PHYSICAL-CHEMICAL AND NUTRITIONAL CHARACTERIZATION OF *SOLANUM* SSP. ACCESSIONS

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ABSTRACT

Tomato is grown on a large scale in Brazilian agriculture and is one of the most important vegetables in the world, standing out for its commercial and nutritional properties. It is a crop with a relatively short cycle, high yields, and good economic prospects; due to this, the area cultivated with this horticultural crop has been increasing along with its economic importance. The physical, chemical, and nutritional characteristics of fruits from different tomato accessions grown under greenhouse conditions in Rio Paranaíba, MG, were evaluated in this experiment. Accessions BGH 985, 1490, 1258, 2001, 2089, PI 127826, and the cultivar 'Santa Clara' were evaluated. The experiment was conducted in a completely randomized design with seven treatments and six replications. Fruits were harvested, properly identified, and evaluated for the following characteristics: fruit firmness, number of locules, pH, soluble solids, titratable acidity, and ascorbic acid content. There was no statistical difference among tomato accessions for fruit firmness and ascorbic acid content. Regarding the number of locules, 'Santa Clara' and BGH 2089 were superior to the others; the highest pH values were observed in BGH 985 and BGH 1490; higher °Brix values were recorded in BGH 985 and PI 127826; meanwhile, titratable acidity was higher in BGH 1258. Thus, the accessions that stood out overall were 'Santa Clara', PI 127826, and BGH 2089, 985, 1490, and 1258. Accessions BGH 1258 and BGH 2089 exhibited general characteristics of fruits that can be consumed either fresh or destined for industrial processing.

KEYWORDS: *Solanum lycopersicum*, Nutritional quality, Postharvest, Physical-chemical characterization.

CARACTERIZAÇÃO FÍSICO-QUÍMICA E NUTRICIONAL DE ACESSOS DE *Solanum* SSP.

RESUMO

O tomate é cultivado em grande escala na agricultura brasileira e é uma das hortaliças mais importantes do mundo, se destacando por suas propriedades comerciais e nutricionais. A caracterização dessas propriedades relacionadas à qualidade nutricional é fundamental para identificação de possíveis acessos que poderão ser usados para processos de melhoramento genéticos. Objetivou-se avaliar as características físicas, químicas e nutricionais de frutos de diferentes acessos de tomateiro nas condições de casa de vegetação em Rio Paranaíba- MG. Foram avaliados os acessos BGHs 985, 1490, 1258, 2001, 2089, PI 127826 e 'Santa Clara'. O experimento foi conduzido em delineamento inteiramente casualizado com sete tratamentos e seis repetições. Os frutos foram colhidos, devidamente identificados e avaliados quanto às seguintes características: firmeza dos frutos, número de lóculos, pH, sólidos solúveis, acidez titulável e teores de ácido ascórbico. Não foi verificada diferença estatística entre os acessos de tomateiro quanto a firmeza dos frutos e o teor de ácido ascórbico. Quanto ao número de lóculos 'Santa Clara' e BGH 2089 mostraram-se maiores que os demais. BGH 985 e BGH 1490 apresentaram maior pH, já quanto a sólidos solúveis BGH 985 e PI 127826 apresentaram °Brix mais elevados e enquanto isso a acidez titulável foi maior no BGH 1258. Assim, os acessos que apresentaram maiores valores foram Santa Clara, PI 127826 e os BGHs 2089,985, 1490 e1258. Os acessos BGH 1258 e BGH 2089 apresentam características gerais próprias de frutos que podem ser consumidos tanto *in natura* quanto serem destinados para indústria.

PALAVRAS-CHAVE: *Solanum lycopersicum,* Qualidade nutricional, Pós-colheita, Caracterização fisíco-química.

INTRODUCTION

Tomato (Solanum lycopersicum) is cultivated on a large scale in Brazilian agriculture and is one of the most important vegetable crops worldwide, standing out for its commercial and nutritional properties, with global production exceeding 190 million tons in 2023 (FAO, 2023). Brazil ranks among the world's largest tomato producers, with a total planted area of 63.3 thousand hectares, production of 4.7 million tons, and productivity of approximately 74 tons per hectare. The major tomato-producing states are Goiás, São Paulo, and Minas Gerais, with productions of 1,587,303, 858,000, and 753,506 tons, respectively; together, they account for most of the national production (IBGE, 2025). Regarding the origin of cultivars in Brazil, most are derived from European and United States genetic material, and even traditionally Brazilian varieties originated from seeds brought by European immigrants. Furthermore, some wild materials are occasionally found (WANG *et al*., 2024).

