2025 Southern Region Small Fruit Consortium Progress Report

Title

Assessing Fruit Quality and Shelf-Life Variability of New Strawberry Cultivars for Alabama

Public Abstract

Alabama's strawberry industry is growing rapidly, but most farms still rely on older cultivars that are disease-prone and have limited postharvest performance. This study evaluated ten newer strawberry cultivars from Florida and California breeding programs to determine how well they maintain quality during storage when cultivated under Alabama conditions. Plants were grown at the E.V. Smith Research Station (Tallassee, AL) and harvested weekly during peak production in April 2025. After harvest, fruit were stored at 4 °C and 85% relative humidity for 10 days, and measurements of firmness, sweetness (°Brix), acidity, and color were taken. Results showed clear differences among cultivars and storage time. Percent weight loss increased over time for all cultivars, with 'Felicity' and 'Royal Royce' having the lowest while 'Pearl-109' and 'Golden Gate' were highest. 'Victor' and 'Mojo' maintained the highest firmness, while 'Mojo' also had the highest sweetness. Fruit acidity and pH were variable during storage in all cultivars with 'Felicity' having highest acidity at harvest. 'Felecity' also maintained optimal colorimeter values and visual appeal throughout storage. These findings identified 'Mojo', 'Felicity' and 'Victor' with strong potential for good shelf-life and consumer appeal, supporting Alabama growers in diversifying beyond older varieties.

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Objectives

The goal of this study was to assess the postharvest shelf-life and quality composition of established strawberry genotypes not typically grown in Alabama production systems. The specific objectives are:

> **Objective 1:** Assess tissue firmness, composition (pH, soluble solids and titratable acidity) and phytonutrient content through 10 days of postharvest storage on 10 strawberry cultivars grown in central Alabama.
>
> **Objective 2:** Provide outreach/extension activities to inform Alabama growers of the differences in postharvest quality among the strawberry cultivars

Justification and Description

Strawberries are a major U.S. fruit crop, valued at $3.42 billion in 2021, with production expanding in

Alabama (USDA NASS, 2022 accessed on 10-08-2024). Over the past decade, Alabama has seen a 40% increase in strawberry farms, yet growers rely heavily on the aging cultivar 'Camarosa,' which is disease-prone despite good shelf-life. Thus, new cultivars with improved disease resistance and postharvest quality are urgently needed (Seijo et al. 2008; Guan et al. 2023).

Strawberries provide essential nutrients and antioxidants (Van De Velde et al. 2013), but have a short shelf-life typically ranging between 7–10 days under cold storage. Fuit quality declines rapidly due to tissue softening and the onset of physiological disorders (Piston et al. 2021). Firmness and acidity at harvest strongly influence storage life, yet consumer preference emphasizes sweetness and flavor. Data on how new cultivars from University of California Davis and Crown Nursery (Florida) perform under central Alabama conditions, particularly regarding shelf-life and postharvest quality, are limited.

This project addressed these gaps by evaluating ten new cultivars from Florida and California breeding programs under Alabama conditions. Fruit shelf-life, compositional traits, and phytonutrient content were assayed to identify cultivars that maintain quality and meet consumer expectations. Results will guide growers in selecting cultivars that reduce postharvest losses and improve consumer acceptance.

Materials and Methods

Plant material and strawberry production. A total of ten cultivars were selected from Dr. Sushan Ru's strawberry breeding program. Five cultivars from the University of Florida (Crown Nursery) and five from the University of California Davis (UCD) breeding programs were chosen based on known harvest traits and are reported in **Table 1**. 'Victor' and 'Royal Royce' were considered the control, which had comparable performance with 'Camarosa' in the 2023-2024 season. Fruit were grown at the E.V. Smith Research Center (Tallassee, AL, 32°29'48.7"N, 85°53'33.8"W) under an open bed conventional operation. The production was set up as a randomized complete block design with 3 replications (blocks). Experimental plots were 9 m long with 1.5 m alleys between the plots. Strawberry plants were planted as staggered rows (30 cm within the row) resulting in a total of 20 plants/plot in late October 2024 (Vinson et al. 2021).

