









Post-harvest cherry tomatoes (*Lycopersicon esculentum*, Mill) under modified atmosphere packaging with application of sucralose and Instantgum BB®



Postcosecha de tomates cherry (*Lycopersicon esculentum*, Mill) en atmósfera modificada con aplicación de sucralosa e Instantgum BB®

Pós-colheita em tomates-cereja (*Lycopersicon esculentum*, Mill) na atmosfera modificada com aplicação de sucralose e Instantgum BB®

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Abstract

Cherry tomatoes (*Lycopersicon esculentum*, Mill.) were immersed in 1.5 % or 3 % sucralose solutions with 0.5 % Instantgum BB®, and stored under modified atmosphere conditions (11.9 °C and 73 % RH) in selectively permeable bags with CO₂ injection (450 mbar). Sensory attributes, nutritional parameters, and microbiological quality were assessed at 20 and 35 days. The treatments were as follows: T₀: no sucralose, no CO₂; T₁: CO₂ only; T₂: 1.5 % sucralose + 0.5 % Instantgum BB®, no CO₂; T₃: 1.5 % sucralose + 0.5 % Instantgum BB®, with CO₂; T₄: 3 % sucralose + 0.5 % Instantgum BB®, no CO₂; T₅: 3 % sucralose + 0.5 % Instantgum BB®, with CO₂. Thirteen panelists evaluated aroma, color, flavor, texture, appearance, and overall acceptability. The following were measured: vitamin C (mg.100 g⁻¹), total sugars (%), water content (%), titratable acidity (%), pH ([H⁺]), soluble solids (°Brix), and total coliform counts (CFU.g⁻¹). The experimental design was a randomized block design with 95 % confidence (p < 0.05). Results were analyzed using ANOVA. The combination of sucralose, Instantgum BB®, and CO₂ did not alter the nutritional status of the cherry tomatoes. Microbiological analysis showed counts <10 CFU.g⁻¹, within the limits established by the Chilean Food Sanitary Regulation. The cherry tomatoes showed no differences in appearance, with a score of 7 (“like moderately”). At 20 days, samples without CO₂ showed higher panelist acceptance (score 8: “like very much”) compared to those with CO₂ injection.

Resumen

Tomates cherry (*Lycopersicon esculentum*, Mill.) fueron sumergidos en concentraciones de 1,5 % ó 3 % de sucralosa, con 0,5 % de Instantgum BB®, almacenados en atmósfera modificada: 11,9 °C y 73 % HR, en bolsas de permeabilidad selectiva, con inyección de CO₂ (450 mbar), midiendo atributos sensoriales, parámetros nutricionales y microbiológicos a los 20 y 35 días. Los tratamientos fueron: T₀: sin sucralosa, sin CO₂; T₁: solo CO₂; T₂: 1,5 % de sucralosa + 0,5 % de Instantgum BB®, sin CO₂; T₃: 1,5 % de sucralosa + 0,5 % de Instantgum BB®, con CO₂; T₄: 3 % de sucralosa + 0,5 % de Instantgum BB®, sin CO₂; T₅: 3 % de sucralosa + 0,5 % de Instantgum BB®, con CO₂. Trece panelistas evaluaron: aroma, color, sabor, textura, apariencia y aceptabilidad. Se midió: vitamina C (mg.100 g⁻¹), azúcares totales (%), agua (%); acidez titulable (%), pH ([H]⁺), sólidos solubles (°Brix) y recuentos de coliformes totales (UFC.g⁻¹). El diseño experimental fue un bloque al azar, con 95 % de confianza (p<0,05). Los resultados fueron evaluados con ANDEVA. La sucralosa con Instantgum BB® y CO₂, no alteraron el estado nutricional de los tomates cherry. El análisis microbiológico fue <10 UFC.g⁻¹, según rango del Reglamento Sanitario de los Alimentos de Chile. Los tomates cherry no exhibieron diferencias en apariencia con valoración de 7, ("me gusta moderadamente"). A los 20 días, sin CO₂, presentaron mayor aceptación de panelistas (8: "me gusta mucho") versus sin inyección de CO₂.

Palabras clave: atributos sensoriales, climaterio, contenido nutricional.

