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ORIGINAL ARTICLE

Ripening dynamics of landrace tomato under different storage temperatures

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Abstract – Landrace, traditional or local varieties are of great importance in family farming, as they are genetical materials preserved across generations and promote biodiversity conservation. Post-harvest knowledge can reduce losses and help the farmers make informed decisions regarding the optimal point of sale. The aim of this work was to determine the storage time of seven landrace tomato accessions collected in the Rio Grande do Sul/Brazil. For this, physical and chemical quality parameters were measured under two storage conditions: ambient (25 ºC) and refrigerated (10 ºC), at 0, 7 and 14 days of storage, evaluating the pH, total soluble solids, titratable acidity, weight, pulp firmness and color. The experiment was carried out in a completely randomized design, and the means were compared using Tukey's test (5 %). Refrigeration helps maintain the pulp firmness and increased total soluble solids and titratable acidity, which, together with pH was better preserved under refrigerated storage. Under these conditions, after 14 days, fruits stored in refrigeration remained within acceptable commercial quality standards, whereas those kept at room temperature had already entered the senescence process. Landrace tomatoes can be stored for 14 days in a domestic refrigerator (10 °C) without significant losses in their physicochemical parameters.

Keywords: *Solanum lycopersicum* L. Seed guardians. Family farming. Sustainability.

Dinâmica da maturação de tomate crioulo armazenado em diferentes temperaturas

Resumo – Variedades de tomateiro crioulas, tradicionais ou locais, possuem grande importância na agricultura familiar, pois são materiais mantidos entre gerações promovendo a conservação da biodiversidade. O conhecimento do seu comportamento pós-colheita pode reduzir perdas e auxiliar o produtor na tomada de decisão quanto ao ponto de comercialização. O objetivo deste trabalho foi determinar o potencial de armazenamento de sete acessos de tomateiros crioulos, coletados no Rio Grande do Sul. Para isso, atributos físico-químicos de qualidade foram obtidos em dois sistemas de armazenamento: em ambiente (25 °C) e refrigerado (10 ºC), aos 0, 7 e 14 dias de armazenamento, analisando-se pH, teor total de sólidos solúveis, acidez total titulável, peso, firmeza da polpa e cor. O experimento foi conduzido no delineamento inteiramente casualizado, sendo as médias comparadas pelo teste de Tukey (5 %). A refrigeração influenciou significativamente a qualidade dos tomates mantendo a firmeza de polpa, aumentando os sólidos solúveis e a acidez titulável e reduzindo o pH. Nessas condições, aos 14 dias, os frutos apresentavam-se em condições de comercialização *in natura*, enquanto os frutos em temperatura ambiente já estavam em processo de senescência. Tomates crioulos podem ser armazenados por 14 dias, em refrigerador doméstico (10 ºC), sem perdas consideráveis de atributos físico-químicos.

Palavras-chave: *Solanum lycopersicum* L. Guardiões de sementes. Agricultura familiar. Sustentabilidade.

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Introduction

The tomato plant (*Solanum lycopersicum* L.), belonging to the family Solanaceae, order Tubiflorae, and genus *Solanum*, is one of the most widely cultivated vegetables in the world, with a global production exceeding 192 million tons in 2023 (FAO; Our World in Data, 2025). In Brazil, the cultivated area in 2023 was 59,010 ha, with a production of 4,166,017 tons (IBGE, 2025). Of this area, approximately 35 % was used to industrial tomato crops, while the remaining area was used for fresh-market tomato production (Machado, [2021]). The two largest tomato-producing states in Brazil are Goiás and São Paulo, whereas Rio Grande do Sul ranks tenth in national production (IBGE, 2024).

The tomato (*S. lycopersicum* L.) stands out among the species maintained by "Seed Guardian" farmers. Landrace varieties, also referred to local or traditional varieties, are genetic resource maintend by family farmers, Indigenous peoples, or Quilombola communities (known as "Seed Guardians"). These are genotypes with broad genetic diversity, adapted to specific habitats through natural selection combined with human influence on the local environment (Stella; Kageyama; Nodari, 2006). According to Elste (2017), landrace seeds are preserved in seed banks and protected by guardians, being passed down from generation to generation along with knowledge of management, cultivation practices, and uses within their community of origin, such as planting and harvesting times and seed storage for the next season. This transmission also benefits other communities by adding cultural and traditional value. Moreover, native materials can be used in breeding programs for the development of new varieties, helping recover characteristics that have been lost in commercial cultivars (Pérez-Díaz *et al.*, 2020). Biodiversity ensures food security, supports farmers' permanence in rural areas, and promotes the sustainability of agricultural systems.

Despite its significant share in the agricultural market, tomato production, like that of many other plant-derived products, is considered high risk, with substantial losses occurring from production to final consumption (Fernandes, 2016). Post-harvest losses are mainly associated with mechanical injuries resulting from inadequate packaging and improper handling. These damages begin at harvest, continue during grading and sorting in packing houses, and extend through retail and consumer stages, representing a major challenge within the production chain (Guerra *et al.*, 2018). Such losses render the product unsuitable for consumption due to mechanical, pathogenic, or physiological injuries that alter its physical, chemical, microbiological, and organoleptic characteristics (Guerra *et al.*, 2017).

Furthermore, tomato is a climacteric fruit with a short post-harvest shelf life, which makes it susceptible to physiological disorders in addition to mechanical damage. At the ripe stage, it becomes highly perishable due to the fragility of its tissues and accelerated metabolic activity, with post-harvest losses reaching up to 21 %. This high perishability is mainly associated with its elevated water content (approximately 90–95 %), requiring careful postharvest handling to minimize water loss and preserve quality during storage (Al-Dairi; Pathare; Al-Yahyai, 2021; Yadav *et al*, 2022).

Therefore, the adoption of storage techniques that extend shelf life is essential, particularly for fresh-market tomatoes. Among the most widely used methods is refrigerated storage, which effectively prolongs the post-harvest life of many vegetables. Refrigeration consists of lowering the product's temperature in order to slow deterioration by reducing respiration rates and biochemical reactions. Although it does not eliminate microorganisms, refrigeration limits their growth, thereby delaying food spoilage (Al-Dairi; Pathare; Al-Yahyai, 2021). However, tomatoes are sensitive to chilling injury (Luiz, 2005), which typically occurs at temperatures below 12 °C (Saltveit, 2001). Chilling injury leads to physiological disorders such as abnormal ripening, skin darkening, increased decay incidence, and enhanced membrane permeability (Saltveit, 2005; Malacrida; Valle; Boggio, 2006).

In Brazil, post-harvest losses represent a substantial economic burden for the retail sector, averaging approximately 600 million reais per year (Costa Neta *et al*., 2020). According to Rinaldi (2011), post-harvest loss rates for tomatoes in the country are particularly high due to their elevated perishability. Under ambient temperature conditions, tomato shelf life varies according to factors such as ripening stage, cultivar, post-harvest handling, and packaging. Nevertheless, storage generally lasts only a few days, since exposure to room temperature accelerates deterioration processes (Kluge; Minami, 1997; Sanino; Cortez; Mederos, 2002). As a result, tomatoes intended for fresh consumption are typically harvested and rapidly marketed, with limited adoption of refrigerated storage.

