Investigation note

Physicochemical characterization of Tinguaraque fruits (*Solanum lycopersicum* var. Cerasiforme) grown in greenhouse

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Abstract

The Tinguaraque (*Solanum lycopersicum* var. cerasiforme), wild fruit similar to the tomato, grows in oak forests, disturbed areas and cultivated land. Its easy development in different conditions, together with a tart flavor and its small size, make this fruit a more attractive product than the commercial tomato. This work physicochemically characterized fruits of Tinguaraque and compared the response with Cherry tomato, both in greenhouse, as a first step for its improvement and incorporation in the human diet. In August and September of 2017, wild Tinguaraque (JT) plants were collected to obtain seeds, which were germinated together with Cherry tomato seeds (JC) in a greenhouse. Among the parameters evaluated were plant growth pattern, weight and production of mature fruits, for the physicochemical analysis the AOAC methodology was followed registering flavor, energy intake, ethereal extract, crude protein, moisture, dry matter and ash, among others. The information was analyzed through Anova and the differences were obtained by the Tukey test at $\alpha= 0.05$. The sweetness was observed in the JT cultivar in greenhouse compared to JC (13.4 ±0.5 and 7.6 ±0.8 °Brix respectively) and was slightly higher in pH than in JC (4.3 ±0.1 and 4.1 ±0.1 respectively). Likewise, JT compared to JC recorded similar values in terms of protein (17.5 ±2.2 and 16.6 ±0.6%, respectively) and energy content (5.1 ±0.4 and 4.9^{B} ±0.1 kcal g^{-1} MS, respectively). These attributes of quality can position the Tinguaraque as a fruit with potential for improvement and immediate commercialization.

Keywords: plant rescue, protected crop, solanaceae, wild tomato.

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The Tinguaraque (*Solanum lycopersicum* var. Cerasiforme) is a wild fruit of pleasant flavor, with a size of 1 to 2.5 cm, similar to tomato. It is distributed in temperate and transitional zones, associating with oak forests and acts as a pioneer in disturbed areas from the United States to Central America (Álvarez-Hernández *et al*., 2009). In Mexico it develops in the western and southeastern part. This fruit has been temporarily collected for fresh consumption, sauces, salads and regional stews and is sometimes collected for sale and provide additional income (Martínez-De-La-Cruz, 2015).

The studies carried out in the use of this plant have been directed mainly to understand their defense mechanisms to confer them to commercial materials. Álvarez-Hernández (2013), reported that the Tinguaraque plant can be used as a commercial tomato rootstock thanks to its adaptive capacity and resistance to soil pathogens (*Alternaria solani* and *Fusarium* sp.), and even confer tolerance to pests such as paratrioza (*Bactericera cockerelli*) and whiteflies (*Bemicia* spp., *Trialeurodes* spp. and *Aleurothrixus* spp.).

Regarding nutritional quality, the works are scarce, mentioning Crisanto-Juárez *et al*. (2010) that the Tinguaraque under fertigation presents high values of acidity, lycopene and vitamin C. In this sense, more information is needed on an adequate management of the fruit crop for its use and generate biotechnological strategies that can be applied to the plant for its improvement (Camarena-Mayta *et al*., 2014). Therefore, the objective of this work was to characterize the physicochemical response of the Tinguaraque fruits (*Solanum lycopersicum* var. cerasiforme) and to compare with the response of the commercial Cherry tomato, both grown in greenhouse.

During the months of August and September wild plants of Tinguaraque (*Solanum lycopersicum* var. Cerasiforme) with fruit were collected in the municipality of Parácuaro, Michoacán (19° 10’ 00’’ north latitude 102° 12’ 00’’ west longitude) and their identity was confirmed in INECOL, in Patzcuaro, Michoacán (reference number 254838). Once the materials were collected they were transferred to the Laboratory of Bromatology of the Faculty of Agrobiology ‘Presidente Juárez’ of the Michoacan University of San Nicolás de Hidalgo, where the seeds of Tinguaraque (JT) were obtained and together with seeds of Tomato Cherry (JC) were germinated in a greenhouse of the Institution.