Fruit was hand harvested once a week from 1 April to 29 April 2025. A minimum of **two harvests** were collected on each cultivar. Fruit was harvested into labeled clamshells, then immediately sorted in the field to remove diseased/decayed fruit. After harvest fruit were transported to the postharvest laboratory in Funchess Hall, (Auburn University, AL) and further sorted to remove unripe or bruised fruit. The postharvest experiment was set up as a randomized complete block design with 3 replications (blocks). Fruit was stored at 4 °C, 85% relative humidity for 10 days in vented clamshells.

Postharvest and shelf-life measurements. Non-destructive postharvest evaluations began on harvest day (day 0, 0d) and continued every 3 days for a total of four postharvest timepoints (0d, 3d, 6d and 9d). Clamshells were weighed at each postharvest timepoint to calculate the percentage of weight loss (%weight loss) during storage. Then, color was recorded on a minimum of 5 fruit/clamshell. Color was taken using a CM-600 Konica Minolta Colorimeter to analyze L*, a*, b*, c* and hue angle in CIELAB units. Color data was taken on the perpendicular side to the stem end of each berry and reported as an average across each replication and cultivar.

Destructive evaluations of fruit firmness, general composition and phytonutrient extractions were also completed. In short, 3 strawberries per cultivar, block and timepoint (~12 fruit per cultivar/timepoint) were analyzed for firmness using a TA.XT Texture Analyzer equipped with a flat probe. After firmness, fruit were cut in half and placed into 50 mL conical tubes then frozen at -20 °C until all firmness and non-destructive data was obtained. Once all non-destructive data was collected, fruit samples were ground via Geno/Grinder and general compositional data was taken. In short, to take soluble solids content (SSC) a square cut cheese cloth (approx. 4 cm^2) was placed onto the ATAGO refractometer set for strawberry. Using a 5 mL plastic pipette, homogenized samples were dispensed onto the cheese cloth and strawberry juice was squeezed onto the lens. Following SSC, samples were diluted 0.5g strawberry puree to 24.5 mL di-water for titratable acidity (TAcid). The diluted sample was gently poured on the ATAGO meter for the TAcid reading. Finally, pH was taken using a Thermo Scientific pH meter equipped with a Ross Ultra Triode (product no. 263745-001, Thermo Scientific Orion, Waltham, MA). After pH, samples were then re-capped stored at -20 °C for total phytonutrient assays.

Phytonutrient analysis. Homoginized samples were thawed and the pre-weighed (~ 300 mg) into labeled 5 mL test tubes. All samples were extracted with acidified methanol and assayed for total phenolics, total anthocyanin and total antioxidant activity. *Critical note: total phytonutrient assays are currently ongoing in the postharvest laboratory thus data is not being reported.

Data analysis. All data were analyzed using JMP 19.0.0 (SAS Intitute, Cary, NC). A Three-Way ANOVA was used to model the independent effects of harvest date, cultivar and storage timepoint. All interactions were analyzed including the three-way and two-way interactions. Dependent variables for the model include percent weight loss (%weight loss), fruit firmness (N), colorimeter values (L*, a*, b*, c* and hue angle), SSC, TAcid and pH. Replication was treated as a random variable. A report on the overall statistical significance of each model can be found in **Table 2**. All data excluding the phytonutrient assays are final.

Results

No significance was found in the three-way interaction or two-way interactions of harvest date*cultivar and harvest date*storage timepoint. Significant interactions were found only on cultivar*storage timepoint for %weight loss, TAcid and pH.

Percent weight loss (%weight loss) differed by harvest date and was lowest on fruit from the first harvest (2.3%) compared to all other harvests (3.9%) (**Fig. 1a**). The interaction of cultivar*storage timepoint indicated %weight loss increased in all cultivars as storage progressed and was highest in ‘Pearl-109’ and ‘Golden Gate’ at 10.5% and 8.6%, respectively (**Fig. 1b**). Fruit firmness (N) was highest in the second (13.1) and third harvest (10.2) but significantly decreased by 2.3 N as storage progressed (**Fig. 2a, b**). ‘Victor’ and ‘Mojo’ had the highest firmness at 12.3 and 11.92 N compared to all other cultivars (**Fig. 2c**).

Colorimeter values of L*, a*, b*, c* and hue angle differed by harvest date with all variables highest on the first harvest (**Table 3**). Storage days differed and indicated fruit from d9 had the lowest a* (21.1), b* (8.9) and hue angle (22.2) (**Table 3**). Cultivar differences were found and indicated lightness (L*), blueness (b*), and color tone (hue angle) was highest in ‘Pearl-109’ at 52.0, 18.9, and 48.0, respectively. Conversely, ‘Fronteras’ was lowest in L* (30.7) but ‘Golden Gate’ was lowest in b* (7.0) and hue angle (18.5), respectively. Redness (a*) and saturation (c*) were highest in 'Victor' (26.6 and 29.3) followed by and 'Felicity' (25.7 and 27.3), respectively (**Table 4**).

