold Stress Conditions," *Molecular Horticulture* 3 (2023): 24, https://doi.org/10.1186/s43897-023-00073-0.

13. C. H. Crisosto, F. G. Mitchell, and Z. Ju, "Susceptibility to Chilling Injury of Peach, Nectarine, and Plum Cultivars Grown in California," *HortScience* 34, no. 6 (1999): 1116–1118, https://doi.org/10.21273/HORTSCI.34.6.1116.

14. S. Lurie, "Proteomic and Metabolomic Studies on Chilling Injury in Peach and Nectarine," *Frontiers in Plant Science* 13 (2022): 958312, https://doi.org/10.3389/fpls.2022.958312.

15. A. P. Dhanapal, and C. H. Crisosto, "Association Genetics of Chilling Injury Susceptibility in Peach (Prunus persica (L.) Batsch) Across Multiple Years," *3 Biotech* 3, no. 3 (2013): 481–490, https://doi.org/10.1007/s13205-012-0109-x.

16. G. A. Manganaris, I. Minas, M. Cirilli, R. Torres, D. Bassi, and G. Costa, "Peach for the Future: A specialty Crop Revisited," *Scientia Horticulturae* 305 (2022): 111390, https://doi.org/10.1016/j.scienta.2022.111390.

17. M. Farcuh, and H. Hopfer, "Aroma Volatiles as Predictors of Chilling Injury Development During Peach (Prunus persica (L) Batsch) Cold Storage and Subsequent Shelf-Life," *Postharvest Biology and Technology* 195 (2023): 112137, https://doi.org/10.1016/j.postharvbio.2022.112137.

18. T. Shan, P. Jin, Y. Zhang, Y. Huang, X. Wang, and Y. Zheng, "Exogenous Glycine Betaine Treatment Enhances Chilling Tolerance of Peach Fruit During Cold Storage," *Postharvest Biology and Technology* 114 (2016): 104–110, https://doi.org/10.1016/j.postharvbio.2015.12.005.

19. S. C. Fonseca, F. A. Oliveira, and J. K. Brecht, "Modelling Respiration Rate of Fresh Fruits and Vegetables for Modified Atmosphere Packages: A Review," *Journal of Food Engineering* 52, no. 2 (2002): 99–119, https://doi.org/10.1016/S0260-8774(01)00106-6.

20. L. Contador, M. Díaz, M. Millanao, et al., "A Proposal for Determining the Flesh Softening of Peach and Nectarine in Postharvest Through Simplified Targeted Modeling," *Scientia Horticulturae* 209 (2016): 47–52, https://doi.org/10.1016/j.scienta.2016.06.015.

21. B. Zhang, X. Chen, N. Wang, et al., "Effects of Harvest Maturity on the Fruit Quality of Different Flesh-Type Peach Stored at Near-Freezing

Point Temperature," *Foods* 11, no. 15 (2022): 2200, https://doi.org/10.3390/foods11152200.

22. K. J. Bradford, P. Dahal, J. Van Asbrouck, et al., "The Dry Chain: Reducing Postharvest Losses and Improving Food Safety in Humid Climates," in *Food Industry Wastes* (Academic Press, 2020), 375–389.

23. F. Buonsenso, S. Prencipe, S. Valente, et al., "High Humidity Storage Close to Saturation Reduces Kiwifruit Postharvest Rots and Maintains Quality," *Horticulturae* 11, no. 8 (2025): 883, https://doi.org/10.3390/horticulturae11080883.

24. M. J. Gidado, A. A. N. Gunny, S. C. B. Gopinath, A. Ali, C. Wongs-Aree, and N. H. M. Salleh, "Challenges of Postharvest Water Loss in Fruits: Mechanisms, Influencing Factors, and Effective Control Strategies – A Comprehensive Review," *Journal of Agriculture and Food Research* 17 (2024): 101249, https://doi.org/10.1016/j.jafr.2024.101249.

25. Y. Wang, L. Deng, J. Meng, et al., "Transcriptomic and Metabolic Analyses Reveal the Mechanism of Ethylene Production in Stony Hard Peach Fruit During Cold Storage," *International Journal of Molecular Sciences* 22, no. 21 (2021): 22, https://doi.org/10.3390/ijms222111308.

26. C. Belisle, U. T. X. Phan, K. Adhikari, and D. J. Chavez, "A Fruit Quality Survey of Peach Cultivars Grown in the Southeastern United States," *Hort Technology* 28, no. 2 (2018): 189–201, https://doi.org/10.21273/HORTTECH03870-17.

27. V. Prasanna, T. N. Prabha, and R. N. Tharanathan, "Fruit Ripening Phenomena–An Overview," *Critical Reviews in Food Science and Nutrition* 47 (2007): 1–19, https://doi.org/10.1080/10408390600976841.

28. D. Cáceres, M. Díaz, P. Shinya, and R. Infante, "Assessment of Peach Internal Flesh Browning Through Colorimetric Measures," *Postharvest Biology and Technology* 111 (2016): 48–52, https://doi.org/10.1016/j.postharvbio.2015.07.007.

29. C. J. Stanley, C. Scofield, I. C. Hallett, and R. Schröder, "Dissecting the Role of Cell Wall Changes in Chilling Injury-Induced Gel Formation, Rubberiness, and Mealiness in Apricots," *Horticulturae* 9, no. 10 (2023): 1115, https://doi.org/10.3390/horticulturae9101115.

30. M. Tatsuki, Y. Sawamura, H. Yaegaki, Y. Suesada, and N. Nakajima, "The Storage Temperature Affects Flesh Firmness and Gene Expression Patterns of Cell Wall-Modifying Enzymes in Stony Hard Peaches," *Postharvest Biology and Technology* 181 (2021): 111658, https://doi.org/10.1016/j.postharvbio.2021.111658.

31. L. Sun, S. Liu, Z. Fan, et al., "The Impact of Storage Temperature on Fruit Quality and Chilling Injury of 'Okubao'peaches," *International Journal of Food and Bioscience* 1 (2018): 12–18.