Behavior of cherry varieties in northwestern Chihuahua, Mexico

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ABSTRACT

Objective: To evaluate the yield performance and fruit quality of various cherry cultivars (*Prunus avium* L.) cultivated in northwestern Chihuahua, Mexico.

Methodology: Four cherry cultivars 'Benton', 'Brooks', 'Lapins', and 'Sweetheart' were assessed using a randomized complete block design, with nine trees per cultivar. Key fruit quality parameters, including fruit weight, size, color, soluble solids content, titratable acidity, juice density, and trunk cross-sectional area productivity, were systematically evaluated.

Results: Among the cultivars, 'Lapins' exhibited the most favorable fruit quality attributes, whereas 'Brooks' demonstrated the highest productivity, yielding 34.35% more than 'Lapins'.

Conclusions: Cherry cultivation in Chihuahua proves to be viable, with 'Brooks' emerging as the most productive cultivar and 'Lapins' distinguished by superior fruit quality. These findings support targeted cultivar selection strategies aimed at optimizing both fruit quality and yield performance.

Keywords: *Prunus avium* L., cherry, fruit quality, yield, Chihuahua.

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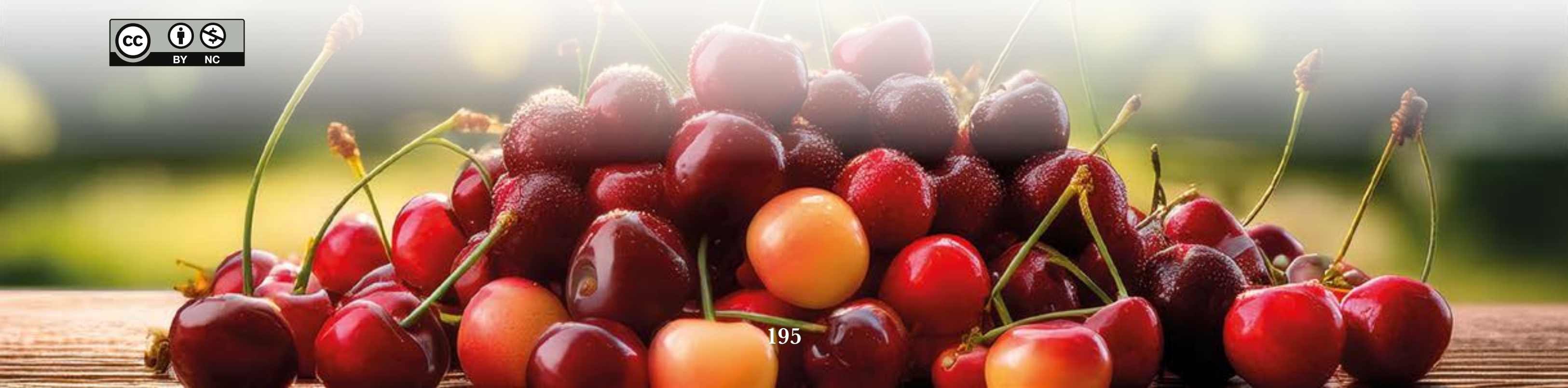
INTRODUCTION

The sweet cherry (*Prunus avium* L.) is one of the most popular temperate-climate fruits, highly valued by consumers for its flavor, vibrant color, sweetness, and its notable nutritional and bioactive properties. It belongs to the genus *Prunus* within the Rosaceae family, which comprises hundreds of species distributed across temperate regions worldwide (McCune *et al.*, 2011). Cherry trees are commercially cultivated in over 40 countries, spanning much of Europe, North Africa, the Middle East, Southern Australia, New Zealand, and the temperate zones of the American continent (Chadha, 2003; Bastos *et al.*, 2015). In 2023, global cherry production reached a total of 2,963,780.9 tons (FAO, 2023). In Mexico, cherry production for the same year amounted to 129.76 tons, with the state of Chihuahua emerging as the leading national producer, contributing 91.06 tons (SIAP, 2023). There is a growing consumer trend favoring cherry cultivars with diverse flavors and organoleptic properties, prompting an urgent need to cultivate a wider variety of cherries with distinct