Soluble solids content (°Brix) differed by harvest date and was highest on the third harvest at 8.8 °Brix compared to the other harvests (**Fig. 3a**). Cultivar differences were also evident and indicated 'Mojo' (9.9 °Brix) was highest followed by 'Warrior' (8.6 °Brix), while 'Victor' and 'Valiant' were lowest (6.9 and 7.1 °Brix) (**Fig. 3b**). TAcid differed by harvest date and was highest on the second and third harvest at 0.59 and 0.55%, respectively (**Fig. 4a**). TAcid and pH indicated significant interaction of cultivar*storage timepoint. TAcid was highest in 'Felicity' on d0 at 0.78% but was highly variable throughout the cultivars and storage timepoints (**Fig. 4b**). Fruit pH was highest in 'Pearl-109' on d0 and d3 at 3.95 and 3.93 (pH not being reported).

Discussion

The absence of significant three-way and most two-way interactions suggests that harvest date, cultivar, and storage time largely influenced fruit quality independently, with limited combined effects. However, the significant cultivar*storage timepoint interaction for %weight loss, TAcid, and pH highlights that postharvest responses are cultivar-specific and dynamic during storage.

Weight loss increased progressively across storage for all cultivars, with 'Pearl-109' and 'Golden Gate' exhibiting the greatest losses, indicating high susceptibility to dehydration and decay (Peng et al. 2017). Firmness declined during storage across all cultivars which is consistent with other postharvest reports (Peng et al. 2017; Zhang et al. 2022). However, cultivars that maintain higher firmness (e.g., 'Victor' and 'Mojo') likely have lower enzyme activity, better structural integrity and potential for extended shelf-life (Zhang et al. 2022).

Color attributes in this study were strongly influenced by harvest date, with fruit from the first harvest showing superior lightness and hue values. Similarly, Geisseler et al. (2016) reported early-season strawberries exhibited better visual quality, a trend linked to cooler temperatures and optimal light conditions during the early growing season. As storage progressed, all strawberry cultivars indicated reduced redness and hue angle suggesting color quality degraded over time. Enzymes such as polyphenol oxidase and fruit respiration continue during cold storage and gradually break down pigments leading to reduced visual quality (Peng et al. 2017). Cultivar differences in color values, particularly the high lightness in 'Pearl-109' and intense redness in 'Victor' are likely due to genetic variability in visual quality traits (Schwieterman et al. 2014). Intense redness and blueness among some of the cultivars may also be related to enhanced/increased anthocyanin content in the tissue (Howard et al. 2014).

Soluble solids content (sweetness) and titratable acidity varied by harvest date, with later-season fruit generally exhibiting higher values. This is commonly attributed to physiological and environmental factors such as prolonged sunlight exposure, warmer temperatures, and increased abiotic stress during the latter part of the season (Sánchez-Gómez et al., 2022). The cultivar*storage interaction for TAcid and pH suggests that acid balance during storage is not uniform across cultivars; for example, 'Felicity' maintained high initial acidity, while 'Pearl-109' exhibited higher pH early in storage, potentially influencing perceived sweetness and flavor stability (Patel et al. 2023).

Outreach activities. Planned outreach activities for 2025 were limited due to the principal investigator's maternity leave, which coincided with scheduled field days and workshops. To ensure stakeholders receive timely information, research findings will be presented at two conferences in early 2026, and results will be shared directly with growers during the May Chilton County Strawberry Field Day. These efforts will fulfill the outreach objective and strengthen knowledge transfer to Alabama producers.

Conclusions

This study demonstrated significant variability in postharvest performance among the ten strawberry cultivars evaluated under Alabama growing conditions. All cultivars exhibited progressive %weight loss and loss of firmness during cold storage. Soluble solids content and titratable acidity varied widely among cultivars. Color stability also declined over time, with hue angle and saturation decreasing significantly by day nine of storage. Finally, harvest timing influenced quality, as fruit from the first harvest had lower weight loss and better color retention compared to later harvests. Collectively, these findings highlight cultivar selection and harvest timing are critical factors for optimizing postharvest shelf-life and quality in Alabama strawberry production systems.