The landrace or traditional varieties cultivation is generally associated with family farming systems and low technological input. Therefore, understanding the post-harvest behavior of these materials is essential to support farmers in managing and improving product durability, thereby enabling better market opportunities.

In this context, the aim of this study was to determine the storage duration of seven accessions of landrace tomato varieties from the Serra region of Rio Grande do Sul, stored under ambient and refrigerated conditions.

Materials and Methods

The research was conducted at the Centro de Pesquisa Celeste Gobbato (CPCG) of the Secretaria da Agricultura, Pecuária e Desenvolvimento Rural of the state of Rio Grande do Sul (DDPA-SEAPI/RS) in Caxias do Sul, Brazil, from September 2018 to February 2019. The approximate geographical coordinates are 29º08’ S latitude, 50º59’ W longitude, and an altitude of approximately 725 meters above sea level. According to the Köppen-Geiger classification, the climate is Cfb, with an average annual precipitation of 1,736 mm, an average annual temperature of 17.2 °C, and the soil classified as a Typical Dystrophic Red Latosol (Embrapa, 2006).

Seeds from seven landrace tomato varieties were collected. These landrace accessions are part of the traditional seed collection of the Universidade Federal do Rio Grande do Sul (UFRGS) and registered in the SisGen database under registration numbers A76BE95 (accessions 1, 2, and 3) and A44C106 (accessions 4, 5, 6, and 7) (Fig. 1). All accessions were collected in the state of Rio Grande do Sul.

All landrace accessions were cultivated in beds with an approximate width of 0.40 m. Each plot consisted of eight plants, spaced 0.5 m between plants and 0.8 m between rows. Plants were supported using a crossed-wire or “inverted V” trellis system, which consists of tying the plants to bamboo stakes arranged in an inverted “V” shape between two consecutive rows (Marim *et al*., 2005).

Initially, the experimental area was characterized through soil analysis, and soil fertility was adjusted according to the recommendations for tomato cultivation provided in the *Manual of Liming and Fertilization for the States of Rio Grande do Sul and Santa Catarina* (CQFS-RS/SC, 2016). Irrigation and fertigation were managed using drip tapes, following

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crop requirements. Pest and disease control was based on daily monitoring, with the rational application of products approved for organic agriculture when necessary.

When the plants were in full production, 60 fruits from each landrace variety were harvested at the harvest stage (full physiological development, at the onset of color change, corresponding to the "green" stage with light green color) and taken to the Plant Biotechnology Laboratory at CPCG for post-harvest behavior evaluation. The harvested fruits were standardized by size, according to the predominant phenotypic characteristics of each landrace accession, and selected to be free from physiological defects, disease, pest, or mechanical damage. Each landrace accession was harvested and placed in individual plastic trays (43.5 cm × 29.6 cm × 7.5 cm; volume: 7.5 L) for transport to the laboratory.

Figure 1. Diversity of fruits from landrace tomato variety evaluated in this study (white bars correspond to 1 cm).

The accessions were individually characterized and subjected to post-harvest longevity analysis under two storage conditions: ambient temperature (25 ± 2 °C) and refrigeration (10 ± 2° C). Temperature was monitored using digital thermometers placed inside the refrigerator (relative humidity ≈ 52 %) and near the fruits at ambient temperature (relative humidity 55 – 80 %). The fruits were packed in low-density polyethylene (LDPE) bags and kept under each condition until analysis.

At 0, 7, and 14 days after harvest (DAH), the fruits were physically characterized for weight (g) using a precision balance; transverse and longitudinal diameters (mm) using a digital caliper (precision 0.01 mm) to determine the transverse/longitudinal ratio; and pulp firmness (N/m²) using a penetrometer with an 8 mm tip (model PTR-100). For pulp firmness determination, 1 cm² portion of skin was removed from the equatorial region of the fruit, and measurements were taken on six fruits per sampling date (DAH).

For chemical characterization, 50 mL of juice were used to determine soluble solids (SS), expressed in °Brix, using a bench refractometer (Hanna®); titratable acidity (TA), determined by titration with 0.1 N NaOH to pH 8.2, with results expressed as mg citric acid 100 g^{-1} of fruit; the ratio (SS/TA); and pH, measured using a digital pH meter (Digimed®). The chemical analyses followed the methodologies of the Association of

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Official Analytical Chemists (AOAC, 1997).

To evaluate epidermis color development, classification standards from CEAGESP (2003) were used, with the following adaptations: Green (1): entire fruit surface green; Salad (2): up to 30 % of the surface red; Turning (3): up to 60 % red; Pink (4): up to 90 % red; and Red (5): more than 90 % of the surface red (Fig. 2a). For accession 3, which had yellow-skinned fruits, a scale from 1 to 3 was used: 1 – completely green; 2 – light yellow; and 3 – mature yellow (Fig. 2b).

Figure 2. Color scale for evaluating tomato fruit ripening: (a) red-skinned fruits scale: Green (1): entire fruit surface green; Breaker (2): up to 30 % of the surface red; Turning (3): up to 60 % red; Pink (4): up to 90 % red; and Red (5): more than 90 % of the surface red; and (b) yellow-skinned fruits scale: Green (1): entire fruit surface green; Turning (2): up to 60 % red; Ripe (3): more than 90 % of the surface yellow.

The experimental design was completely randomized, in a factorial arrangement of 7 accessions × 2 storage temperatures × 3 evaluation times. Regression analysis was performed for variables that showed interaction with the storage period (DAH). Each treatment consisted of three replicates of 10 fruits. Mean comparisons were performed using Tukey's test ($p \leq 0.05$). Statistical analyses were conducted using the Costat statistical software.

Results and Discussion

Cultivated tomato varieties have been progressively modified to meet market demands, resulting in a high degree of phenotypic uniformity. In contrast, genetic variability in wild tomato species can still be inferred from their morphological diversity. Key morphological traits used to identify species within the genus *Lycopersicon* include flower size, inflorescence type, leaf shape, growth habit, cross-compatibility, and fruit characteristics (Egashira *et al.*, 2000), such as color, weight, and shape.

In the present study, significant differences were observed in the physical and chemical characteristics of the evaluated accessions, corroborating the findings of Carelli (2003), who reported substantial morphological variability among heirloom tomato accessions from southern Brazil. However, fruit physical attributes (specifically fruit weight and the transverse-to-longitudinal diameter ratio) were not affected by storage period or storage type (Table 1), indicating that the fruits maintained their structural integrity and did not experience deformation or excessive water loss during storage.

Over the 14-day storage period, fruit weight decreased by only 1.14 %. When different storage conditions were compared, weight loss was limited to 0.75 %, indicating that the evaluated accessions maintained their physical integrity for an extended

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period after harvest and are therefore suitable for fresh consumption. These findings are consistent with the CEAGESP ([2025]) classification, which reports that tomatoes belonging to the "Elongated" and "Oblong" market groups - both represented in this study, exhibit firmness grades of 3 and 2, respectively, traits associated with reduced water loss capacity.

