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Effect of sanitizers on the sensory shelf-life of chia (*Salvia hispanica* L.) microgreens

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ABSTRACT

Objective: To compare the efficacy of different sanitizing agents in extending the sensory shelf life and maintaining the quality of chia (*Salvia hispanica* L.) microgreens in terms of overall quality, color, rot development and off-flavor.

Design/methodology/approach: Different parametric models (gamma, exponential, Weibull and log-logistic) were evaluated to determine the most appropriate one to analyze the sensory shelf life of treatments with sanitizing agents. The functions proposed by Guillermo Hough were used to calculate the sensory shelf life for each treatment. Finally, the Kruskal-Wallis test was used to compare the effects of the different sanitizing agents.

Results: Survival rates of microgreens varied according to the sanitizing agent used. On day two, sodium hypochlorite showed a survival rate of 80%, which decreased with time. On the other hand, colloidal silver reached a survival rate of 90% on day two, while calcium oxide saturated solution showed a survival rate of 85% in the same period. The control revealed a rate of 65% by day two, a lower percentage than the previous ones.

Limitations on study/implications: In this study, three sanitizers (colloidal silver, sodium hypochlorite and saturated solution of calcium oxide nanoparticles) were evaluated and other possible treatments or combinations of treatments that could be effective in preserving the quality and sensory shelf life of chia microgreens were not considered.

Findings/conclusions: The study revealed that colloidal silver treatment was the most effective in extending the sensory shelf-life of microgreens, with an estimated shelf life of 1.78 days at 10% rejection, followed by chlorine and saturated calcium oxide solution.

Keywords: microgreens, disinfectants, postharvest, shelf life, models.

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INTRODUCTION

Microgreens are gaining popularity in modern nutrition due to their high concentration of bioactive compounds. These plants are young and fragile vegetables with limited post-harvest life. Their optimal consumption period is usually between 7-21 days after harvest (Kyriacou *et al.*, 2016).

Since microgreens have young tissues at the time of harvest, they are highly susceptible to deterioration which is associated to a stress reaction more than to natural aging (Xiao *et al.*, 2016). Previous research has identified that, once they are cut, both pre- and post-harvest treatments, as well as packaging materials and packaging in a modified atmosphere, are determining factors of the shelf- life of microgreens (Kyriacou *et al.*, 2016).

The use of sodium hypochlorite in post-harvest washing has been shown to be beneficial for the visual quality and microbiological safety of microgreens, such as broccoli, by keeping them in optimal condition at 5 °C. Although it has been studied how the oxygen permeability of the packaging material affects the levels of CO_2 and O_2, this does not seem to have a significant impact on the shelf-life of the products. However, it has been confirmed that the temperature at which microgreens are stored is the most critical factor in preserving their freshness and prolonging their shelf-life (Ghoora *et al.*, 2020).

Sensory analysis supports the evaluation of food quality, allowing the identification of signs of deterioration and taking measures to preserve its integrity (Mondino *et al.*, 2023). The aim of the study was to determine the effect of different sanitizers on the sensory shelf-life of chia microgreens based on overall quality, rot development, color and unpleasant aroma.

MATERIALS Y METHODS

Materials

The sanitizers used in the study were: 1) sodium hypochlorite (Cloralex, Alen del Norte, S.A. de C.V. Mexico), 2) colloidal silver (Microdyn® Alen del Norte, S.A. de C.V, Mexico) and 3) calcium oxide nanoparticles (CONP, Oxical® Cal de Alta Pureza, Mexico) with a particle diameter of 90 nm and 95% purity.

Methods

Chia microgreen production

The production of chia (*Salvia hispanica*) microgreens was carried out in the facilities of the Facultad de Ciencias Biológicas y Agropecuarias of Universidad Veracruzana using a micro tunnel with a transparent plastic cover. Trays of 55 cm×28 cm×6 cm were used for microgreen growing. Sand was used as a substrate up to a height of 2.5 cm (approximately 1.30 Kg of substrate per tray). A total of 9 g of chia seeds were sown per tray. The seeds were distributed on the substrate and kept in darkness using a black plastic layer for three days to allow the seed germination (Kou *et al.*, 2013). After germination, the seedlings still in autotrophic condition were fed with a Soluponics® Standard A+B Universal hydroponic solution from Inverfarms Hidroponics (Mexico) applied daily by subirrigation until harvest.