Resumo

Tomates-cereja (*Lycopersicon esculentum* Mill.) foram imersos em soluções de sucralose a 1,5 % ou 3 % com 0,5 % de Instantgum BB®, armazenados em atmosfera modificada (11,9 °C e 73 % UR) em sacos seletivamente permeáveis com injeção de CO₂ (450 mbar), e os atributos sensoriais, parâmetros nutricionais e microbiológicos foram medidos aos 20 e 35 dias. Os tratamentos foram: T₀: sem sucralose, sem CO₂; T₁: apenas CO₂; T₂: 1,5 % de sucralose + 0,5 % de Instantgum BB®, sem CO₂; T₃: 1,5 % de sucralose + 0,5 % de Instantgum BB®, com CO₂; T₄: 3 % de sucralose + 0,5 % de Instantgum BB®, sem CO₂; T₅: 3 % de sucralose + 0,5 % de Instantgum BB®, com CO₂. Treze provadores avaliaram aroma, cor, sabor, textura, aparência e aceitabilidade. Foram mensurados: vitamina C (mg.100 g⁻¹), açúcares totais (%), água (%), acidez titulável (%), pH ([H]⁺), sólidos solúveis (°Brix) e contagem total de coliformes (UFC.g⁻¹). O delineamento experimental foi em blocos casualizados com nível de confiança de 95 % (p < 0,05). Os resultados foram avaliados por meio de ANOVA. A sucralose com Instantgum BB® e CO₂ não alterou o estado nutricional dos tomates-cereja. A análise microbiológica apresentou <10 UFC.g⁻¹, de acordo com os limites estabelecidos pela Vigilância Sanitária de Alimentos do Chile. Os tomates-cereja não apresentaram diferenças na aparência, com nota 7, ("gostei moderadamente"). Aos 20 dias, sem a injeção de CO₂, apresentaram maior aceitação pelos provadores (8: "gostei muito") em comparação com os tomates sem injeção de CO₂.

Palavras-chave: atributos sensoriais, climatério, conteúdo nutricional.

Introduction

The main destination for this vegetable like tomato cv. Regy (*Lycopersicon esculentum* Mill.) is the domestic market (Odepa, 2015). Exports do not exceed 1 % of production, with the main destinations being Argentina, Uruguay, and the United Kingdom (Odepa, 2015, 2016).

The tomato is a climacteric fruit (Velásquez *et al.*, 2024); although different techniques have been implemented to prolong its postharvest life, it continues to present losses, leading to the joint use of different technologies. Edible films (EF) and coatings (EC) have shown an improvement in the sensory and nutritional quality of fruit and vegetable products (Abbas *et al.*, 2024).

Actually, the losses observed during fruit transport and storage are the main causes affecting sensory attributes and nutritional content, shortening tomato quality during postharvest.

The hypothesis proposed that active modified atmosphere packaging during postharvest, combined with the application of sucralose and Instantgum BB® on cherry tomatoes cv. Regy (*Lycopersicon esculentum* Mill.), improves sensory quality and safety while preserving nutritional content.

Accordingly, the objective was to evaluate the effect of sucralose and Instantgum BB® on sensory attributes, total coliform presence, and nutritional quality, including vitamin C, total sugars, moisture content, and physicochemical parameters (pH, acidity, and soluble solids), in cherry tomatoes stored under active modified atmosphere conditions.

Materials and methods

Study area

The trial was carried out at the Catholic University of Maule (UCM), San Isidro Campus, Los Niches, Curicó Commune, Maule Region (35°02' SL; 71°19' WL, altitude XX m.a.s.l.), where the laboratory analyses were also performed. The Cherry tomatoes cv. Regy, produced through conventional greenhouse management, were acquired in the commune of Limache, Valparaíso Region.

The climate of the area is warm temperate with a prolonged dry season and abundant cloudiness in the dry season; with average precipitation and temperatures of 462 mm and 14.4 °C, respectively (Uribe *et al.*, 2012). The soil described by CIREN (1997) belongs to the Lo Vásquez series, corresponding to "sandy clay loam". Loam superficially, moderately deep, and with good drainage.

Material and methods

Flow diagram with the essay realized with cherry tomatoes (Figure 1).

Application of treatments

Two replications were performed for each treatment, with fruits analyzed at 20 and 35 days of storage (Table 1).

