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ORGANOLEPTIC AND QUALITY ASSESSMENT IN THREE BLACK CHERRY TOMATO VARIETIES

EVALUACIÓN ORGANOLÉPTICA Y DE CALIDAD EN TRES VARIEDADES DE TOMATE CHERRY NEGRO

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Resumen

Se determinaron las características morfológicas de la planta, los parámetros de calidad físico-químicos y la evaluación organoléptica en tres variedades de tomate cherry negro. Ni la altura de la planta ni el número de racimos por planta indican diferencias en el comportamiento vegetal de las tres variedades. La variedad kumato sobresalió en los parámetros de calidad físico-químicos. Por lo demás, la variedad indigo cherry drops se destacó en los parámetros de calidad química. La variedad indigo cherry drops tiene la preferencia de los jueces no calificados en la combinación de los atributos sensoriales: Aspecto Visual, Tacto y Gusto. Estos resultados sugirieron que la percepción sensorial y las características físico-químicas aumentaron las posibilidades de comercialización de los tomates cherry negros, así como desarrollar un producto comercial que satisfaga las necesidades y demandas de los consumidores y así promover el consumo de tomates cherry negro de calidad.

Palabras clave: °Brix, acidez titulable, Kumato, Indigo Cherry Drops, Indigo Rose

Abstract

The morphological characteristics of the plant, physico-chemical quality parameters, and organoleptic evaluation were determined in three varieties of black cherry tomatoes. Neither the plant height nor the number of clusters per plant indicate differences in the vegetative behavior of the three varieties. The Kumato variety stood out in physico-chemical quality parameters. Furthermore, the Indigo Cherry Drops variety excelled in chemical quality parameters. The Indigo Cherry Drops variety is preferred by untrained judges in the combination of sensory attributes: Visual Appearance, Touch, and Taste. These results suggest that sensory perception and physico-chemical characteristics enhance the marketing possibilities of black cherry tomatoes. Additionally, developing a commercial product that meets the needs and demands of consumers could promote the consumption of high-quality black cherry tomatoes.

Keywords: °Brix, titratable acidity, Kumato, Indigo Cherry Drops, Indigo Rose.

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Introduction

Tomato is the most produced and consumed agricultural product in the world; its global production has increased recently at a rate of 35% per year [1]. Another factor that renders it an essential vegetable is its minerals and antioxidants content. Since many non-contagious chronic-degenerative diseases are associated with smoking, sedentary lifestyles and stressful working days, these nutrients are essential in health protection [2], [3], [4].

Tomato demand has increased in recent years, which positions it as the most valuable vegetable in the world [5]. This easily grown crop and its varieties have become a popular alternative worldwide [6]. Cherry tomato varieties have opened up opportunities in Mexico due to their agronomic attributes such as climate adaptability, physical characteristics, environmental stress resistance, and profitability [7], [8].

Popularity of cherry tomatoes is a result of their aroma, flavor, texture, and color. However, they also contain organic acids, like citric and malic acid, mixed with sugars like glucose and fructose [9]. Further, the aroma is developed by around 400 organic compounds; some of these are precursors of fatty acids, aminoacids, and other phenolic compounds that also contribute to flavor [10]. Besides, there is a wide range of colors and shapes depending on the variety, like red, green, yellow-orange, white, pink, stripped, bi-color, or black tomatoes [11].

Standard tomato quality is indicated by its nutraceutical and organoleptic properties, such as appearance (color, shape, size and integrity) firmness, texture, and taste [12]. An "attractive color" in this sense means bright and uniform, which implies that the product is free from

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oxidation or improper cooling, among other negative factors [13]. On the other hand, the total soluble solids content (TSS) relates to cell composition and structure. Cherry tomato TSS is mainly composed of sugars and constitutes between 4.5-8.5% of the fruit. Determined during the production stage, this parameter is an essential indicator in the tomato industry. TSS is usually measured by the refractometry method, and is expressed as equivalent Brix degrees (or % TSS). Finally, titratable acidity is a flavor-related index influenced by malic and citric acids, which account for around 15% of the dry content of fresh ripe tomatoes [14]. Moreover, organic acids regulate juice pH, which must be below 4.5 to prevent the growth of thermophilic microorganisms in tomatoes [15].

TSS and pH are closely related parameters in establishing the ripeness and postharvest quality of tomatoes. Tomato chemical structure varies along the maturation process, resulting in texture changes, as well as pigmentation, brightness and flavor [16]. In this context, sensory characteristics —mainly color, texture and flavor— are key for acceptability and quality; that is, purchase decision depends greatly on such factors. However, research on new products has found that sensory evaluation of food quality and origin significantly affects the price [17].