Therefore, tomato cultivation has considerable importance in the Brazilian market and economy, being cultivated on a large scale. It is worth noting that tomato is a crop with a relatively short cycle, high yields, and good economic prospects. As a result, the cultivated area of this vegetable crop has increased along with its economic importance in both national and international markets, and it may be destined for fresh consumption or processing (IBGE, 2025).

The nutritional quality of tomatoes encompasses several attributes related to appearance, texture, flavor, and nutritional value. The fruits are mainly composed of water, soluble solids, volatile compounds, phenolics, organic acids, carotenoids, and vitamins C and E (YANG *et al.,* 2025). According to Zhang *et al.* (2023), consumer preference is determined by characteristics such as size, color, shape, pulp firmness, skin, and overall fruit appearance, which confer visual quality, whereas sensory quality is related to texture, aroma, and flavor.

Analyzing the physicochemical characteristics of the fruit is extremely important for its improvement and commercialization. Therefore, precise information regarding these characteristics has become increasingly necessary. The percentage of soluble solids measured in degrees Brix is one of the most important parameters for defining fruit quality, since it expresses sugar and acid contents and influences industrial yield. In contrast, total titratable acidity, represented by citric acid content, mainly influences fruit flavor (SANTOS *et al.,* 2024). Furthermore, characteristics such as pH, soluble solids, titratable acidity, and fruit firmness are important attributes for commercialization, as they determine flavor and postharvest shelf life (NASCIMENTO *et al.,* 2023).

The ascorbic acid content in tomatoes may vary from 0.09 to 0.16 mg g^{-1} (DZHOS *et al*., 2024). When compared with acerola, which ranges from 7.79 to 24.44 mg g^{-1} of pulp, this value is very low; therefore, the selection of tomato cultivars with higher ascorbic acid contents becomes necessary (FARINELLI *et al.,* 2021). Furthermore, the presence of ascorbic acid in meals increases iron absorption, even in the presence of foods containing inhibitory factors, through the formation of the iron-ascorbate chelate (BHOOT *et al.,* 2023).

Therefore, the objective of this study was to evaluate, among accessions from the Vegetable Germplasm Bank of the Federal University of Viçosa (BGH-UFV), tomato fruit firmness, number of locules, pH, soluble solids, titratable acidity, and finally determine the ascorbic acid contents.

MATERIAL AND METHODS

Experimental site and plant material

The experiment was conducted at the Federal University of Viçosa – Rio Paranaíba Campus (UFV-CRP), and the tomato accessions were obtained from the Vegetable Germplasm Bank of UFV (BGH-UFV), except for the commercial cultivar ‘Santa Clara’. Seven treatments were used: BGHs 985, 1490, 1258, 2001, 2089; ‘Santa Clara’; and PI127826 (wild cultivar). Seedlings were produced in the UFV-CRP seedling nursery. The accessions were sown in 128-cell trays filled with Carolina® commercial substrate and irrigated daily until they presented three fully expanded leaves, at which point seedlings were transplanted. Two seedlings per pot were transplanted into eight-liter pots containing Red-Yellow Latosol soil amended with 0.13 g of dolomitic limestone with a total relative neutralizing power (TRNP) of 85%. Plants were trained with a bamboo stake and vertically trellised using plastic twine, except for PI127826. Irrigation was performed daily, and fertilization consisted of 3.14 g of NPK 4-14-8 per pot applied in two applications, the first at transplanting and the second 30 days after transplanting. Disease management consisted of applying 10% milk for the control of powdery mildew (*Erysiphe diffusa*). After tomato fruiting, fruits were harvested and taken to the laboratory to evaluate the following characteristics: fruit firmness, number of locules, pH, soluble solids, titratable acidity, and ascorbic acid contents. The experimental design was completely randomized

with six replicates, except for titratable acidity and ascorbic acid content, for which only three replicates were performed.

Fruit characteristics

Fruit firmness

Fruit firmness was determined using a digital penetrometer (Soil Control: PDF-200) equipped with an 8 mm diameter probe. Measurements were performed without removing the skin, taking two readings per fruit on opposite sides of the equatorial region, with six replicates for each side. Results were expressed in Newtons (N) (COSTA *et al.,* 2025).