The CEAGESP ([2025]) tomato classification system provides a standardized commercial framework, establishing well-defined criteria based on market groups, firmness grades, mass or equatorial diameter ranges, and a "best choice" index that assesses commercial cost-benefit. The main market groups include Elongated (firmness grade 3; Italian type 'Andréa'), Oblong (firmness grade 2; 'Santa Cruz' group, including the 'Débora' cultivar), Flattened (firmness grade 1; 'Carmen' type), Persimmon (firmness grade 2; including the 'Caqui' variety), and Mini (firmness grade 2; including Cherry and Grape types). Each group is further classified into size categories (1A, 2A, 3A, etc.).

Table 1. Physical parameters: fruit weight (g) and transverse/longitudinal diameter ratio in heirloom tomato accessions collected in Rio Grande do Sul, evaluated over time and under different storage conditions (2025).

Treatments	Fruit weight (g)		Diameter transverse (mm)		Diameter transverse/longitudinal	
Days after harvest						
0	36,64	ns	30,41	b	1,43	ns
7	33,94		31,10	a	1,39	
14	33,37		31,96	a	1,38	
Storage						
Room temperature	33,68	b	30,85	ns	1,41	ns
Refrigerated	35,64	a	31,47		1,39	
Acessions						
1	17,05	c	25,05	d	1,37	c
2	18,01	c	25,45	d	1,49	b
3	17,95	c	27,05	d	1,27	d
4	38,59	b	34,48	b	1,42	bc
5	98,38	a	49,27	a	1,07	c
6	37,51	b	29,31	c	1,61	a
7	23,22	c	26,96	d	1,60	a
Days after harvest (DAP)	0,4937	ns	0,0406	*	0,2152	ns
Storage	0,0776	ns	0,2325	ns	0,2814	ns
Acessions	0	***	0	***	0	***
DAP X storage	0,4688	ns	0,0048	**	0,534	ns
CV (%)	15,77		12,25		10,38	

Means followed by the same letter in the column do not differ from each other according to Tukey's test at 5%. Data transformed as $\sqrt{(x+1)}$.

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Fruit shape, expressed as the transverse-to-longitudinal diameter ratio, indicates that values closer to 1.0 correspond to round fruits, values greater than 1.0 indicate oblong fruits, and values below 1.0 indicate flattened fruits. Based on this ratio, accession 5 differed from the other accessions by exhibiting a round fruit shape, classified within the "Oblong" market group ("Santa Cruz"), according to CEAGESP ([2025]). In contrast, the remaining accessions displayed oblong to elongated fruits and were classified as belonging to the "Elongated" ("Italian") market group (Table 1). Accession 5 also presented the highest mean fruit mass (98.38 g), followed by accessions 4 and 6, which did not differ significantly from each other and differed from the smaller-fruited accessions classified within the "Mini" group (accessions 1, 2, 3, and 7) (Table 1).

However, all accessions were classified as very small to small according to IPGRI (1996), which categorizes tomatoes into eight predominant fruit shapes - flattened, slightly flattened, round, high round, heart-shaped, cylindrical, pear-shaped, and ellipsoid (plum-shaped), and five size classes based on fruit diameter: very small (< 3 cm), small (3–5 cm), intermediate (5.1–8 cm), large (8.1–10 cm), and very large (> 10 cm).

Regarding pulp firmness, a significant interaction ($p < 0.0005$) was observed between storage time and storage conditions. Firmness decreased more rapidly in fruits stored at ambient temperature than in those kept under refrigeration (Table 2). In addition, the interaction between storage time and accessions indicated that accession 5 consistently exhibited higher firmness than the other accessions throughout the storage period.

Table 2. Pulp firmness (N/m²) during postharvest storage of heirloom tomato accessions collected in Rio Grande do Sul, evaluated over time and under different storage conditions (2025).

Pulp firmness (N/m²)	**Days after harvest**		
Storage	0	7	14
Room temperature	19,62 Aa	9,71 Bb	2,45 Bb
Refrigerated	36,68 Aa	26,97 Ab	28,93 Ab
Acessions			
1	36,78 Ba	19,91 Bb	14,81 Bb
2	37,08 Ba	17,95 Bb	14,71 Bb
3	22,66 CDa	8,14 CDb	6,67 CDb
4	13,04 Ca	7,84 Cb	16,77 Cb
5	54,24 Aa	54,05 Ab	52,58 Ab
6	6,96 Da	9,61 Db	4,51 Db
7	12,85 CDa	10,79 CDb	5,78 CDb
CV %			19,28
Days after harvest X Acessions			0,0104 *
Days after harvest X Storage			0,0005 ***

Means followed by the same letter in the column do not differ from each other according to Tukey's test at 5%. Data transformed as √(x+1).

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Tomato composition undergoes substantial changes during ripening, and firmness is a practical indicator of fruit maturity, largely determined by the cohesion strength among pectic substances in the cell wall (Cerqueira *et al*., 2011). During this process, macromolecules such as protopectins, cellulose, hemicellulose, and starch are progressively degraded, leading to reduced cell wall cohesion and, consequently, decreased firmness (Chitarra; Chitarra, 2005; Alvarenga; Coelho; Souza, 2013). According to Schouten *et al*. (2007), firmness loss over time results from the combined effects of biochemical processes, particularly cell wall degradation, and physical factors, such as temperature-dependent reductions in turgor pressure. Tomatoes are commonly stored under refrigerated conditions (10 – 15 °C) to extend shelf life, as deterioration rates double or triple with each 10 °C increase in temperature (Saltveit, 2003), primarily due to increased respiration rates (Chitarra; Chitarra, 2005). The present study corroborated this pattern, as fruits stored at ambient temperature - approximately 15 °C higher than refrigerated conditions, exhibited a faster and more pronounced loss of firmness.

The firmness results are consistent with Chitarra and Chitarra (2005), who reported that higher temperatures increase the activity of cell wall-degrading enzymes, such as cellulase and polygalacturonase, thereby accelerating fruit softening. Tomatoes are highly perishable, with postharvest losses reaching up to 21% (Rinaldi *et al*., 2011), and their high-water content (90–95%) increases susceptibility to moisture loss, softening, and quality deterioration during storage (Al-Dairi; Pathare; Al-Yahyai, 2021; Yadav *et al*, 2022). Firmness is a key quality attribute influencing consumer acceptance, as it reflects ripeness; for producers, it is closely associated with shelf life, and for the processing industry, it determines texture uniformity among varieties (Sugai, 2002). Among the evaluated accessions, accession 5 retained pulp firmness for the longest period (Table 2).

Chemical characterization of the landrace accessions, conducted on the first day after harvest, demonstrated substantial variability among genotypes. Soluble solids ranged from 4.16 to 6.08 °Brix, with the highest value observed in accession 2. Titratable acidity varied from 0.22 to 0.38 mg citric acid 100 g^{-1}, with higher values in accessions 3 and 6. The SS/TA ratio ranged from 13.36 to 19.67, reaching its maximum in accession 2, while pH values varied from 4.25 to 4.63 (Table 3)

Soluble solids (SS) indicate the percentage of dissolved solids, mainly sugars (sucrose and hexoses, 65 %), acids (citrate and malate, 13 %), and minor compounds (phenolics, amino acids, soluble pectins, ascorbic acid, and minerals) (Balibrea *et al*., 2006; Kader, 2008). SS values may vary among genotypes and can be affected by abnormal acidity levels (Gautier *et al*., 2008; Luengwilai *et al*., 2010). SS also inversely correlate with fruit size: large fruits (3-5 %), medium (5-7 %), and mini tomatoes (9-15 %) (Baxter *et al*., 2005; Gautier *et al*., 2010; Georgelis; Scott; Baldwin, 2004; Rick, 1974). This explains the present results, where the largest fruit (accession 5) had the lowest SS (4.16 °Brix), while accession 2, among the smallest fruits, reached 6.08 °Brix, significantly higher than others (Table 3).