After their emergence, the JT and JC plants were subjected to the same agronomic management for comparison, according to the recommendations of Lesur (2006) and Tjalling-Holwerda (2006). For this, vertical trellis was implemented, omitting pruning work. The irrigation was 1 L day^{-1} plant^{-1} during the ramification stage and in the flowering period and productive phase was 1.5 L and 1.9 L day^{-1} plant^{-1}. The fertilization used was: 275N-100 P_2O_5-500 K_2O-150 CaO-100 MgO-75 S. The variables evaluated were pattern of plant growth, weight and production of fruits plant^{-1} as well as weight and size of seeds fruit^{-1}.

The ripe fruits harvested during five months were used for the analysis of flavor, juiciness, energy intake and physicochemical properties such as texture, volume, total soluble solids, pH, titratable acidity, ether extract (EE), crude protein (PC), humidity (H), dry matter (MS) and ash, all determinations were made in quadruplicate. The analyzes were performed by AOAC (2012) methods for fresh fruits, while the energy contribution was estimated using a calorimeter (Parr Instrument®) with static jacket and manual oxygen pump.

The methodology was carried out according to what was recommended by the manufacturer, recording the initial and subsequent temperature every 30 s until reaching 5 min (ignition time), after that the temperature was recorded every 20 s until it reached 15 min. To determine the external color of the fruit, a portable colorimeter (Lovibond^{R}) was used, with which the parameters L*, a*, b*, c* and h* were obtained. The results were calculated with the hue angle °Hue, with some modifications to what was reported by De-Paula-Olivera (2016).

The information collected was analyzed; through the Anova methodology and the differences between the tomato materials (JT and JC) were obtained by the Tukey test at α= 0.05. For the statistical analysis, the statistical package SAS 9.1 was used.

The results showed that, when developed in an optimal and controlled environment, in general the JT growth pattern did not show significant changes compared to its development outside the greenhouse, this coincides with that reported by Letschert and Frese (1993), who they worked with *Beta vulgaris* under controlled conditions and observed minimal changes in their growth pattern. However, in comparison to JC, differences were observed in fruit weight and yield of fruit production per plant, where JT produced less than half the registered JC weight of fruit^{-1} (Table 1).

Table 1. Comparison of the evaluated physical variables of plants, fruit and seeds.

Variable	Tinguaraque	Cherry
	Average	Average
Weight per fruit (g)	0.71^{A} ±0.7	3.17^{B} ±0.3
Equatorial diameter (mm)	10.1^{A} ±0.5	18.2^{B} ±0.1
Longitudinal diameter (mm)	10.9^{A} ±0.6	17.5^{B} ±0.3
Number of seed per fruit (units)	41.7^{A} ±7.5	71.5^{B} ±11.7
Seed weight (%)	6.7^{A} ±1.4	3.5^{B} ±0.3
Yield* (t ha^{-1})	34.7	74

±= standard deviation; *= calculated based on planting density and average plant production (kg of fruit plant^{-1}); $^{A, B}$= indicate differences (p< 0.05) between averages within row.

With the obtained values of weight per fruit and production per plant, a production of 34.7 and 74 t ha^{-1} cultivated with JT and JC, respectively, was estimated. Expected data for the significantly smaller size of JT (10.9 ±0.6 and 10.1 ±0.5 mm for the longitudinal and equatorial diameter, respectively compared to the size of the JC (17.5 ±0.3 and 18.2 ±0.1 mm for the longitudinal and equatorial diameter, respectively).

Although the number of seeds was statistically higher for JT (41.7 ±7.5) compared to JC (71.5 ±11.7), the size of JT (< 0.4 cm in length) is less noticeable than the seeds of the commercial material.

Regarding the proximal chemical composition of the Tinguaraque fruits, they presented higher values (p< 0.05) with respect to the mineral content (5.4 ±0.3% g^{-1} MS); likewise, the values of energy content (5.05 ±0.4 kcal g^{-1}) and protein content (17.5 ±2.2) were the same as those obtained in the JC (Table 2).

Table 2. Comparison of the proximal chemical composition of fruit according to the species.

Component	Tinguaraque	Cherry
	Average	Average
Humidity (%)	85.9^{A} ±0.6	89.5^{B} ±0.9
Dry material (%)	14.1^{A} ±0.6	10.5^{B} ±0.9
Ashes (%)	5.4^{A} ±0.3	4.5^{B} ±0.6
Ethereal extract (%)	7.4^{A} ±1.7	9.3^{A} ±0.8
Energetic content (kcal g^{-1} MS	5.1^{A} ±0.4	4.9^{A} ±0.1
Protein (%)	17.5^{A} ±2.2	16.6^{A} ±0.6

±= standard deviation; $^{A, B}$= indicate differences ($p< 0.05$) between averages within row.