Number of locules

For the number of locules, after the fruit was harvested at its physiological maturity stage, six measurements were performed for each treatment (KUTZ *et al.,* 2023).

Pulp preparation

Ten fruits from each accession were collected at the physiological maturity stage, with uniform red coloration, except for PI127826, for which 12 fruits were harvested at the mature green stage. The fruits were homogenized using a blender (Mondial Premium) for 3 minutes. The pulp was then filtered through a fine-mesh tea strainer and stored in a beaker for subsequent analyses of pH, soluble solids, titratable acidity, and ascorbic acid content.

pH

The pH was determined using a calibrated digital potentiometer (Model Q400 AS), directly from the homogenized and sieved tomato pulp, with six replicates performed (AOAC, 1997).

Soluble solids (SS)

Soluble solids content was determined using a portable digital refractometer (Model 104-D) and expressed in degrees Brix (°Brix). Four drops of pulp were placed on the refractometer reading surface, which was adjusted to 26 °C and properly calibrated. Six replicates were performed for each treatment (AOAC, 1997).

Titratable acidity (TA)

For the determination of titratable acidity, 20 g of pulp were weighed and diluted in 50 mL of distilled water, and the solution was then divided into three 10 mL aliquots in an Erlenmeyer flask. This material was titrated with a standardized 0.05 M NaOH solution, using phenolphthalein as an indicator at pH 8.1. Results were expressed as percentage of citric acid using the formula below, with three replicates performed for each treatment (AOAC, 1997).

$$AT = \frac{VxNxE}{10xM}$$

Where: AT = titratable acidity (% citric acid); V = volume of NaOH solution used to reach pH 8.1 (mL); N = normality of the NaOH solution; E = equivalent weight of the predominant acid (64.02 g for citric acid); M = mass of the sample used (g).

Ascorbic acid (AA)

The ascorbic acid content was determined by direct titration using Tillmans' solution (2,6-dichlorophenolindophenol – DCPIP), properly standardized with ascorbic acid, according to the methodology described by Strohecker and Henning (1967). A 25 g sample of tomato pulp was diluted in 50 mL of 1% oxalic acid. The titration was carried out with the standardized Tillmans' solution using ascorbic acid as a standard until a persistent pink color was observed for 15 seconds. Results were expressed as mg of ascorbic acid per gram of tomato pulp, calculated using the formula shown below, with three replicates performed.

$$AA = \frac{n}{\frac{n'}{AA'} xM}$$

Where: AA = ascorbic acid content in mg g^{-1}; n = volume of Tillmans' solution used in the sample titration (mL); n' = volume of Tillmans' solution used in the standardization (mL); AA' = amount of ascorbic acid used in the standardization; M = mass of the sample (g) or sample volume used in the titration.

Statistical analysis

The obtained data were subjected to Cochran's test and Lilliefors test to verify homogeneity of variance and normality of errors, respectively. Subsequently, the data were submitted to analysis of variance (ANOVA), and means were compared using the Scott-Knott test at $p < 0.05$. The statistical software Speed Stat was used for all analyses.

RESULTS AND DISCUSSION

It was observed that there was no statistically significant difference in fruit firmness. These results are possibly due to the fact that the fruits were harvested at the same ripening stage. According to Costa *et al.* (2025), fruit firmness is strongly correlated with the content of pectic substances present in fruits and vegetables. These substances are the main chemical components of plant tissues and are responsible for changes in fruit and vegetable texture. As fruits ripen, pectic substances are degraded, which can be easily observed through pulp softening (WANG *et al.,* 2022). Thus, since the fruits were harvested at the same ripening stage, it is assumed that this is why firmness did not differ among the tested treatments.

Regarding the number of locules, differences were detected among the tested accessions. In this context, treatments BGH 2089 and 'Santa Clara' showed the highest number of locules, with mean values of 2.70 and 3.80, respectively (Table 1). Similar results for 'Santa Clara' (2.80) and BGH accessions 985 (1.90), 1490 (2.70), and 1258 (3.7) were reported by Marim *et al.* (2009), who characterized the genetic diversity of tomato accessions from the Vegetable Germplasm Bank of the Federal University of Viçosa (BGH-UFV), aiming to evaluate the relative importance of traits in determining this diversity. According to Nguyen *et al.* (2026), fruits with a higher number of locules consequently present larger size and weight. The number of locules is also related to firmness, which, according to Resende *et al.* (1999), is one of the most important attributes associated with fruit quality, both for fresh consumption and industrial processing, as it is a determining factor for storage period.