characteristics (Szpadzik *et al.*, 2022). In terms of sensory quality, key attributes include skin color, sweetness, acidity, firmness, and fruit weight (Papapetros *et al.*, 2018). Beyond intrinsic fruit traits, growers also aim to extend harvest periods by cultivating cultivars with staggered maturation times. In response to consumer demand for flavor diversity, it becomes essential to produce and evaluate a broader range of cultivars (Antognoni *et al.*, 2020). Selecting cultivars that are well-adapted to specific regional conditions is critical to enhancing fruit quality, as ecological factors play a significant role in determining fruit attributes (Ateş & Öztürk, 2022). Therefore, identifying and cultivating regionally suitable varieties is a necessary step toward improving production outcomes. Accordingly, the aim of this study was to evaluate the yield and fruit quality of different cherry cultivars cultivated in northwestern Chihuahua.

MATERIALS AND METHODS

Plant material

The experimental orchard is located at Field 2B in the municipality of Cuauhtémoc, Chihuahua, Mexico (latitude 28.482° N, longitude 106.971° W, elevation 2,060 masl). The soil is classified as strongly sandy loam, with a pH of 7.49, electrical conductivity of 0.23 mmhos/cm, and organic matter content of 0.42%. The cultivars evaluated in the experiment were 'Benton', 'Brooks', and 'Lapins' grafted onto 'Colt' rootstock, and 'Sweetheart' grafted onto 'Gisela 12'. The orchard covers an area of 1,000 m^2, arranged in a square 4×4 m planting design, with trees established in 2013. Agronomic management included the application of liquid worm humus, calcium carbonate, calcium sulfate, seaweed extracts, silica, zeolite, magnesium sulfate, zinc sulfate, and iron sulfate.

Experimental design and treatments

A randomized complete block design was employed with nine replications (trees) and four treatments corresponding to the cultivars: 'Benton', 'Lapins', 'Brooks', and 'Sweetheart'. Harvesting took place on May 25, 2022. From each replication, 40 fruits were collected and divided into four subsamples of 10 fruits each.

Fruit weight and diameter

Individual fruit weight (FW) was measured using a digital scale with a 5 kg capacity and ±0.1 g precision. Fruit size was determined by measuring both equatorial (ED) and polar diameter (PD) using a vernier caliper (±0.01 cm precision), measuring the widest points on each axis.

Fruit color

Five fruits from each 10-fruit subsample were selected for color measurement. Opposing sides of each fruit were assessed using a chroma meter (CR-300, Minolta, Japan), which reports color in terms of L*, a*, and b* values. Chroma (C*) was calculated using the formula: $C^* = \left(a^2 + b^2\right)^{1/2}$ (Correia *et al.*, 2019).

Fruit firmness

Pulp firmness (FF) was measured on the same five fruits used for color evaluation. Skin was removed from two opposite equatorial zones, where color was intermediate. A handheld penetrometer (WILSON Fruit Tester FT 327, 0-29 lbs/in^2 capacity, 6 mm plunger) was used, inserting the probe to its marked depth. Two readings per fruit were taken (one per side) and averaged.

Juice density and volume

Juice density (JD) was calculated from the weight and juice volume of five fruits, extracted using a Turmix TUO5 (USA). Density was expressed in g/mL by dividing fruit mass by juice volume. Juice volume (JV) was measured using a 50 mL graduated cylinder.

Total soluble solids (TSS)

TSS was determined from the juice of the same five fruits using a handheld refractometer with automatic temperature compensation (model PN#90681, 0-32 °Brix scale). Approximately 0.5 mL of juice was applied to the refractometer surface, and readings were taken immediately (Zhang & Whiting, 2011).

Titratable acidity (TA)

Titratable acidity, expressed as percentage of malic acid (%MA), was determined by titrating 10 mL of juice with 0.1 N NaOH after adding six drops of phenolphthalein indicator (prepared by dissolving 0.5 g phenolphthalein in 70 mL ethanol and diluting to 100 mL with distilled water). Titration was performed until a wine-red endpoint appeared. TA was calculated using the formula: $\left(\left((0.1 \times \text{mL})/10\right) \times 67\right)/10$ (Torres-Beltrán *et al.*, 2023).

Sugar-to-acid ratio

The sugar-to-acid ratio (TSS/TA) was determined by dividing total soluble solids by titratable acidity, expressed as parts of sugar per part of acid (Flores *et al.*, 2018).