Regarding the physicochemical analysis, the JT exceeded the JC values in soluble solids (°Brix), an indicator that, together with the low recorded acidity (0.01 Meq ac citric) and a pH of 4.3 ±0.1 of the JT, favored the taste organoleptically from this wild fruit to a pleasant sweetness (Table 3). In terms of percentage of juiciness, the Tinguaraque, when presenting the same statistical value as the Cherry tomato, adds another optimum attribute of quality.

Table 3. Comparison of the physicochemical characterizations of fruit according to the species.

Characteristic	Tinguaraque	Cherry
	Average	Average
Juiciness (%)	54.93^{A} ±8.2	43.6^{A} ±7.3
pH	4.3^{A} ±0.1	4.1^{B} ±0.1
Titratable acidity (meq acid citric)	0.01^{A} ±0	0.01^{A} ±0
Soluble solids (°Brix)	13.5^{A} ±0.6	8.9^{B} ±0.3
(%) pulp	40.1^{A} ±7.6	46.9^{A} ±8.2
Colour (°Hue)	52.8^{A} ±2.4	41^{B} ±2.2
Brightness (L^{*})	42.9^{A} ±0.6	36.6^{B} ±1.2
Texture (mm penetrated)	1.9^{A} ±0.1	1.2^{B} ±0.1

±= standard deviation; $^{A, B}$= indicate differences ($p< 0.05$) between averages within row.

According to the results obtained in this investigation, the Tinguaraque (wild species) is susceptible to improve its agronomic and physicochemical characteristics when established in the greenhouse. However, it takes hard work in the selection (yield: kg of fruit $plant^{-1}$ and fruit weight) and propagation of the best specimens, since the yield of this wild species (Table 1) is just 45.9 % with respect to the yield observed with the commercial species (Cherry tomato) and whose productive yield 80 t ha^{-1} was similar to that reported by Márquez-Quiroz *et al*. (2014).

Despite the low productive yield of Tinguaraque, the high values of soluble solids presented by the wild fruit, make it attractive to use for the elaboration of nectars, since the blackberry (*Rubus fructicosus* L.) with values of 10.5 ±0.2 °Brix it is useful for this purpose (Valencia-Sullca and Guevara-Pérez, 2013). Additionally, if the Tinguaraque was used in winemaking, it could have a probable alcohol yield of 7.5%, 2.5% less than that of grape vines (*Vitis vinifera*), but with the possibility of being applied (Sotomayor-Soler, 1984).

Regarding the JT percentage of juiciness, this is slightly higher than that of vegetables such as carrots (*Daucus carota*): 51.7 to 51.7% (Hoyos-Echevarria and Sancho-Barrio, 2002), which is a possible application in the industry of making juices. For the case of the MS of Tinguaraque, the observed value was similar to that reported for mature paprika peppers (*Capsicum annum*) var. Rokita^{R} (14.16%). Aspect that makes it feasible as an ingredient for dehydrated foods (Buczkowska and Łabuda, 2015).

An important finding within the physicochemical values of Tinguaraque was the high content of minerals (Table 1), since it was higher than that of many fruit such as blueberry (*Vaccinium corymbosum*) of which 0.2 g 100 g^{-1} are reported (Roe *et al*., 2013) and even higher than that of foods such as amaranth (*Amaranthus* spp.), of which 3% is reported (Peralta *et al*., 2011).

Within the color, the Tinguaraque in the greenhouse showed a greater luminosity than the Cherry tomato (Table 3) and the maximum reported for the fruit in a wild way (Crisanto-Juárez, 2010). Likewise, the reddish coloration (52.8 ±2.36 °Hue) was more attractive than that reported for mature saladdette type tomatoes (59.3 °Hue) by López-Camelo and Gómez (2004).

Due to the morphological characteristics of the Tinguaraque (fruit of small dimensions) the productive yield (kg of fruit per plant) under greenhouse, was very low compared to the yield of the Cherry fruit. However, it has physicochemical characteristics that surpass the commercial fruit: it contains more dry matter, it is juicier and richer in minerals. Attractive appearance for the cultivation and uses of this wild fruit. However, a strategy must be established for the Tinguaraque to be incorporated into the breeding programs.

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