Major Impacts

- **Grower Decision-Making:** This study provides Alabama growers with cultivar-specific postharvest performance data, enabling informed choices that reduce losses and improve profitability.
- **Diversification Beyond 'Camarosa':** Identifying cultivars such as 'Victor' and 'Mojo,' which exhibited high firmness and reduced weight loss during storage, indicates strong potential for superior quality and extended shelf-life.
- **Consumer Satisfaction:** cultivars with higher SSC, moderate TAcid and better color retention (e.g., 'Mojo' and 'Felicity') align with consumer preferences for sweetness and visual appeal.
- **Regional Adaptation Insights**: Results highlighted how Florida and California genotypes behave under Alabama conditions. This postharvest data paired with Dr. Sushan Ru's production data can support the adoption of new genotypes that are well-suited to Alabama growing conditions.
- **Future Work**: Narrowing the selection to a smaller set of promising strawberry genotypes and conducting consumer or trained sensory panels at harvest will provide deeper insights into flavor, texture, and overall acceptance.

Budget 2025-2026

Supplies (solvents, chemicals, materials and mineral analysis)	$1500
Labor for sample preparation/extraction and data summary	$2200
Undergraduate support: 10 weeks * 10 hrs* $10 = $1000	
TES support: 8 weeks * 7.1 hrs * $18 = $1022	
TES Fringe (17.3%) = $178	
Outreach materials (posters and pamphlets):	$200
Travel to collect strawberry samples:	$250
Travel to Growers' meetings:	$850
Total Direct Cost:	**$5,000**
Total Indirect Cost:	**$0**

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Table 1. Selected cultivars for postharvest study with their breeding programs and trait attributes.

Cultivar	Breeding Program	Trait Attributes
Royal Royce	Crown Nursery (FL)	High yielder, decent flavor (control)
Victor	Crown Nursery (FL)	High yielder & high sweetness (control)
Fronteras	Crown Nursery (FL)	Large & attractive fruit, low flavor
Felicity	Crown Nursery (FL)	High yielder, great quality
Pearl 109	Crown Nursery (FL)	White fruit, firm, moderate shelf-life
Valiant	UC Davis (CA)	Early season, high yielder, excellent flavor
Warrior	UC Davis (CA)	High disease resistance, attractive fruit
Mojo	UC Davis (CA)	Firm, sweet & large fruit
Warrior	UC Davis (CA)	Firm, long shelf-life
Keystone	UC Davis (CA)	High disease resistance, moderate flavor

Table 2. Statistical results on the postharvest strawberry trial reporting significance on the independent variables and their interactions.

	Dependent Variables									
Independent Variables	%Weight loss	SSC	TAcid	pH	L*	a*	b*	c*	Hue Angle	Firmness
Harvest date	**	**	**	*	**	**	**	**	**	**
Cultivar (CV)	**	**	**	**	**	**	**	**	**	**
Timepoint	**	NS	**	*	**	**	**	**	**	**
Replication	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Harvest*CV*Timepoint	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Harvest*CV	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Harvest*Timepoint	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV*Timepoint	**	NS	**	**	**	NS	NS	NS	NS	NS

Table 3. Colorimeter values (CIELAB units) differed by harvest date and storage timepoint in the 10 strawberry cultivars.

Harvest Date	Harvest Number	L*	a*	b*	C*	Hue angle
4/01/2025	1	36.3a	25.0a	12.0a	27.9a	24.7a
4/15/2025	2	34.3b	21.3b	8.8b	23.2b	21.7b
4/22/2025	3	34.2b	22.6b	10.3b	25.4b	24.2a
4/29/2025	4	34.7b	22.7b	10.3b	25.4b	23.5ab
Storage Timepoint		**L***	**a***	**b***	**C***	**Hue angle**
d0	-	35.7a	23.5a	10.6ab	26.1a	23.5b
d3	-	34.5ab	22.5a	10.2b	25.1a	23.6ab
d6	-	33.0b	23.9a	11.2a	26.8a	24.5a
d9	-	34.2ab	21.1b	8.9c	23.2b	22.2c

Colorimeter values are reported as averages across the replications and cultivars. Means were separated by Student's T Test. d0 = harvest, day 0; d3 = day 3, d6 = day 6; d9 = ay 9.