According to Schwarz *et al*. (2013), tomato fruits with soluble solids (SS) above 3 °Brix are suitable for fresh-market commercialization. The SS values observed in this study (4.06-6.08 °Brix) represent an important quality attribute of tomatoes, as sweetness is highly valued for fresh consumption.

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Table 3. Chemical parameters: soluble solids (°Brix), titratable acidity (mg citric acid/100 g pulp), soluble solids/titratable acidity ratio (SS/AT), and pH in heirloom tomato accessions collected in Rio Grande do Sul. Caxias do Sul (2025).

Acessions	Solubles Solids (°Brix)	Titratable acidity (mg/100g citric acid)	Ratio (SS/AT)	pH
1	5,84 ab	0,32 b	19,67 ab	4,63 a
2	6,08 a	0,31 b	19,67 ab	4,58 ab
3	5,58 bc	0,38 a	14,65 cd	4,25 d
4	5,24 dc	0,33 ab	16,39 bc	4,35 c
5	4,16 f	0,22 c	18,89 ab	4,52 b
6	5,30 cd	0,34 ab	16,71 bc	4,26 cd
7	4,34 e	0,38 a	13,36 d	4,26 cd
CV %	8,89 ***	16,96 ***	22,38 ***	2,12 ***

Means followed by the same letter in the column do not differ from each other according to Tukey's test at 5%. Data transformed as √(x+1).

Another major determinant of tomato flavor is the acidity, commonly assessed by titratable acidity and pH. Citric acid is the predominant organic acid in tomatoes, occurring at concentrations up to 30 times higher than those of other organic acids (Hobson; Davies, 1971). In this study, titratable acidity ranged from 0.22 to 0.38 mg citric acid 100 g^{-1}, with accessions 3, 4, 6, and 7 exhibiting lower acidity values. Acidity declined more sharply under ambient temperature conditions (Fig. 5).

According to Nascimento *et al*. (2013), tomato flavor results from the balance between sugars and acids. Kader *et al*. (1978) suggest that SS ≥ 5 and TA ≥ 0.4 yield a desirable SS/TA ratio of about 12.5 for flavorful table tomatoes. All accessions exhibited ratios above 12.5 (range: 13.36–19.67), indicating favorable sensory quality. Accession 2, with the highest SS/TA (19.67), combined low fruit weight with high sugar concentration (Table 3). The evolution of the SS/TA ratio during storage demonstrated that refrigerated conditions contributed to maintaining a more stable balance between soluble solids and titratable acidity, preserving fruit quality for a longer period when compared to ambient storage conditions (Fig. 6).

Values of pH below 4.5 are desirable, as they inhibit microbial growth and reduce sterilization time during processing (Monteiro *et al*., 2008). Ferreira (2004) reported that pH decreases during the early stages of ripening but increases slightly at overripe stages as acidity ta declines. Similarly, in the present study, tomatoes stored at ambient temperature exhibited a gradual increase in pH over time (Fig. 4a). According to Chitarra and Chitarra (2005) and Borguini and Silva (2005), organic acids in fruits contribute not only to acidity but also to aroma development.

Significant pH differences were found only for accessions 1 and 2; the storage period did not affect significantly pH adn titratable acidity (Table 3). Under refrigeration, SS and acidity remained stable, while pH decreased (Fig. 4b), preserving the fruits' commercial quality longer.

During the storage period, only SS showed significant variation (Fig. 3), decreasing over time. According to Moura *et al*. (2005), adequate concentrations of soluble sugars and organic acids determine flavor development and overall quality. Since metabolic activity slows under lower temperatures, refrigerated fruits retained their SS content longer (Fig. 3).

Fruit color is a key quality attribute influencing consumer choice. In tomatoes, it is a complex external indicator of ripening and postharvest life, as fruits are generally consumed at full red color (for red-skinned types) but before excessive softening (Alves, 2017).

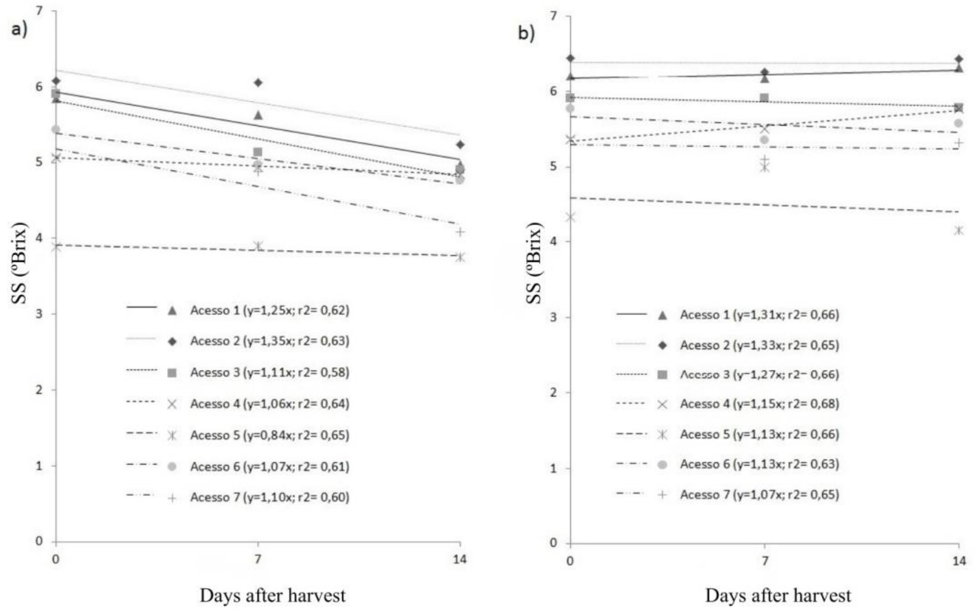

Figure 3. Soluble solids (SS - °Brix) in fruits stored (a) at ambient temperature and (b) under refrigerated conditions of landrace tomato accessions collected in Rio Grande do Sul (2025).