Preparation of saturated calcium oxide solution

The calcium oxide saturated solution was prepared as follows: 100 g of CONP was mixed in 500 mL of distilled water and stirred for 30 min. It was then left to stand for 24 h and the precipitate was removed. The pH of the saturated solution was measured with a Thermo Scientific™ Orion™ 3-Star Plus potentiometer (USA). Subsequently, a portable refractometer HI96801 HANNA® (USA) was used to determine the percentage of soluble solids.

Harvest and storage of chia migrogreens

Microgreens were harvested using previously sterilized gloves and scissors. Microgreens were cut once they reached a height of 7 to 10 cm. After harvesting, they were treated with the sanitizers: 1) chlorinated water was prepared at a concentration of 200 ppm using sodium hypochlorite (Villenas *et al.*, 2010); 2) saturated solution of calcium oxide nanoparticles and 3) commercial disinfectant for vegetables (Microdyn® colloidal silver) at a concentration of 1 mL L^{-1} according to the manufacturer›s instructions. The immersion time of the microgreens in the sanitizers was 15 min. Additionally, a control group without sanitizing treatment was included in the study. After sanitizing, microgreens were dried on absorbent paper towels and placed in disposable 11 cm hinged dome-type polystyrene containers (code RB9X9, Reyma, Mexico) and stored at 4 °C. Storage was carried out for 5 days (Dayarathna *et al.*, 2023).

Determination of sensory shelf-life

To assess the sensory shelf life of chia microgreens, an evaluation was conducted with n=8 panelists who had prior experience with vegetable consumption. An information session introduced and defined the attributes under consideration, including overall quality, rot development, color, and unpleasant aroma (Mondino *et al.*, 2023). Participants rated their acceptance using a binomial scale (yes/no) and then assessed the intensity of each quality characteristic (overall quality, rot development, color, and unpleasant aroma) on a 5-point verbal scale (excellent, good, regular, bad, and very bad). Sample evaluations were performed every 24 hours in Current Status Data mode (Araneda, 2008).

Statistical analysis

The deterioration of microgreens was modeled using the acceptance data and different parametric models were employed: gamma, exponential, Weibull, and log-logistic. To identify the best model, the highest log-likelihood value of the regression was used. The sensory shelf-life values for each treatment were estimated using the function described by Hough (2010) for survival analysis in a Current Status Data design. The comparison among treatments based on the quality data (overall quality, rot development, color, and unpleasant aroma) measured on an ordinal scale was performed with the Kruskal-Wallis test.

RESULTS AND DISCUSSION

pH and soluble solids of the saturated solution of calcium oxide nanoparticles

The saturated solution of calcium oxide nanoparticles resulted with pH values of 12.1 and 0.5% soluble solids. However, this compound has been scarcely used in a nanometric form, so there is limited information on the subject (Roy *et al.*, 2011).

Evolution of deterioration of microgreens

Figure 1 shows the survival probabilities of microgreens treated with the different sanitizers from day zero to day four. Sodium-hypochlorite-treated microgreens decreased their survival rate to 80%. Those treated with colloidal silver reached 90% on day two, whereas those treated with saturated lime solution had an 85% survival rate on day two. The control treatment had a rate of 65% for day two. Storage temperature is crucial, with optimal ranges between 1 and 10 °C to maintain product quality (Priti *et al.*, 2022). However, other elements such as relative humidity, packaging material quality, and initial microbial load also play significant roles. These findings underline the importance of integrated cold chain management and hygienic practices to extend the shelf-life of these perishable products. The study conducted by Xiao *et al.* (2014) examined the postharvest preservation of radish microgreens, concluding that the optimal storage temperature is 1 °C. Furthermore, they indicated that the use of a chlorine solution at a concentration of 100 mg/L as a washing method considerably decreases the amount of microorganisms present (0.5 log CFU g^{-1}). However, they observed that the amount of microorganisms tends to increase after one week of storage.

Determination of sensory shelf-life

The shelf-life estimation using various sanitizers at various acceptance levels (90, 75, and 50%) is shown in Table 1. The treatment with saturated lime solution at 90% acceptance presented an estimated shelf life of 1.68 days. Calcium is essential to improve the nutritional quality and extend the postharvest life of fruits and vegetables (Aghdam *et al.*, 2012). Colloidal silver at 90% acceptance had a superior performance compared to chlorine and saturated lime solution with a shelf life of 1.78 days. As expected, the estimation in the control treatment at 90% acceptance resulted in a value of 1.42 days since no external factor was applied that could affect the shelf-life of the microgreens.