Sensory evaluation

Cherry tomatoes were chosen at random from each of the respective treatments and after 7 days at room temperature (≈20 °C). Thirteen semi-trained panelists participated, evaluating the perception of attributes: aroma, color, flavor, and texture, using unstructured and structured sensory evaluation cards (Stone and Sidel, 2004; Wittig, 2001).

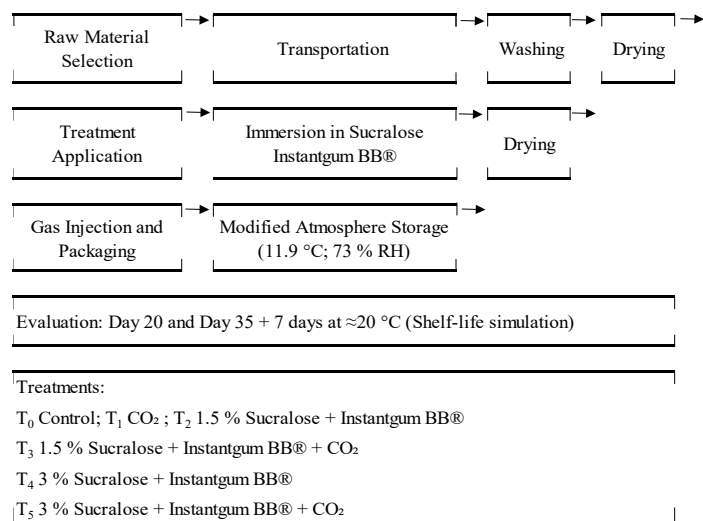


Figure 1. Lateral flow diagram to cherry tomatoes (*Lycopersion esculentum* Mill.) c.v. Regy, treated with sucralose, Instantgum BB®, and CO₂ under modified atmosphere storage with San Jorge Packaging S.A. selective permeability bags, in Los Niches, Curricó Commune, Maule Region, Chile.

Table 1. Applied concentrations of sucralose with Instant gum BB®, vacuum, and CO₂ to cherry tomatoes (*Lycopersion esculentum* Mill.) c.v. Regy, in Los Niches, Curricó Commune, Maule Region, Chile.

Treatments	Sucralose concentration (%)	Instantgum BB® Concentration (%)	Vacuum (mbar)	CO ₂ concentration (mbar)
T ₀	0	0	400	----
T ₁	0	0	450	450
T ₂	Solution at 1.5	0.5	400	----
T ₃	Solution at 1.5	0.5	450	450
T ₄	Solution at 3	0.5	400	----
T ₅	Solution at 3	0.5	450	450

Nutritional analysis

L-ascorbic acid content (Vitamin C)

The determination of vitamin C was performed by titration of 2,6 Dichlorophenolindophenol (DFI) (AOAC 967.21, 2023).

Total sugars

The determination of total sugars (%) was according to the Lane and Eynon volumetric method, approved by AOAC 923.09 (2023); however, sample clarification was modified and performed with activated carbon (Soto, 2007).

Water content

The sliced sample for each treatment and replication was placed in the oven (Binder, model FD115) at 65 °C for 35 hours (Petruzzi *et al.*, 2005), with the difference between wet and dry weight providing the moisture content of the cherry tomato.

Chemical parameters

pH

The pH was determined using a calibrated pH-meter (Hamna HI8424, made in Rhode Island, EE.UU.) utilized 30 mL of tomato juice obtained with a juice extractor (model Thomas TH-2660i, China); filtered with muslin.

Titrateable acidity

Acidity was determined using the official method AOAC 942.15 (2023).

Soluble solids

The determination of soluble solids was performed according to method AOAC 932.12 (2023), using a refractometer (Milwaukee MA871, Szeged, Hungary) (0 to 85 °Brix).

Safety analysis

The presence of total coliforms was evaluated through a microbiological analysis performed by Quality Lab C.A., according to the Food Sanitary Regulations (Ministerio de Salud de Chile, 2021).

Experimental design and statistical analysis

Treatments T₀, T₁, T₂, T₃, T₄, and T₅ were carried out with two replications each, where the experimental unit consisted of 11 Cherry tomatoes cv. Regy in selective permeability bags adjusted to 2000 mL each, which were stored in a cool environment. Experimental measurements for the trial were taken at 20 and 35 days of storage. Sensory evaluations were performed with 7 days at room temperature (≈ 20 °C), additional to the 20 and 35 days of storage. A randomized block experimental design was used with 95 % confidence (p ≤ 0.05). Analysis of variance (ANOVA) was carried out using the statistical software InfoStat, in addition to evaluating significance through Tukey and Kruskal-Wallis tests, for parametric and non-parametric values, respectively. The Shapiro-Wilk test was used for normality assessment.