Table 4. Colorimeter values (CIELAB units) differed among the strawberry cultivars from all harvests and storage timepoints.

Cultivar	L*	a*	b*	C*	Hue angle
Felicity	33.3bc	25.2b	10.1c	27.3b	21.3cd
Fronteras	30.7d	21.5de	8.7ef	23.3de	20.9de
Golden Gate	31.3cd	20.3e	7.0g	21.5e	18.5f
Keystone	33.5bc	22.4d	9.2de	24.3d	21.8cd
Mojo	32.8bc	21.6d	7.7fg	23.0d	18.9ef
Pearl-109	52.0a	17.3f	18.9a	26.5b	48.0a
Royal Royce	32.5bc	23.7c	9.8c	25.7c	21.7cd
Valiant	32.9bc	24.3bc	10.5c	26.6bc	22.5bc
Victor	34.1b	26.6a	12.1b	29.3a	23.7b
Warrior	33.6b	22.3d	8.9ef	24.1d	20.9de

Colorimeter values are reported as averages across the replications, harvest dates and storage timepoints. Means were separated by Student's T Test.

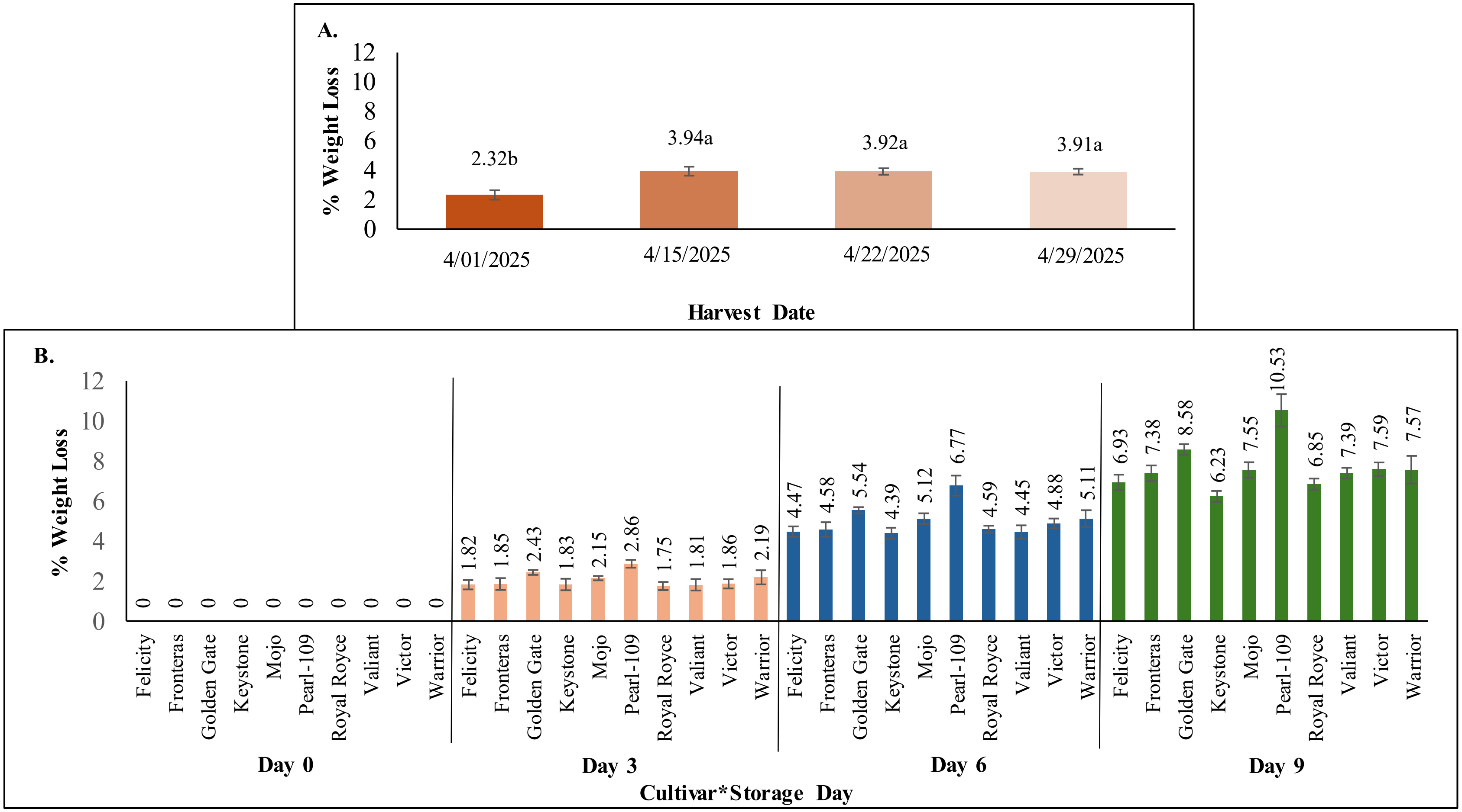

Figure 1. The percentage of weight loss (% weight loss) differed by harvest date (**a**) and the interaction of cultivar*storage day (**b**). The significance was determined using Students T-Test ($p \leq 0.05$); different letters indicate significant differences.

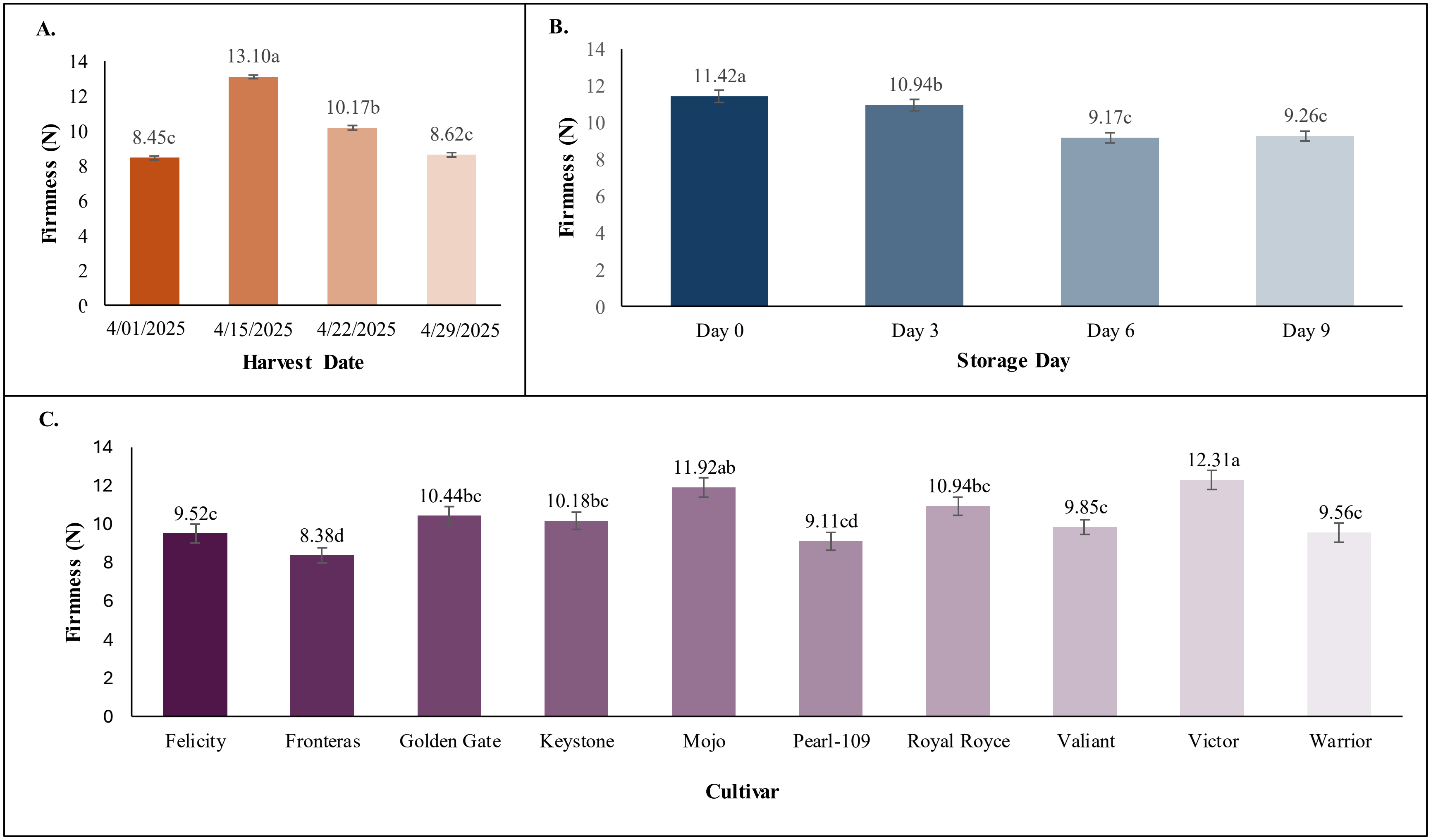

Figure 2. Tissue firmness (N) differed by harvest date (**a**) storage day (**b**) and cultivar (**c**). The significance was determined using Students T-Test ($p \leq 0.05$); different letters indicate significant differences.