Grams per trunk cross-sectional area (TCSA)

Trunk cross-sectional area (TCSA) was calculated by measuring trunk circumference 30 cm above the graft union and applying the formula: $TCSA = \left(C^2\right)/(4\pi)$, where C represents trunk circumference (Barrios *et al.*, 2017).

Statistical analysis

All data were subjected to analysis of variance (ANOVA) according to the proposed experimental design. Mean comparisons were conducted using the least significant difference (LSD) test at $p \leq 0.05$, with statistical analyses performed using SAS version 9.0 (SAS, 1989).

RESULTS AND DISCUSSION

The results obtained from the experiment are presented in Table 1, detailing the data by treatment and cultivar for each evaluated fruit quality variable.

Table 1. Cherry yield and quality parameters by variety.

Treatment	**ED mm**	**PD mm**	**FW g**	**C***	**FF lb/in^2**	**JD g/ml**	**J ml**	**TSS °Brix**	**TA %AM**	**TSS/TA °Brix/%AM**	**GTCSA g**
Benton	24.18ab	20.84b	7.41b	19.73b	2.56b	2.22ab	20.94a	19.02a	1.05b	18.46a	28.48a
Lapins	26.11a	22.80a	9.27a	23.87a	3.36a	2.18ab	21.6a	17.94a	1.37a	13.47b	10.82b
Brooks	23.43b	20.30b	7.15b	18.81b	2.67b	2.01b	21.04a	18.68a	1.04b	17.96a	34.35a
Sweetheart	20.03b	20.37b	6.87b	20.38ab	2.17c	2.48a	18.13a	19.26a	1.09b	18.31a	15.23b
DMS	2.11	1.58	1.33	4.04	0.37	0.43	4.11	2.54	0.21	3.54	8.60
CV	8.95	7.71	17.74	20.00	14.26	19.84	20.56	13.89	19.45	21.25	39.61
μ	24.19	21.08	7.68	20.70	2.69	2.22	20.44	18.73	1.14	17.05	22.22

Different letters between treatments denote significant differences (LSD, $p<0.05$).

RESULTS AND DISCUSSION

Fruit diameter and weight

For fruit diameter and weight, the highest values were recorded in the 'Lapins' cultivar, with an equatorial diameter of 26.11 mm, followed by 'Benton' at 24.18 mm, which exhibited a direct interaction with 'Lapins'. In contrast, 'Brooks' (23.43 mm) and 'Sweetheart' (20.03 mm) differed significantly from 'Lapins'. Regarding fruit weight, 'Lapins' displayed the greatest weight at 9.27 g, which was significantly higher than the other cultivars. Previous cherry studies indicate that fruit diameter and weight depend on the specific cultivar characteristics (Zhang & Whiting, 2011), which may justify the observed differences in diameter and weight across cultivars. In one study of various cherry cultivars, diameters ranged from 22.4 to 25.8 mm with weights between 5.9 and 9.2 g (Corneanu *et al.*, 2020), results similar to those obtained in this study.

Color

In terms of color, 'Lapins' achieved the highest chroma (C*) value of 23.87, representing a 21.2 % difference compared with the least-colored cultivar, 'Brooks', which showed a C* value of 18.81. Values of C* reported for cultivar 'Van' are about 19.89, akin to a dark-red coloration, and thus 'Lapins' tended toward a more intense mahogany-red hue (Vursavuş *et al.*, 2006). Fruit color is the most commonly used harvest index, and generally correlates with an increase in soluble solids content; however, overall fruit quality depends on the cultivar (Yommi *et al.*, 2012). The colour of fresh and processed cherries is influenced primarily by the concentration and distribution of different anthocyanins in the skin, as well as by pH, phenolic compounds levels and types, and other factors such as light, temperature, and oxygen (Gonçalves *et al.*, 2007).

Firmness

Regarding fruit firmness, 'Lapins' was highest with 3.36 lb/in^2, followed by 'Benton' and 'Brooks', which did not differ significantly from each other, while 'Sweetheart' showed the lowest firmness at 2.17 lb/in^2. These results indicate differences in maturity status of the fruits as well as inherent cultivar characteristics (Choi *et al.*, 2002). In a study conducted in Poland on various cherry cultivars, firmness values ranged between 1.2 and 1.9 lb/

in^2 (6.2-8.7 N) (Szpadzik *et al.*, 2019), values which are lower than those obtained in the present work.