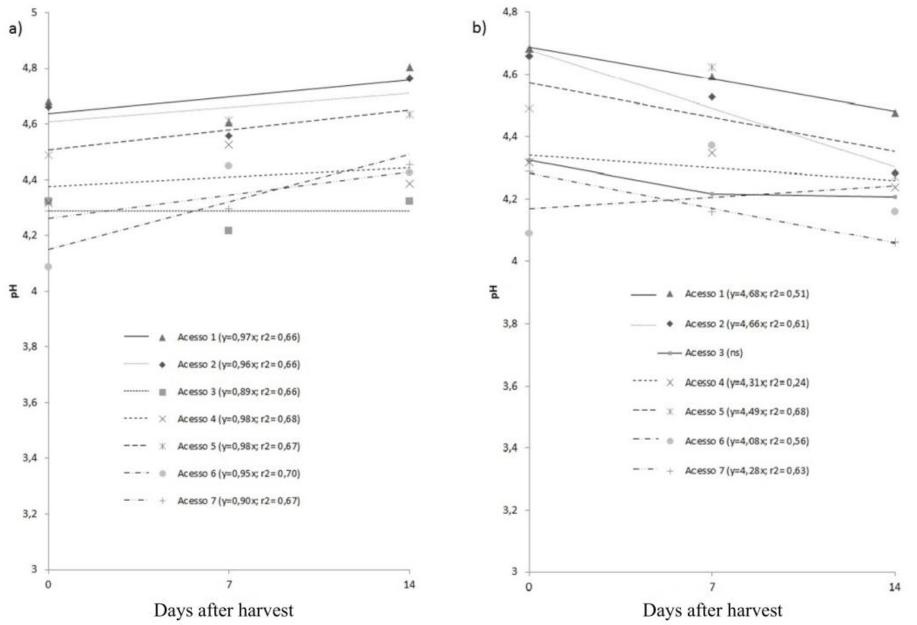

Figure 4. pH (hydrogen potential) of landrace tomatoes stored (a) at ambient temperature and (b) under refrigerated conditions, from accessions collected in Rio Grande do Sul (2025).

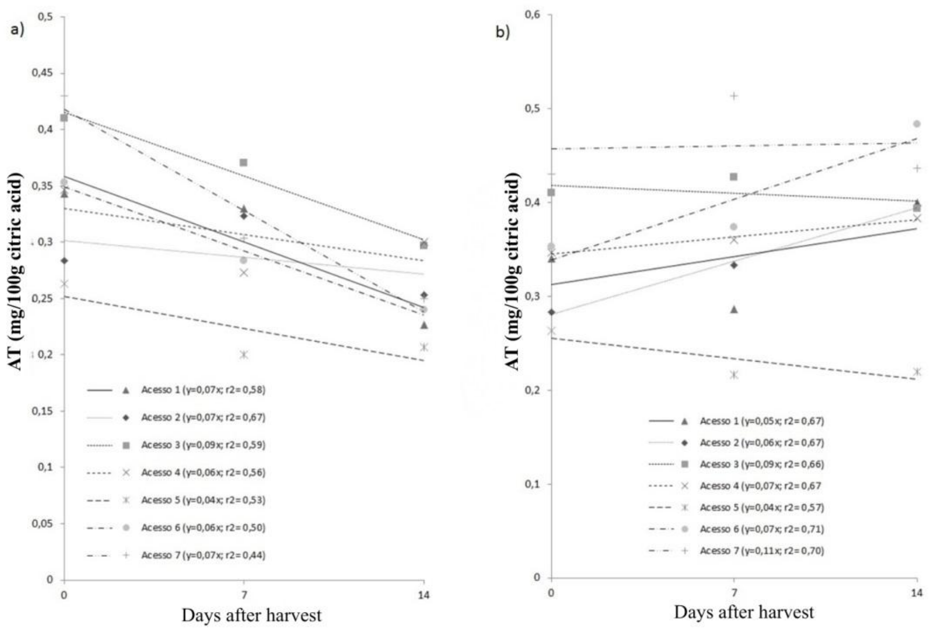

Figure 5. Titratable acidity (AT – mg citric acid / 100 g pulp) in fruits stored (a) at ambient temperature and (b) under refrigerated conditions of landrace tomato accessions collected in Rio Grande do Sul (2025).

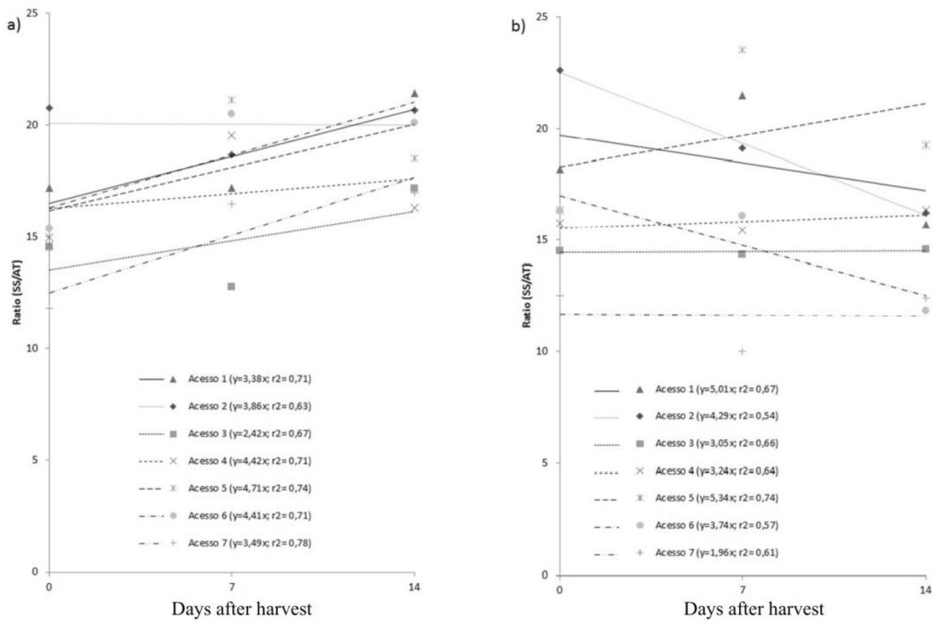

Figure 6. Soluble solids/titratable acidity ratio (SS/AT ratio) in fruits stored a) at ambient temperature and b) under refrigerated conditions of landrace tomato accessions collected in Rio Grande do Sul (2025).

Fruit color is a key quality attribute influencing consumer choice. In tomatoes, it is a complex external indicator of ripening and postharvest life, as fruits are generally consumed at full red color (for red-skinned types) but before excessive softening (Alves, 2017).

For fruits stored under ambient conditions, the regression model fitted for accessions 1, 4, 5, and 6 showed a quadratic pattern in color index evolution,

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reaching maximum red intensity during the evaluation period. For accessions 2, 3, and 7, the fitted regression model was linear, indicating continued color development beyond 14 days (Fig. 7a). Under refrigerated storage, color progression was slower, and after 14 days the fruits reached the light-red stage, which is considered optimal for fresh-market commercialization (Fig. 7b).