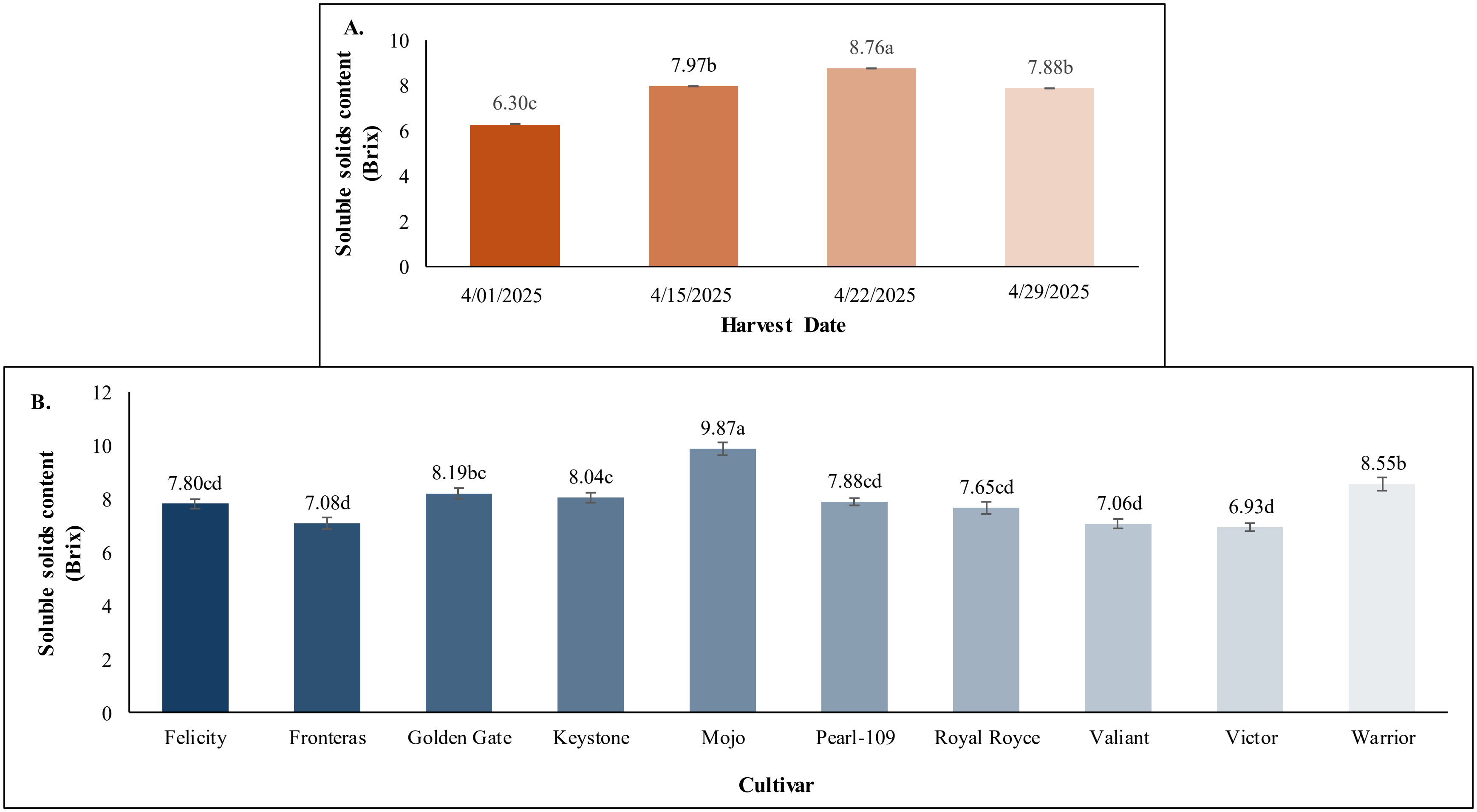

Figure 3. Soluble solids content (Brix) differed by harvest date (**a**) and cultivar (**b**). The significance was determined using Students T-Test ($p \leq 0.05$); different letters indicate significant differences.