Results and discussion

Panelists reported the highest aroma acceptance in the treatment containing 1.5% sucralose, Instantgum BB®, and 450 mbar CO₂ (T₃), whereas the lowest aroma scores were associated with tomatoes lacking both sucralose and Instantgum BB®, despite being subjected to the same CO₂ level (450 mbar; T₁). Aroma perception was not significantly affected by storage duration (20 vs. 35 days) or CO₂ application, as no statistical differences were observed among treatments for these factors.

Fernández Váldez *et al.* (2015) suggest that the use of edible coatings (EC) enhances the release and perception of volatile compounds, an effect that is further intensified by oral processing, particularly through mastication and saliva–matrix interactions. This mechanism may explain the higher sensory acceptance observed among panelists (Table 2 and 3).

Color

Higher color intensity was observed in tomatoes stored for 20 days without CO₂ (T₀ and T₂), with a mean score of 7.08 on the 13 cm scale. In contrast, fruit stored under 450 mbar CO₂ for 35 days exhibited lower color intensity (mean: 4.57). These differences indicate that both storage time and CO₂ significantly influence color development, likely due to delayed accumulation of carotenoids such as lycopene and β-carotene under modified atmosphere conditions (López Valenzuela *et al.*, 2011).

Table 2. Treatment means and storage period (days) for aroma, color, flavor, and texture attributes, obtained through sensory analysis of cherry tomatoes (*Lycopersion esculentum* Mill.) c.v. Regy, in Los Niches, Curricó Commune, Maule Region, Chile.

Treatment	Storage	Aroma	Color	Flavor	Texture
T ₀	20	5.1 de	6.4 cd	5.0 a	2.5 a
	35	4.9 cde	6.5 d	4.6 a	4.1 bcd
T ₁	20	3.2 a	7.8 e	7.0 bcd	2.8 ab
	35	3.9 abc	3.8 a	4.6 a	3.8 abcd
T ₂	20	5.4 ef	8.5 e	7.3 cd	3.5 abc
	35	3.7 ab	5.6 bc	5.5 abc	4.5 cd
T ₃	20	5.5 ef	4.6 ab	5.4 ab	4.4 bcd
	35	6.0 f	4.5 ab	8.1 d	6.4 e
T ₄	20	4.4 bcd	6.4 cd	4.6 a	3.9 abcd
	35	4.9 cde	5.5 bcd	8.2 d	5.4 de
T ₅	20	4.6 bcd	6.2 cd	6.1 abc	5.3 de
	35	4.6 bcd	5.4 bc	6.4 abcd	4.3 bcd

Means with different letters indicate significant differences ($p < 0.05$).

Table 3. Treatment means and storage period (days) for appearance and acceptability attributes, obtained through sensory analysis.

Treatment	Storage	Appearance	Acceptability
T ₀	20	7.1	6.9 c
	35	7.1	7.1 c
T ₁	20	6.8	5.9 ab
	35	7.1	6.3 bc
T ₂	20	7.0	6.9 c
	35	7.6	6.9 c
T ₃	20	7.2	6.5 bc
	35	6.8	5.1 a
T ₄	20	7.0	6.9 c
	35	7.4	5.4 ab
T ₅	20	7.2	6.7 c
	35	7.7	6.6 c
Mean		7.2	6.4
Verbal-numerical scale		7	6

Means with different letters indicate significant differences ($p < 0.05$).

Flavor

Greater bitterness was detected in treatments combining sucralose and Instantgum BB®, particularly under 450 mbar CO₂ (T₃) and in the absence of CO₂ at higher sucralose concentration (T₄). Flavor perception is closely associated with the balance between sugars and titratable acidity, as well as the contribution of volatile compounds to overall sensory expression (Zhang *et al.*, 2024).