Specifically, black cherry tomatoes have recently been released on the market and are rather unknown to consumers and, because of their color, they have an exotic and rare appearance. Said pigmentation and other unique physical attributes are due to a specific mix of antioxidants [11]. These compounds are relevant to agro-industry given their potential for the prevention of non-contagious chronic-degenerative diseases [4], [18], [19].

At the moment of purchase attributes evaluation, a well-lighted countertop is required. People who apply the evaluation do not have to communicate with each other. Evaluators can measure many samples for purchase attributes because fatigue is usually not the leading factor as it is for consumption attributes. It is important to avoid superimposing the coding of samples for purchase and consumption, nor the results, because the purchase attributes are not solid predictors of consumption attributes [20]. The aim of this study was to measure the plant morphological characteristics, physical-chemical quality parameters, and to predict consumers' organoleptic assessment of kumato, indigo cherry drops and indigo rose cherry tomato varieties; finally, to establish typical quality parameters of black cherry tomato marketing possibilities.

Materials and methods

Plant material and growth conditions

The black cherry tomato varieties selected for the study were kumato, indigo cherry drops, and indigo rose. 50 plants per variety were grown in a 30 m^2 chapel-type greenhouse. The experiment was conducted during fall-winter 2019 in the Amazcala campus of the Autonomous University of Querétaro, located in El Marqués, Querétaro, Mexico. Seedlings were transplanted to the greenhouse 28 days after sowing (DAS); and flowers started sprouting 60 DAS. In each phenological stage, the nutrient solution was adjusted according to the nutritional requirements of the plant. The temperature registered in-greenhouse ranged from 16 to 32 °C, and the average relative humidity was 65%. The samples consisted of randomly selected tomatoes from the third harvest at 120 DAS.

Morphological characteristics of the plant

Per-variety average morphological characteristics of the plant were recorded upon harvest: plant height (tape-measured from base to tip of the shoot), number of clusters and frequency of disease signs (although this parameter depends on the crop scheme). Plant growth and flowering changes, flower size, fruit shape, and fruit set were obtained from the data sheet and reported in this document for future reference [5], [11], [20].

Physical-chemical quality measurements

The surface appreciation stage required 20 fruits from each variety; the physical test was carried out on the same sample, and the organoleptic stage evaluated 50 fruits from each variety. The black cherry tomatoes weight was reported in [21]. Equatorial and longitudinal diameters were measured with a digital Vernier caliper in millimeters separately [22]. The sample was divided into four replicates, five tomatoes each. The external color determination was carried out under the Munsell system using a colorimeter (Model-CR-10, Konica Minolta, Japan) on a harvest day; hue (H), value (V) and chroma (C) were measured [23].

Afterwards, the cherry tomatoes were liquefied into a homogeneous sample of the fruit for the quality analysis. An aliquot of the mix was placed on the portable refractometer prism (HI 96811; Hanna Instruments, Woonsocket, RI, USA) at room temperature to determine TSS. Results were reported in °Brix [24], [25]. Regarding acidity, a potentiometer was implemented into the puree; findings appear in pH [26]. All varieties total titratable acidities (TA) were determined according to [23] with modifications (TA expressed in milliliters of sodium hydroxide, NaOH). The juice was titrated against a 0.1 N NaOH standard, using phenolphthalein as an indicator [23].

Organoleptic assessment

The surveys were conducted on a sample of 50 tomato-untrained judges (52% women, 48% men). The study was carried out at the Autonomous University of Querétaro (UAQ) in Querétaro, Mexico in February 2020 in a specially designed area. The judges were briefed through the informed consent document that: tomatoes did not contain residues of any agrochemical product, nor were they genetically modified, nor underwent any process that would put human health at risk. Each judge evaluated three similarly sized cherry tomatoes, one from each variety. Judges were unfamiliar with black cherry tomatoes and their taste, so that they were not biased toward any of the varieties [17]. Three different organoleptic characteristics (visual, touch, and taste) were included in the evaluation scheme and were expressed on a scale of 0 to 100. This score evaluates the liking of the judge for each attribute (0 = unacceptable, and 100 = acceptable).

Appearance: judges rated their liking for the combination of brightness, color and visible integrity.

Touch: judges graded their liking for texture and firmness.

Taste: aroma and flavor of the fruit.