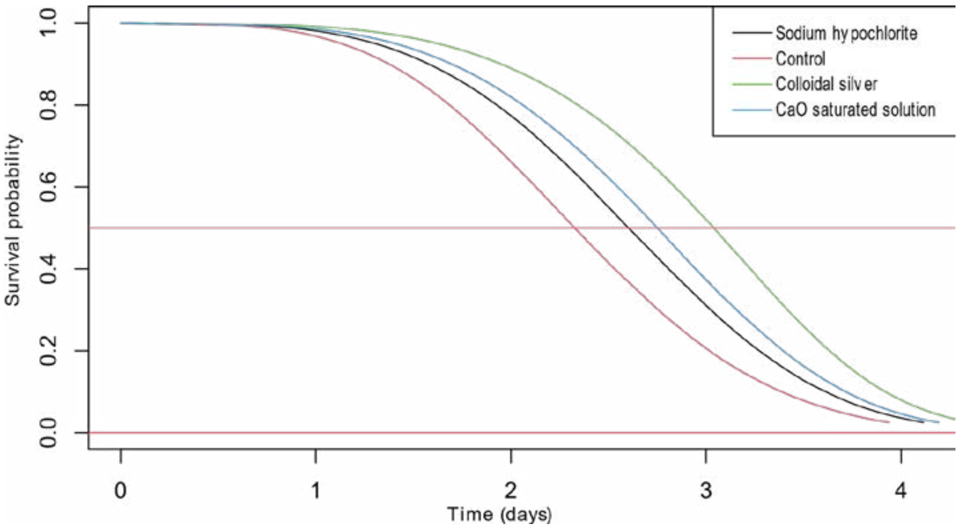

Figure 1. Evolution of microgreen survival probabilities for different treatments modeled with a Weibull function.

Table 1. Shelf life evaluation with different sanitizing agents using a Weibull model at various acceptance levels*.

	Percent Acceptance	**Shelf-Life (days)**	**Lower ci (days)**	**Upper ci (days)**	**Serror**
Sodium hypochlorite	90	1.63	1.25	2.11	0.22
	75	2.12	1.74	2.59	0.22
	50	2.68	2.27	3.16	0.23
Control	90	1.42	1.08	1.86	0.20
	75	1.85	1.49	2.29	0.20
	50	2.33	1.94	2.80	0.22
Colloidal silver	90	1.78	1.38	2.29	0.23
	75	2.32	1.91	2.83	0.23
	50	2.93	2.47	3.48	0.26
CaO saturated Solution	90	1.68	1.30	2.17	0.22
	75	2.19	1.80	2.67	0.22
	50	2.76	2.34	3.26	0.23

Lower ci=lower confidence interval; Upper ci=Upper confidence interval; Serror=standard error.

Colloidal silver (Microdyn®) is widely used in Mexico (Rangel-Vargas *et al.*, 2017). In their study with drug-resistant *Salmonella serotypes* (M-RSs) isolated from cilantro, they found that extracts from hibiscus flower calyx can be as effective as colloidal silver for the control of these pathogens.

Data analysis using the Kruskal-Wallis test indicated that consumers did not detect differences among treatments in terms of overall quality, rot development, color and unpleasant aroma, but they did detect deterioration in these variables over the days ($p\text{-value} < 0.05$).

CONCLUSIONS

The deterioration of microgreens was adequately modeled with a Weibull function. The difference between treatments was significant. Colloidal silver extended the sensory shelf-life of microgreens up to 1.78 days whereas the saturated solution of calcium oxide nanoparticles up to 1.68 days at 90% acceptance. The panelists were able to identify the deterioration of microgreens over time. The use of sanitizing agents is essential to maintain the quality of microgreens during their postharvest period.