Texture

Tomatoes without sucralose addition (T₀ and T₁) showed the highest turgidity, whereas treatments containing sucralose and Instantgum BB® (T₂–T₅) were associated with reduced firmness. Panelists consistently perceived these treatments as more flaccid. This effect may be related to the barrier properties of polysaccharide-based edible coatings, which modify gas exchange and, together with CO₂ exposure, can negatively impact tissue firmness (Fernández Vázquez *et al.*, 2015).

Appearance

No significant differences in overall appearance were detected (Kruskal–Wallis test), with panelists rating samples around “like moderately” on the hedonic scale. Despite this, previous studies suggest that elevated CO₂ may help preserve visual attributes such as color and firmness over extended storage periods (Gómez and Camelo, 2002).

Acceptability

Significant differences in overall acceptability were observed among treatments ($p = 0.0001$). The highest acceptability was recorded in tomatoes without CO₂ injection, whereas the lowest scores corresponded to treatment T₃ (1.5 % sucralose + 0.5 % Instantgum BB® under 450 mbar CO₂) after 35 days of storage (Table 3). On the verbal–numerical scale, the most accepted samples reached a score of 7 (“like moderately”), while the least accepted were rated at 6 (“like slightly”).

Although CO₂ application contributed positively to attributes such as color and firmness, this did not translate into improved overall acceptability. In particular, flavor perception in treatment T₃ was not enhanced by the modified atmosphere or CO₂ injection, consistent with findings reported by Gómez and Camelo (2002).

Nutritional and chemical analyses

Vitamin C

Statistical analysis revealed no significant effects of the interaction between sucralose concentrations, Instantgum BB®, CO₂ injection, and storage time on ascorbic acid content (data not shown). However, mean vitamin C levels across treatments decreased over storage, reaching 2.37 mg.100 g⁻¹ at 20 days and 1.88 mg.100 g⁻¹ at 35 days. These values correspond to 17.3 % and 13.7 %, respectively, of the average ascorbic acid content in fresh tomatoes (13.7 mg.100 g⁻¹) reported by USDA (2017).

According to Xueon *et al.* (2025), low storage temperatures (4 °C and 14 °C) are effective in preserving tomato appearance and total soluble solids (TSS). Moreover, storage at 4 °C significantly delays the degradation of ascorbic acid, thereby contributing to improved nutritional retention.

Total sugars

Total sugar content in cherry tomatoes exhibited a normal distribution, with no significant differences among treatments ($p = 0.3432$), averaging 1.3 g.100 g⁻¹. USDA (2017) reports an average total sugar concentration of 2.63 g.100 g⁻¹ in ripe tomatoes, which is higher than the values observed in this study. This discrepancy may be attributed to genotypic variability, as sugar accumulation is strongly dependent on cultivar.

Water content

The moisture percentages obtained in the analyses showed that there were no significant differences ($p = 0.6180$) between treatments, nor influence of CO_2 or the sucralose mixture with Instantgum BB® applied. The mean obtained was 93.39 % water stored at 11.9 °C and 73 % RH. The results obtained are similar to those described by USDA (2017), which indicates means for green and red ripe tomatoes of: 93 and 94.5 %, respectively. For instance, comprehensive quality assessments conducted by Li *et al.* (2025) and Zhang *et al.* (2023) confirm that both standard and cherry tomatoes retain moisture levels within this range, reflecting their high cellular water fraction and low dry matter content. Similar values have also been reported for cherry tomato cultivars stored under controlled conditions, supporting the characterization of tomato as a high-moisture commodity and validating the observed results within the context of current postharvest quality literature pH.

pH

The hydrogen ion concentration (pH) present in the analyzed cherry tomatoes did not present significant differences between treatments ($p = 0.2936$), as a response to the presence or absence of sucralose with Instantgum BB®, CO_2 , or variation in storage time. The mean pH obtained for the 6 treatments was 4.3; similar to those recorded by Monge Pérez (2015) in 60 tomato genotypes grown under greenhouse conditions (3.52 to 4.82).

Titrateable acidity

Tomatoes with application of sucralose and Instantgum BB®, injection of 450 mbar of CO_2 , and a storage time of 35 days; presented a citric acidity higher than those without sucralose and Instantgum BB®, without CO_2 , and with 20 days of storage. Cherry tomatoes without sucralose and Instantgum BB® (T_0 and T_1) presented a lower percentage of acidity in relation to those with 1.5 and 3 % sucralose and Instantgum BB®. The acidity range for the trial was from 0.35 to 0.50; regardless of the treatment and storage period; similar to that described by San Martín-Hernández *et al.* (2012), who recorded a mean TA of 0.61 for tomatoes cv. Caimán.