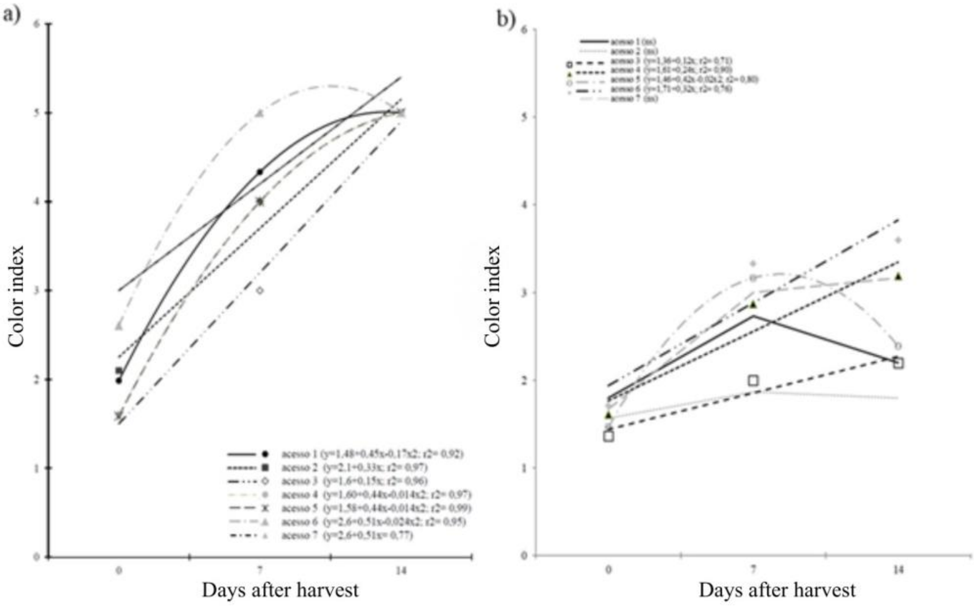

Figure 7. Skin color index evolution of fruits stored (a) at ambient temperature and (b) under refrigerated conditions during the post-harvest period of landrace tomato accessions collected in Rio Grande do Sul (2025).

The presence of fruits at different ripening stages in retail markets increases product availability over time, as more mature fruits are sold first (Teixeira *et al*., 2022). As a climacteric fruit, tomatoes are commonly harvested at the green or breaker stage to extend shelf life. In the specific case of the materials accessions, typically produced in smaller volumes and marketed locally, the lower handling intensity contributes to the preservation of fruit quality. Moreover, under refrigerated storage, these fruits maintained marketable quality for up to 14 days, which is suitable for small-scale commercialization.

In fresh markets, consumer preferences for sweeter or more acidic cultivars depend on local dietary habits and cultural patterns. Thus, it is essential to provide cultivars with diverse physicochemical and sensory profiles (Nascimento *et al*., 2013).

Based on the experimental conditions and results obtained, it can be concluded that the landrace tomato accessions evaluated exhibit suitable qualitative parameters for fresh-market commercialization (soluble solids, acidity, SS/TA ratio, and pH) and can be stored for up to 14 days under refrigeration.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any potential conflicts of interest.

Ethical Statements

The authors confirm that the ethical guidelines adopted by the journal were followed by this work, and all authors agree with the submission, content and transfer of the publication rights of the article to the journal. They also declare that the work has not been previously published nor is it being considered for publication in another journal.

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References

AL-DAIRI, M.; PATHARE, P. B.; AL-YAHYAI, R. Chemical and nutritional quality changes of tomato during postharvest transportation and storage. **Journal of the Saudi Society of Agricultural Sciences,** v. 20, n. 6, p. 401-408, 2021. https://doi.org/10.1016/j.jssas.2021.05.001.

ALVARENGA, M. A. R.; COELHO, F. S.; SOUZA, R. A. M. Colheita, classificação, embalagens e pós-colheita. In: ALVARENGA, M. A. R. (Ed.). **Tomate: produção em campo, casa de vegetação e hidroponia.** 2. ed. Lavras: Editora Universitária de Lavras, 2013. cap. 14, p. 413-446.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS (AOAC). **Official methods of analysis of AOAC International**. 16. ed. Washington, DC: AOAC, 1997. v. 2, p. 16-17.

ALVES, R. M. **Qualidade pós-colheita de tomate italiano adubado com potássio em ambiente protegido**. 2017. Dissertação (Mestrado em Agricultura Tropical e Subtropical) – Curso de Pós-Graduação em Agricultura Tropical e Subtropical, Instituto Agronômico, Campinas, 2017. Available from: https://www.iac.sp.gov.br/areadoinstituto/posgraduacao/repositorio/storage/teses_dissertacoes/pb446015.pdf. Accessed: Aug. 25, 2025.

BALIBREA, M. E. *et al*. The high fruit soluble sugar content in wild Lycopersicon species and their hybrids with cultivars depends on sucrose import during ripening rather than on sucrose metabolism. **Functional Plant Biology**, v. 33, n. 3, p. 279-288, 2006. https://doi.org/10.1071/FP05134.

BAXTER, C. J. *et al*. Comparison of changes in fruit gene expression in tomato introgression lines provides evidence of genome-wide transcriptional changes and reveals links to mapped QTLs and described traits. **Journal of Experimental Botany**, v. 56, n. 416, p. 1591-1604, 2005. https://doi.org/10.1093/jxb/eri154.

BORGUINI, R. G.; SILVA, M. V. Physical-chemical and sensorial characteristics of organic tomato in comparison to the conventional tomato. **Alimentos e Nutrição**, Araraquara, v. 16, n. 4, p. 355-361, 2005. Available from: https://www.researchgate.net/profile/Renata-Borguini/publication/49599892_Caracteristicas_fisico-quimicas_e_sensorias_do_tomate_Lycopersicon_esculentum_produzido_por_cultivo_organico_em_comparacao_ao_convencional/links/54eb27380cf25ba91c86242a/Caracteristicas-fisico-quimicas-e-sensorias-do-tomate-Lycopersicon-esculentum-produzido-por-cultivo-organico-em-comparacao-ao-convencional.pdf. Accessed: Aug. 25, 2025.

CARELLI, B. P. **Estimativas de variabilidade genética em acessos crioulos e cultivares comerciais de tomates (*Lycopersicon esculentum Mill.)* do sul do Brasil e avaliação da presença do Gene Mi**. 2003. 116 f. Tese (Doutorado em Ecologia e Recursos Naturais) – Centro de Ciências Biológicas e da Saúde, Universidade Federal de São Carlos, São Carlos, 2003. Available from: https://repositorio.ufscar.br/items/98cec481-2b9b-4e39-8178-5e9b1b361695. Accessed: Aug. 25, 2025.

CEAGESP. **Normas de classificação do tomate**. São Paulo: CQH/CEAGESP, 2003. Available from: http://www.ceagesp.gov.br/wp-content/uploads/2015/07/tomate.pdf. Accessed: Nov. 10, 2018.

CEAGESP. **Tomate**. São Paulo: CEAGESP, [2025]. Available from: https://ceagesp.gov.br/hortiescolha/hortipedia/tomate. Accessed: Aug. 25, 2025.

CERQUEIRA, T. S., *et al*. Protein and chitosan coatings on guavas. **Bragantia**, Campinas, v. 70, n. 1, p. 216-221, 2011. https://doi.org/10.1590/S0006-87052011000100028.

CHITARRA, M. I. F.; CHITARRA, A. B. **Pós-colheita de frutas e hortaliças**: fisiologia e manuseio. 2. ed. Lavras: UFLA, 2005. 785 p.

COMISSÃO DE QUÍMICA E FERTILIDADE DO SOLO – RS/SC (CQFS-RS/SC). **Manual de Calagem e Adubação para os Estados do Rio Grande do Sul e de Santa Catarina.** 11. ed. Porto Alegre: Sociedade Brasileira de Ciência do Solo – Núcleo Regional Sul, 2016. 376 p.

COSTA NETA, C. M. *et al*. Post-harvest losses and final destination of fruit in commercial segments of Teresina (PI). **Revista Ibero-Americana de Ciências Ambientais**, v. 11, n. 3, p. 440-453, 2020. Available from: https://www.sustenere.inf.br/index.php/rica/article/view/CBPC2179-6858.2020.003.0034. Accessed: Aug. 25, 2025.