TABLE 1. Mean values of the evaluated characteristics in different tomato accessions and cultivars.

Treatment	Evaluated characteristics*			
	Number of locules	pH	°Brix	Titratable acidity
PI127826	2.00 b	1.20 c	5.00 a	0.08 b
'Santa Clara'	2.70 a	1.96 c	3.78 c	0.03 e
BGH 985	2.10 b	8.04 a	5.02 a	0.07 c
BGH 1490	2.00 b	7.13 a	3.95 b	0.05 d
BGH 1258	2.17 b	4.68 b	3.78 c	0.09 a
BGH 2001	2.00 b	5.70 b	4.05 b	0.04 e
BGH 2089	3.80 a	4.76 b	3.06 d	0.07 c

*Means followed by the same letter do not differ statistically according to the Scott-Knott test at 5% probability.

Regarding pH, the fruits of accessions PI127826 and 'Santa Clara' showed statistically lower values, 1.20 and 1.96, respectively, and may be considered acidic fruits (CHANG *et al.,* 2024). According to Borguini e Silva (2007), fruits most preferred by consumers are those with higher pH values, rather than more acidic ones. The accessions BGH 1258 (4.68) and BGH 2089 (4.76) showed similar pH values, close to those described by Guilherme *et al.* (2008) and Rodrigues *et al.* (2008), who characterized high-quality tomatoes as those with pH between 3.70 and 4.5; genotypes within this range are suitable for both industrial processing and fresh consumption. When the fruit is intended for processing, values above 4.50 require longer sterilization periods of the raw material (SINGH; RAMASWAMY, 2023). Thus, it can be observed that accessions BGH 2001 (5.70), BGH 1490 (7.13), and BGH 985 (8.04) would require longer sterilization periods if intended for industrial processing.

It was observed that the accessions BGH 985 (5.02) and PI127826 (5.00) showed higher total soluble solids content. Total soluble solids represent the percentage, by weight, of solids dissolved in the food. Thus, according to Zhang et al. (2023), total soluble solids content is one of the best indicators for assessing product sweetness, with fruits showing higher values being more preferred by consumers. The values obtained were higher than those reported by Tavares e Rodriguez-Amaya (1994), who found values between 3.80 and 4.60 °Brix in tomato fruits of the cultivar 'Santa Clara'.

For the titratable acidity variable, accession BGH 1258 (0.09% citric acid) was statistically higher than the others, followed by accession PI127826 (0.08% citric acid), which also showed markedly high values when compared to the remaining accessions (Table 1). However, these values are lower than those reported by Anthon and Barrett (2012), who studied 16 cultivars of S. lycopersicum in California (United States), in which values ranged from 0.30 to 0.90%. This is likely due to the fact that all fruits were harvested at the fully ripened stage.

According to Sampaio *et al.* (1998), total titratable acidity in tomato indicates the amount of organic acids and astringency, which significantly contribute to the nutritional quality of tomato fruits (ANTHON; BARRETT, 2012). Thus, the accessions with higher total titratable acidity values, BGH 1258 (0.09% citric acid) and PI127826 (0.08% citric acid), are those with higher levels of organic acids and astringency in

their composition. It should be noted that the amount of organic acids present in fruits varies according to fruit ripening and growth conditions (DOĞAN; ÜNLÜN, 2023).

It was observed that there were no significant differences among the accessions regarding ascorbic acid content. According to Cheng *et al.* (2023), oxidation and reduction reactions occur in ascorbic acid content during tomato ripening; the oxidation products consist of free radicals of the acid, which can be converted back into ascorbic acid, indicating a possible increase in this compound throughout fruit maturation. However, the absence of significant differences among accessions is likely due to the fact that the fruits used for the analyses were harvested at the same ripening stage; thus, no differences in ascorbic acid content would be expected.

CONCLUSIONS

Accessions BGH 1258 and BGH 2089 exhibit characteristics of fruits that can be consumed both fresh and used for industrial processing.

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