Statistical analysis

Statistical comparisons for plant height, number of clusters/plant, weight (g), width (mm), length (mm), hue (H), value (V), chroma (C), TA (°Brix), acidity (pH), aliquot volume (ml), and 0.1 n NaOH solution volume (ml) were performed with a one-way ANOVA. Later, with Tukey's honest significant

difference test using Statgraphics (Statgraphics Technologies, Inc., VA, USA) was applied to compare mean values. Besides, sensory data were analyzed using Statgraphics (Statgraphics Technologies, Inc., VA, USA) via the Kruskal-Wallis test, $p < 0.05$.

Results and discussion

Plant morphological characteristics

No significant difference was found between plant height and number of clusters per plant, nor between growth and flowering rates. Figure 1 shows each tomato variety in the cluster before and after harvest. The views of the clusters correspond to kumato (Figure 1.A), indigo cherry drops (1.B) and indigo rose (1.C) varieties, respectively. Kumato was the tallest plant at 183 cm. Table 1 evidences all the results of the morphological characteristics. For reference, [27] reported a 163.2 cm tall wild cherry tomato plant, a relatively low height attributed to its sylvan condition; on the opposite end, Treatment 1 in [28] registered a taller unspecified variety than the three varieties studied in this work, with 195.75 cm. The results resembled those in [29] for seven lines of wild cherry tomatoes, where the tallest specimen (JCPRV-43) reached 228.1 cm; and the shortest (JCPRV-76), 143.1 cm. The seven heterogeneous results were ascribed to the wild condition of their genomes.

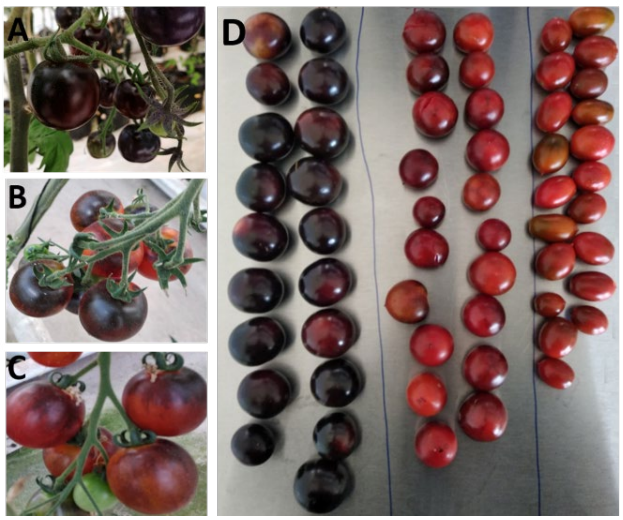

FIGURE 1.

Photos A, B and C correspond to the kumato, indigo cherry drops, and indigo rose clusters, respectively. D shows the scores of each variety tested for surface color and physical measurements; the quick trend by size proportion among tomatoes continued in the following measurement steps.

Table 1.

Results of physical-chemical quality measurements in fruit of three varieties of black cherry tomato. Letters in superscript indicate a statistical difference using the Tukey test ($p < 0.05$).

Other cultivar varieties share a similar rate, like the one reported by [28] with 8.63, or the one measured by [30] with 11.42. However, this number varies greatly; for instance, [31] achieved 40.8, and [27] reached 77.02 in wild cherry tomatoes, but fruit size was close to half the dimensions reported in this work.

Parameters	Indigo rose	Indigo cherry drops	Kumato
Plant height	1.74 ± 0.26[a]	1.80 ± 0.14[a]	1.83 ± 0.13[a]
*Number of clusters/*plant	6.90 ± 2.33[a]	8.00 ± 1.89[a]	7.00 ± 0.94[a]
Plant growth rate	Indeterminate	Indeterminate	Indeterminate
Flowering type	Indeterminate	Indeterminate	Indeterminate
Flower size	Small	Small	Small
Fruit shape	Oblong	Spherical	Spherical
Fruit setting type	Chronological	Chronological	Chronological
Disease incidence	Low	Low	Low

Physical-chemical quality measurements

Kumato topped the results of fruit physical dimensions. For average weight, kumato presented 29.64 g (those found by [22], which reported 74.03 g), followed by 20.3 g for the indigo cherry drops variety and indigo rose at 10.41 g. In parallel, [32] ranked 73.86, 69.24 and 62.09 g in the KM8367, KM8034 and KM1210 kumato cultivar lines, respectively. However, these two reports are unclear on whether they worked with cherry or heirloom varieties. Different research in black cherry tomatoes, or unspecified cherry tomatoes, present weights close to the indigo rose or indigo cherry drop varieties reported in this work. The highest value obtained by [11] in black cherry tomatoes was 9.8 g. Besides, the result in black cherry tomatoes for [33] had 12.84 g in the L-ChNg1 variety. In addition, the result for varieties H13-29 and H13-31 were 9.48 and 9.72 g, respectively. [27] found that wild and cultivar tomato varieties represented 4.55 and 92.98 g, respectively.