EGASHIRA, H. *et al*. Genetic diversity of the '*Peruvianum-complex'* (*Lycopersicon Peruvianum* (L.) Mill. and *L. Chilense* Dun.) revealed by RAPD analysis. **Euphytica**, v. 116, n. 1, p. 23-31, 2000. https://doi.org/10.1023/A:1004064909631.

ELSTE, F. D. R. **Os guardiões de semente no Passo do Lourenço, Canguçu-RS**: a semente crioula e o *habitus* do camponês. 2017. 148 f. Dissertação (Mestrado em Sociologia) – Instituto de Filosofia, Sociologia e Política, Universidade Federal de Pelotas, Pelotas, 2017. Available from: https://wp.ufpel.edu.br/ppgs/files/2017/12/F%C3%A1bio-Ribeiro-Disserta%C3%A7%C3%A3o2017.pdf.

PESQ. AGROP. GAÚCHA, V.32, N.1, P. 69-86, 2026.
ISSN: 0104-9070. ISSN ONLINE: 2595-7686.
Received: 11 Apr, 2025. Accepted: 10 Jun, 2025.

Accessed: Aug. 25, 2025.

EMBRAPA. **Sistema brasileiro de classificação de solos.** 2. ed. Rio de Janeiro: Embrapa Solos, 2006. 306 p. Available from: http://www.infoteca.cnptia.embrapa.br/infoteca/handle/doc/338818. Accessed: Aug. 25, 2025.

FERNANDES, L. S. **Qualidade pós-colheita de tomates submetidos à esforços de compressão e vibrações mecânicas.** 2016. 74 f. Tese (Doutorado em Engenharia Agrícola) – Universidade Federal de Viçosa, Viçosa, 2016. Available from: http://www.locus.ufv.br/handle/123456789/10382. Accessed: Aug. 25, 2025.

FERREIRA, S. M. R. **Características de qualidade do tomate de mesa (*Lycopersicon esculentum* Mill.) cultivado nos sistemas convencional e orgânico comercializado na região metropolitana de Curitiba**. 2004. 249 f. Tese (Doutorado em Tecnologia de Alimentos) – Universidade Federal do Paraná, Curitiba, 2004. Available from: https://hdl.handle.net/1884/659. Accessed: Aug. 25, 2025.

FAO; OUR WORLD IN DATA. **Tomato production**. 2025. Available from: https://ourworldindata.org/grapher/tomato-production. Accessed: Apr. 4, 2025.

GAUTIER, H. *et al*. How does tomato quality (sugar, acid, and nutritional quality) vary with ripening stage, temperature, and irradiance? **Journal of Agricultural and Food Chemistry**, v. 56, n. 4, p. 1241-1250, 2008. https://doi.org/10.1021/jf072196t.

GAUTIER, H. *et al*. Impact of ripening and salinity on tomato fruit ascorbate content and enzymatic activities related to ascorbate recycling. **Functional Plant Science and Biotechnology**, v. 4, Special Issue 1, p. 66-75, 2010. Available from: http://globalsciencebooks.info/Online/GSBOnline/images/2010/FPSB_4(SI1)/FPSB_4(SI1)66-75o.pdf. Accessed: Aug. 25, 2025.

GEORGELIS, N., SCOTT, J. W., BALDWIN, E. A. Relationship of tomato fruit sugar concentration with physical and chemical traits and linkage of RAPD markers. **Journal of the American Society for Horticultural Science**, v. 129, n. 6, p. 839-845, 2004. https://doi.org/10.21273/JASHS.129.6.839.

GUERRA, A. M. N. M. *et al.* Avaliação das principais causas de perdas pós-colheita de hortaliças comercializadas em Santarém, Pará. **Revista Verde de Agroecologia e Desenvolvimento Sustentável**, v. 12, n. 1, p. 34–40, 2017. https://doi.org/10.18378/rvads.v12i1.4809.

GUERRA, A. M. N. M. *et al*. Post-harvest losses on vegetables due to damages at the Santarém-PA retailer network. **Revista Brasileira de Agropecuária Sustentável**, v. 8, n. 2, p. 106-114. 2018. https://doi.org/10.21206/rbas.v8i2.486.

HOBSON, G. E.; DAVIES, J. N. The tomato. In: HULME, A. C. (ed.). **The biochemistry of fruits and their products.** London: Academic Press, 1971. v. 2, cap. 13, p. 437-475.

IBGE. **Produção de tomate**. Rio de Janeiro: IBGE, 2024. Available from: https://ibge.gov.br/explica/producao-agropecuaria/tomate/br. Accessed: Apr. 7, 2025.

IBGE. **Levantamento sistemático da produção agrícola:** produção por período da safra e produto (toneladas). Rio de Janeiro: IBGE, 2025. Disponível em: https://sidra.ibge.gov.br/home/lspa. Accessed: Apr. 4, 2025.

IPGRI. **Descriptores para el tomate (*Lycopersicum* spp.)**. Rome, Italy: IPGRI, 1996. 44 p. Available from: https://hdl.handle.net/10568/73043. Accesseed: Nov. 22, 2018.

KADER, A. A. *et al*. Composition and flavor quality of fresh market tomatoes as influenced by some postharvest handling procedures. **Journal of the American Society for Horticultural Science**, v. 103, n. 1, p. 6-13. 1978. https://doi.org/10.21273/JASHS.103.1.6.

KADER, A. A. Flavor quality of fruits and vegetables. **Journal of the Science of Food and Agriculture**, v. 88, n. 11, p. 1863-1868, 2008. https://doi.org/10.1002/jsfa.3293.

KLUGE, R. A.; MINAMI, K. Effect of sucrose esters on stored `Santa Clara' tomatoes. **Scientia Agricola**, Piracicaba, v. 54, n. 1-2, p. 39-44, 1997. https://doi.org/10.1590/S0103-90161997000100006.

LINO, G. C. L.; LINO, T. H. L. **Congelamento e refrigeração**. 2014. Trabalho acadêmico (Tecnólogo em Alimentos) – Universidade Tecnológica Federal do Paraná, Londrina, 2014. Available from: http://paginapessoal.utfpr.edu.br/lopesvieira/operacoes-unitarias/trabalhos/turma-2013-2/refrigeracao-e-congelamento/refrigeracao%20e%20congelamento.pdf/view. Accessed: Aug. 25, 2025.

LUENGWILAI, K. *et al*. Starch molecular structure shows little association with fruit physiology and starch metabolism in tomato. **Journal of Agricultural and Food Chemistry**, v. 58, n. 2, p. 1275-1282, 2010. https://doi.org/10.1021/jf9032393.

LUIZ, K. M. B. **Avaliação das características físico-químicas e sensoriais de tomates (*Lycopersicum esculentum* Mill) armazenados em refrigeradores domésticos**. 2005. 107 f. Dissertação (Mestrado em Engenharia de Alimentos) – Centro Tecnológico, Universidade Federal de Santa Catarina, Florianópolis, 2005. Available from: http://repositorio.ufsc.br/handle/123456789/102690. Accessed: Aug. 25, 2025.