Juice density and volume

Juice density reveals particular characteristics of the fruits: a lower density implies less pulp content and therefore a higher juice proportion. No significant differences were observed between 'Benton' and 'Lapins', while 'Brooks' exhibited the lowest density, although without significant difference in juice volume. 'Sweetheart' had the highest density an 18.91% increase compared to 'Brooks' and the least juice volume; yet again, differences were not statistically significant. This parameter refers to the grams of fruit utilized to obtain one milliliter of juice; for example, 'Sweetheart' required 2.48 g of fruit to produce 1 mL of juice (Torres-Beltrán *et al.*, 2023).

Total soluble solids (TSS)

Although no significant differences in sugar content (TSS) were detected among cultivars, 'Sweetheart' recorded the highest sugar content, with a minimal margin over the others —indicating advanced maturity, since TSS is directly related to maturity degree. In a study in Italy among different cherry cultivars, TSS values ranged from 13 to 20 °Brix (Di Matteo *et al.*, 2017); the values obtained here lie within those parameters. Sugars also play a key role in cherry quality, since they balance with acidity to contribute to their characteristic flavour (Girard & Kopp, 1998).

Titratable acidity (TA)

For TA, 'Lapins' exhibited the highest organic acid content at 1.37% (malic acid equivalent), significantly different from the other cultivars. Reported values for 'Lapins' range between 0.72 and 0.97% at harvest (Wani *et al.*, 2014), much lower than the results here even compared to 'Brooks', which had TA of 1.04%. According to Bernalte *et al.* (2003), TA also depends on cultivar, with levels between 0.4 and 1.5% of organic acids. The predominant organic acid in cherries is malic acid (≈80%), followed by shikimic, fumaric and citric acids (Usenik *et al.*, 2015). In addition, TSS and TA are closely related to cherry flavour intensity, and consumer acceptance increases with high TSS and TA levels (Wani *et al.*, 2014).

Sugar-to-acid ratio (TSS/TA)

For the TSS/TA ratio, 'Lapins' presented the best sugar-acid balance with a value of 13.47, while 'Benton' recorded 18.46, suggesting it was the most mature cultivar. In an acid cherry study, TSS/TA ratios ranged from 5.63 to 19.54 (Najafzadeh *et al.*, 2014), parameters similar to ours despite the cultivars in our study being sweet cherries. This ratio is related to sweetness perception, acidity, or cherry flavour (Wani *et al.*, 2014), and is a predominant parameter for consumer acceptance (Usenik *et al.*, 2015). Moreover, studies in 'Golden Delicious' apple indicate that a proper sugar–acid ratio is due to decreasing malic acid concentration during maturation, making it a valuable indicator of maturity degree (Flores *et al.*, 2018).

Grams per trunk cross-sectional area (GTCSA)

Regarding grams of fruit per trunk cross-sectional area, 'Brooks' achieved the highest value at 34.35 g, showing a direct interaction with 'Benton' at 28.48 g, whereas 'Lapins' and 'Sweetheart' registered the lowest productions at 10.82 g and 15.23 g respectively; they did not differ significantly from each other but did differ from the other two cultivars. According to Webster *et al.* (2006), low fruit yields may be influenced by climatic conditions such as low light levels and reduced temperature during flowering and fruit set, resulting in fruit abscission.

CONCLUSIONS

This study provides valuable information concerning the adaptation of cherries to the state of Chihuahua, as well as the attributes and qualities that these cultivars can offer when grown in the northwestern region of Mexico. In this experiment, the fruits of the 'Lapins' cultivar exhibited the best organoleptic qualities but the lowest fruit yield. The highest coloration was associated with larger fruits, a greater proportion of pulp, and a lower sugar-to-acid ratio attributes that are critical for fruit quality, thereby providing higher nutrient content and better consumer acceptance. In terms of production, the 'Brooks' cultivar achieved 34.35% greater productivity compared to 'Lapins'. These studies should be complemented by analyses of bioactive compounds, since phytochemicals impart flavour and the unique characteristics of each cultivar.

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