Soluble solids

The data obtained in the measurement of soluble solids presented a non-parametric distribution, therefore the significance of the results was evaluated with the Kruskal-Wallis test. Said test showed that there were no significant differences ($p = 0.6441$) between the TSS of the tomatoes, obtaining a mean of 5.1 °Brix in the trial. Recent studies indicate that the application of starch-based edible coatings, in combination with storage duration, does not inhibit changes in sugar concentration in tomatoes but rather moderates the rate at which total soluble solids (TSS) increase during postharvest storage. Experimental evidence reported by Garnida *et al.* (2022) and Wibowo *et al.* (2023) shows that coated tomatoes exhibit a gradual rise in °Brix values associated with normal ripening, while differences among treatments are often limited or not statistically significant. Similarly, Tchouala-Tazo *et al.* (2023) demonstrated that starch-based formulations delay ripening kinetics without producing marked alterations in TSS compared to uncoated fruits. More recent findings by Yadav *et al.* (2024) further confirm that starch-based edible coatings act as semi-permeable barriers that reduce respiratory activity and slow soluble sugar accumulation, thereby modulating metabolic changes rather than fully stabilizing sugar concentration during storage.

Safety analysis

The total coliform count analyses performed on cherry tomatoes cv. Regy indicated that all treatments equally presented $<10 \text{ CFU.g}^{-1}$. This value is within the parameters described in Arts. 171, 172, and 173 for “Fresh Fruits and Vegetables” of the Food Sanitary Regulations (R.S.A.) (Ministerio de Salud de Chile, 2021). Recent studies confirm that *Escherichia coli* and *Salmonella* spp., continue to be used as key indicator microorganisms for assessing the microbiological quality and potential health risks of fresh vegetables, including tomatoes. Empirical evidence from Mexico shows that these indicators are routinely detected in produce and associated production environments, particularly irrigation water and agricultural soil, highlighting their relevance for food safety evaluation (Gutiérrez-Ibáñez *et al.*, 2022). Importantly, these studies emphasize that microbial counts may remain within regulatory limits while still posing potential sanitary concerns, especially when fecal indicators such as *E. coli* are present. Comprehensive reviews further indicate that the consistent implementation of Good Agricultural Practices across the production and handling chain is essential to minimize microbial contamination in fruits and vegetables (Beltrán-Palacios *et al.*, 2023). Although postharvest control strategies can contribute to limiting microbial proliferation, current evidence indicates that their effectiveness is highly dependent on storage and handling conditions, reinforcing the need for preventive measures throughout the food supply chain.

Conclusions

Sucralose with Instantgum BB® applied as an edible coating on cherry tomatoes showed improvements in some sensory aspects, did not exhibit significant differences in safety assessment, and maintained the nutritional properties of the tomatoes; therefore, the hypothesis is rejected.

Aroma and color were the attributes of highest intensity perceived by the panelists in cherry tomatoes with 1.5 % sucralose and addition of 0.5 % Instantgum BB® and 450 mbar of CO_2 . Flavor and texture were negatively affected by the amount of sucralose and Instantgum BB® applied, perceived by panelists from “faint or tasteless” to “sour”, for treatments with 3 % sucralose and 0.5 % Instantgum BB®; while turgid texture was diminished in treatments with sucralose plus Instantgum BB® and 450 mbar of CO_2 .

Sucralose with Instantgum BB® did not generate significant changes regarding the appearance of the tomatoes, according to the verbal-numerical scale of: 7 = “Like moderately”. The acceptability of the cherry tomatoes by the panelists was diminished, obtaining a valuation of 6 = “Like slightly”, consistent with the negative effect on flavor and texture attributes.

The nutritional content and chemical parameters analyzed were not affected by the application of the edible coating, excepting acidity; which presented an increase when increasing the concentration of sucralose in the EC mixture, CO_2 , and storage period in the tomatoes.

The microbiological analyses did not show changes in response to the application of sucralose with Instantgum BB® therefore, it is concluded that these would not impede or encourage the proliferation of pathogens during the postharvest of Cherry tomatoes.

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