MACHADO, A. W. **Tomate – produção e consumo no Brasil**. Porto Alegre: Agrolink, [2021]. Available from: https://www.agrolink.com.br/culturas/tomate/informacoes-da-cultura/informacoes-gerais/tomate---producao-e-consumo-no-brasil_482706.html. Accessed: Jul. 10, 2025.

MALACRIDA, C.; VALLE, E. M.; BOGGIO, S. B. Postharvest chilling induces oxidative stress response in the dwarf tomato cultivar Micro-Tom. **Physiologia Plantarum**, v. 127, n. 1, p. 10-18, 2006. https://doi.org/10.1111/j.1399-3054.2005.00636.x.

MARIM, B. G.; SILVA, D. J. H.; GUIMARÃES, M. A.; BELFORT, G. Sistemas de tutoramento e condução do tomateiro visando produção de frutos para consumo *in natura*. **Horticultura Brasileira**, Brasília, v. 23, n. 4, p. 951–955, 2005. Available from: https://doi.org/10.1590/S0102-05362005000400018. Accessed: Jul. 10, 2025.

ISSN: 0104-9070. ISSN ONLINE: 2595-7686.
Received: 11 Apr, 2025. Accepted: 10 Jun, 2025.

MONTEIRO, C. S. *et al*. Nutritional quality the antioxidants of the tomato “Italian type”. **Alimentos e Nutrição**, Araraquara, v. 19, n. 1, p. 25-31, 2008. Available from: https://www.academia.edu/download/38579879/QUALIDADE_NUTRICIONAL_E_ANTIOXIDANTE_de_tomate_tipo_italiano.pdf. Accessed: Aug. 25, 2025.

MOURA, M. L. *et al*. Physiology of vine-ripened tomato ‘Santa Clara’ and its mutant ‘Firme’. **Horticultura Brasileira**, v. 23, n. 1, p. 81-85, 2005. https://doi.org/10.1590/S0102-05362005000100017.

NASCIMENTO, A. R. *et al*. Quality of tomatoes for fresh consumption grown in organic and conventional systems in the state of Goias, Brazil. **Horticultura Brasileira**, v. 31, n. 4, p. 628-635, 2013. https://doi.org/10.1590/S0102-05362013000400020.

PÉREZ-DÍAZ, F. *et al*. Crecimiento y características postcosecha de frutos de genótipos nativos de tomate (*Solanum lycopersicum* L.). **Revista Fitotecnia Mexicana**, v. 43, n. 1, p. 89-99, 2020. https://doi.org/10.35196/rfm.2020.1.89.

RICK, C. M. High soluble solids content in large-fruited tomato lines derived from a wild green-fruited-species. **Hilgardia**, v. 42, n. 15, p. 493-510, 1974. Available from: https://my.ucanr.edu/sites/hilgardia/Abstract/index.cfm?a=hilg.v42n15p493. Accessed: Aug. 25, 2025.

RINALDI, M. M. Perdas pós-colheita devem ser consideradas. **A Lavoura**, n. 686, p. 15-17, 2011. Available from: http://www.alice.cnptia.embrapa.br/alice/handle/doc/920540. Accessed: Aug. 25, 2025.

RINALDI, M. M. *et al*. Avaliação da vida útil e de embalagens para tomate de mesa em diferentes condições de armazenamento. **Boletim do Centro de Pesquisa de Processamento de Alimentos**, Curitiba, v. 29, n. 2, p. 305- 316, 2011. https://doi.org/10.5380/cep.v29i2.25510.

SALTVEIT, M. E. Chilling injury is reduced in cucumber and rice seedlings and in tomato pericarp discs by heat-shocks applied after chilling. **Postharvest Biology and Technology**, v. 21, n. 2, p. 169-177, 2001. https://doi.org/10.1016/S0925-5214(00)00132-0.

SALTVEIT, M. E. Temperature extremes. *In*: BARTZ, J. A., BRECHT, J. K. (ed.). **Postharvest Physiology and Pathology of Vegetables**. 2. ed. rev. exp. Boca Raton: CRC Press, 2003. ch. 19, p. 457-483. https://doi.org/10.1201/9780203910092.

SALTVEIT, M. E. Influence of heat shocks in the kinetics of chilling-induced ion leakage from tomato pericarp discs. **Postharvest Biology and Technology**, v. 36, n. 1, p. 87-92, 2005. https://doi.org/10.1016/j.postharvbio.2004.10.007.

SANINO, A; CORTEZ, L. A. B.; MEDEROS, B. T. Vida-de-prateleira do tomate (*Lycopersicon esculentum*), variedade “Débora”, submetido a diferentes condições de resfriamento. *In*: ENCONTRO DE ENERGIA NO MEIO RURAL, 4., 2002, Campinas. **Proceedings [...]**. Campinas: Unicamp, 2002. 6 p. Available from: http://www.proceedings.scielo.br/scielo.php?script=sci_arttext&pid=MSC0000000022002000200068&lng=en&nrm=abn. Accessed: Aug. 25, 2025.

SCHOUTEN, R. E. *et al*. Modelling the firmness

ISSN: 0104-9070. ISSN ONLINE: 2595-7686.
Received: 11 Apr, 2025. Accepted: 10 Jun, 2025.

behaviour of cut tomatoes. **Postharvest Biology and Technology**, v. 45, n. 3, p. 298–307, 2007. https://doi.org/10.1016/j.postharvbio.2010.02.001.

SCHWARZ, K. *et al*. Agronomic performance and physico-chemical quality in tomato hybrids grown without guiding. **Horticultura Brasileira**, v. 31, n. 3, p. 410-418, 2013. https://doi.org/10.1590/S0102-05362013000300011.

STELLA, A.; KAGEYAMA, P. Y.; NODARI, R. Políticas públicas para a agrobiodiversidade. *In*: STELLA, A.; KAGEYAMA, P. Y. (coord.). **Agrobiodiversidade e diversidade cultural**. Brasília: MMA, 2006. ch. 2, p. 43-58. (Série Biodiversidade, 2). Available from: https://antigo.mma.gov.br/estruturas/sbf_agrobio/_publicacao/89_publicacao21092009104952.pdf. Accessed: Aug. 25, 2025.

SUGAI, A. Y. **Processamento descontínuo de purê de manga (*Mangifera indica* Linn), variedade Haden:** estudo da viabilidade do produto para o pronto consumo. 2002. 82 f. Dissertação (Mestrado em Engenharia) – Escola Politécnica, Universidade de São Paulo, São Paulo, 2002. https://doi.org/10.11606/D.3.2002.tde-05052003-151029.

TEIXEIRA, I. S. *et al*. Identification of causes for postharvest loss in tomato cultivars commercialized in Ceasa, Ceará, Brazil. **Revista Verde de Agroecologia e Desenvolvimento Sustentável**, v. 17, n. 2, p. 135-142, 2022. https://doi.org/10.18378/rvads.v17i2.9286.

YADAV, P, *et al.* Edible coating as postharvest management strategy for shelf-life extension of fresh tomato *(Solanum lycopersicum* L.*):* an overview. **Journal of Food Science**, v. 87, n. 10, p. 4310-4327, 2022. https://doi.org/10.1111/1750-3841.16145.

ISSN: 0104-9070. ISSN ONLINE: 2595-7686.
Received: 11 Apr, 2025. Accepted: 10 Jun, 2025.