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REFERENCES

Aghdam, M. S., Hassanpouraghdam, M. B., Paliyath, G., & Farmani, B. (2012). The language of calcium in postharvest life of fruits, vegetables and flowers. *Scientia Horticulturae*, 144, 102-115, https://doi.org/10.1016/j.scienta.2012.07.007

Araneda, M., Hough, G., & De Penna, E. W. (2008). Current-Status Survival Analysis Methodology Applied to Estimating Sensory Shelf Life of Ready-To-Eat Lettuce (*Lactuca sativa*). *Journal of Sensory Studies, 23*(2), 162–170, https://doi.org/10.1111/j.1745-459X.2007.00140.x

Dayarathna, N. N., Gama-Arachchige, N. S., Damunupola, J. W., Xiao, Z., Gamage, A., Merah, O., & Madhujith, T. (2023). Effect of storage temperature on storage life and sensory attributes of packaged mustard microgreens. *Life, 13*(2), 393, https://doi.org/10.3390/life13020393

Ghoora, M. D., Babu, D. R., & Srividya, N. (2020). Nutrient composition, oxalate content and nutritional ranking of ten culinary microgreens. *Journal of Food Composition and Analysis*, 91, 103495, https://doi.org/10.1016/j.jfca.2020.103495

Hough, G. (2010). Survival analysis continued. In: Sensory shelf-life estimation of Food products. CRC Press: Boca Raton. 255 p.

Kou, L., Luo, Y., Yang, T., Xiao, Z., Turner, E. R., Lester, G. E., Wang, Q., & Camp, M. J. (2013). Postharvest biology, quality and shelf life of buckwheat microgreens. *LWT-Food Science and Technology, 51*(1), 73-78, https://doi.org/10.1016/j.lwt.2012.11.017

Kyriacou, M. C., Rouphael, Y., Di Gioia, F., Kyratzis, A., Serio, F., Renna, M., de Pascale, S., & Santamaria, P. (2016). Micro-scale vegetable production and the rise of microgreens. *Trends in Food Science and Technology*, 57, 103-115, https://doi.org/10.1016/j.tifs.2016.09.005

Mondino, M. R., Cuggino, S. G., & Kopp, S. B. (2023). Análisis sensorial y determinación de vida útil de rúcula "baby leaf" obtenida en una producción hidropónica. *Nexo Agropecuario, 11*(2), 24-29.

Priti, Sangwan, S., Kukreja, B., Mishra, G. P., Dikshit, H. K., Singh, A., Aski, M., Kumar, A., Taak, Y., Stobdan, T., Das, S., Kumar, R. R., Yadava, D. K., Praveen, S., Kumar, S., & Nair, R. M. (2022). Yield optimization, microbial load analysis, and sensory evaluation of mungbean (*Vigna radiata* L.), lentil (*Lens culinaris* subsp. *culinaris*), and Indian mustard (*Brassica juncea* L.) microgreens grown under greenhouse conditions. *PLoS ONE, 17*(5), e0268085, https://doi.org/10.1371/journal.pone.0268085

Rangel-Vargas, E., Gutiérrez-Alcántara, E.J., Gómez-Aldapa, C.A., Falfán-Cortés, R.N., Segovia-Cruz, J.A., Salas-Rangel, L.P., & Castro-Rosas, J. (2017). Antibacterial activity of roselle calyx extracts, sodium hypochlorite, colloidal silver and acetic acid against multidrug-resistant salmonella serotypes isolated from coriander. *Journal of Food Chemistry, 37*(2), e12320, https://doi.org/10.1111/jfs.12320

Roy, A., & Bhattacharya, J. (2011). Microwave-assisted synthesis and characterization of CaO nanoparticles. *International Journal of Nanoscience, 10*(03), 10 (03) 413-418, https://doi.org/10.1142/S0219581X11008150

Villenas, P., Luchsinger, L., Obando, J., Hinojosa, A., & Escalona, V. H. (2010). Efectos de diferentes sanitizantes en la calidad microbiológica de berros (*Nasturtium officinale* R. Br.) envasados en atmósfera modificada. *Revista Iberoamericana de Tecnología Postcosecha, 11*(2), 214-220.

Xiao, Z., Lester, G. E., Luo, Y., Xie, Z. K., Yu, L. L., & Wang, Q. (2014). Effect of light exposure on sensorial quality, concentrations of bioactive compounds and antioxidant capacity of radish microgreens during low temperature storage. *Food Chemistry*, 151, 472-479, https://doi.org/10.1016/j.foodchem.2013.11.086

Xiao, Z., Codling, E. E., Luo, Y., Nou, X., Lester, G. E., & Wang, Q. (2016). Microgreens of Brassicaceae: Mineral composition and content of 30 varieties. *Journal of Food Composition and Analysis*, 49, 87-93, https://doi.org/10.1016/j.jfca.2016.04.006