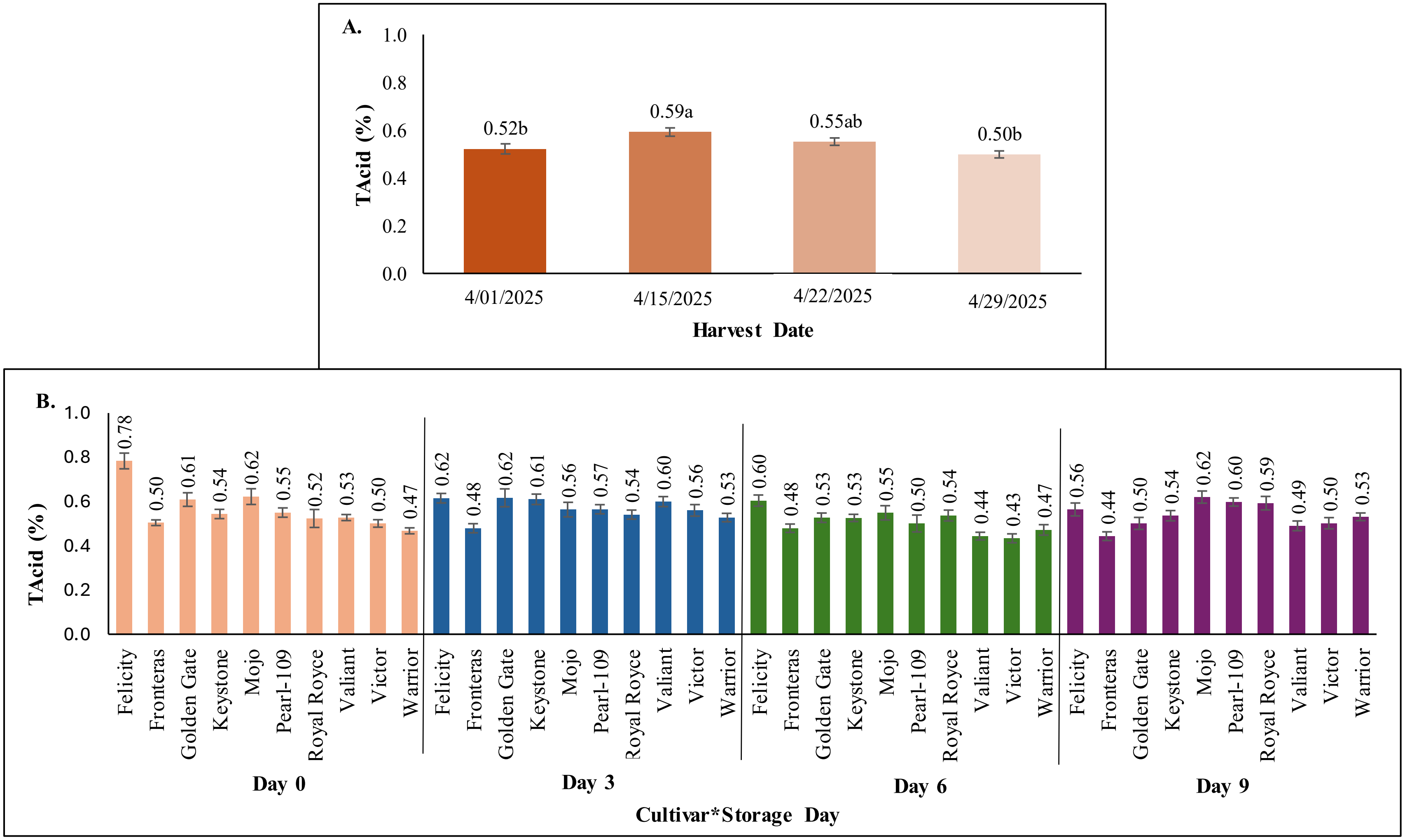

Figure 4. Titratable acidity (TAcid) differed by harvest date (**a**) and the interaction of cultivar*storage day (**b**). The significance was determined using Students T-Test ($p \leq 0.05$); different letters indicate significant differences.