Significant variation was recorded for fruit equatorial diameter (ED) among cherry tomato lines. During this and the other physical test, the toma-

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toes were aligned to facilitate direct comparison (Figure 1.D). Maximum ED was found in kumato with 38.71 mm, and the minimum was found in indigo rose with 23.91 mm (Table 2). The results by [22] for kumato variety were at 45.1 mm. The results by [32] for KM8367, KM8034 and KM1210 cultivar lines of kumato are 73.86, 69.24 and 62.0 mm, respectively. The highest value reported results by [11] in work with unspecified black cherry tomato variety was 9.8 mm. Besides, in a wild cherry tomato variety reported by [27] the ED was 17.05 mm.

TABLE 2.

Results of physical chemical quality measurements in fruit of three varieties of black cherry tomato. Letters in superscript indicate a statistical difference using the Tukey test ($p < 0.05$).

PARAMETERS	INDIGO ROSE	INDIGO CHERRY DROPS	KUMATO
Weight (g)	10.41 ± 0.54^{c}	20.30 ± 1.95^{b}	29.64 ± 1.55^{a}
Equatorial diameter (mm)	23.91 ± 0.72^{c}	30.91 ± 0.07^{b}	38.71 ± 0.54^{a}
Longitudinal diameter (mm)	30.34 ± 4.21^{b}	31.15 ± 1.32^{b}	35.31 ± 0.56^{a}
Hue (H)	7.83 ± 0.23^{a}	9.20 ± 0.40^{a}	8.47 ± 0.32^{a}
Value (V)	5.47 ± 0.23^{a}	6.40 ± 0.26^{a}	4.17 ± 0.25^{b}
Chroma (C)	9.27 ± 0.25^{a}	4.73 ± 0.31^{b}	4.07 ± 0.31^{b}
Fruit Photography			
°Brix	3.93 ± 0.36^{c}	7.33 ± 0.24^{a}	6.03 ± 0.63^{b}
pH	5.30 ± 0.08^{a}	4.88 ± 0.10^{a}	5.08 ± 0.10^{a}
Titratable Acidity (%)	5.23 ± 0.17^{a}	5.18 ± 0.17^{a}	5.03 ± 0.05^{a}
mL NaOH (0.1 N)	2.57 ± 0.12^{b}	6.95 ± 0.29^{a}	4.40 ± 0.14^{a}

Longitudinal Diameter (LD) also showed significant differences. Maximum LD was observed in kumato at 35.31 mm; minimum LD corresponds to indigo rose 30.34 mm (Table 2). The value reported by [22] in Kumato variety is 50.3 mm. In turn, the three cultivar lines of kumato by [32] measured 44.8, 46.2 and 38.1 mm. The highest value obtained by [11] in an unspecified black cherry tomato variety was 41.75 mm. The values reported by [27] for the wild cherry tomato are 15.25 mm. The indigo cherry drops variety tops the total titratable acidity measured with NaOH but was impossible to compare to other black cherry tomato or unidentified cherry tomato varieties.

Surface color results were different among the three varieties (Table 2); the highest H value appeared in indigo cherry drops, with 9.2 on average. The top results in H value by [9] were for brown cherry and brown beefsteak varieties: 67.47 and 66.1, respectively. In the H13-29, H13-31 and

black cherry tomato varieties, [33] obtained values of 49.87, 49.58 and 47.76, respectively. Results by [10] in black cherry, black cherry primabella and black cherry roterno varieties were 57.13, 78.34 and 68.68, respectively. Referencing C values, indigo rose was the variety top measure with 9.27. The C value for brown cherry and brown beefsteak varieties by [9] were 22.06 and 21.5, separately. Aside, the values in cherry tomatoes and black cherry tomatoes by [33] for H13-29, H13-31, and L-ChgNg1 were 36.38, 31.26 and 30.18, respectively. The values obtained by [32] in kumato cultivar lines were KM8367 at 15.82, KM8034 at 19.39, and KM1210 at 18.34. Regarding the V value, the indigo cherry drops variety was located on average at 6.4; the values obtained for indigo rose and kumato varieties are in Table 2. The values of the colorimetry of the black cherry tomatoes in the present document were impossible to compare with other cherry tomato varieties of any other color.

The highest TSS measured in this work was the indigo cherry drops variety with 7.33 °Brix; the second and third scores are in Table 2. [34] ranked 5.8 °Brix for the red cherry variety, 5.4 °Brix for yellow cherry, and 4.7 for Kumato. The most significant value in the report by [11] for black cherry tomato was 3.64 °Brix. Furthermore, values by [33] were 7.03 °Brix for the H13-29 variety, 8.14 °Brix for H13-31, and 7.4 °Brix for L-ChNg1. Indigo rose measured by [35] was 4.2 °Brix. Meanwhile, kumato values by [22] were 5.29 °Brix. The value obtained by [10] for black cherry, black cherry primabella, and black cherry roterno varieties was 7.28, 6.9 and 5.65 °Brix, respectively. In the research by [27] on wild cherry tomato and tomato cultivar varieties, the values obtained were 6.59 and 4.95 °Brix, separately. The high TSS results of the black cherry tomatoes relate to the synthesized products in their biochemical pathway [36]. Since tomatoes produce an important amount of phenolic compounds, this is consistent with the values shown in the present investigation.

Table 2 depicts pH values obtained for the three varieties of black cherry tomatoes. Indigo rose stood out with a 5.3 average. The pH value reported by [35] for indigo rose was close to the reported in this work, at 4.1. In [34], the pH measure of the Kumato variety was slightly lower than the ranked in this document, at 4.31, and their measures for yellow cherry and red cherry varieties were even closer, at 4.41 and 4.46, respectively; however, maturity stage of the black cherry tomatoes was undis-

closed. It is important to remember that pH measurement indicates the accumulation of organic compounds synthesized inside the fruits [36].

Regarding titratable acidity, indigo cherry drops led the study with an average of 6.95%. Indigo rose and Kumato results are shown in Table 2. The work by [35] on indigo rose found 0.6%. Values obtained by [34] in red cherry, yellow cherry and Kumato were 1.07, 1.47 and 0.94%. respectively. Kumato result in [22] was only 0.34%. In [9], brown cherry was 0.29%. and brown beefsteak was 0.03%. Furthermore, [33] reported values for H13-29, H13-31 and L-chgNg1 varieties of 0.52, 0.53 and 0.35%, respectively. [10] measured black cherry at 0.5%, black cherry primabella at 0.49%. and black cherry roterno at 0.33%. Concerning the report by [27], wild cherry tomato value was 0.71%. and tomato cultivar was 0.55%.

Organoleptic assessment

Table 3 shows the sensory evaluation results after the panel test for the three black cherry tomato cultivars. First, it should be noted that variety color was not determinant of perception (Table 3); consequently, the data were reported only in relation to the studied species. In terms of visual aspect, indigo cherry drops rated the highest, followed by kumato. In contrast, indigo rose reached low values. With regards to touch, indigo cherry drops showed the best performance and, to a lesser extent, indigo rose. Black cherry tomato taste was judged excellent for indigo cherry drops with almost maximum range value.

Table 3.

Results of organoleptic testing. Using Kruskal-Wallis ($P < 0.05$). Different superscripts denote statistical difference.

Characteristics	Indigo cherry drops	Indigo rose	Kumato
Visual aspect	78.2 ± 5.7^{a}	66.1 ± 5.3^{a}	74.8 ± 5.1^{a}
Touch	82.9 ± 4.1^{a}	69.2 ± 5.3^{b}	72.8 ± 5.3^{ab}
Taste	83.2 ± 5.8^{a}	72.8 ± 5.3^{a}	73.1 ± 5.4^{a}

The studied black cherry tomatoes showed similarly high taste ratings. Therefore, although the prevailing gastronomic role of the fruit is to provide chromatic attractiveness to dishes, they can also confer a peculiar taste and improve palatability. The preference for black varieties resulted from the combination of visual aspect, touch and taste. On the

other hand, indigo cherry drops, which excelled in the sensory analysis (Table 3), also did for touch. Finally, kumato touch properties could be a middle-ground, resembling both indigo cherry drops and indigo rose.

Conclusion

Morphological characteristics, physical-chemical quality measurements, and organoleptic assessment of black cherry tomatoes were significantly correlated to the cherry tomato variety. Morphology showed that the three varieties could be managed/produced similarly while maintaining physical-chemical quality. Variations between them came from their genetic characteristics. Moreover, sensory evaluation indicated a preference for indigo cherry drops by the unqualified judges in the three organoleptic characteristics (visual, touch, and taste). Nevertheless, visual aspect and taste did not present significant differences among all three varieties. Further analysis of the shelf-life test could be interesting in order to evaluate expanding the reach of these black cherry tomatoes. These results highlight the importance of the physical-chemical and sensorial evaluations to increase these tomato cherry varieties marketing possibilities; in this case, to develop a commercial product that will satisfy the needs and demands of the consumers and thus promote the black cherry tomatoes consumption.

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