

**INFLUENCE OF ACOUSTIC WAVES ON THE SHELF-LIFE QUALITY OF  
OKRA (*Abelmoschus esculentus* L. Moench)**

**DANILYN M. PEREZ**

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## ABSTRACT

**PEREZ, DANILYN M.**, Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Munoz, Nueva Ecija, Philippines, **June 2023**, **INFLUENCE OF ACOUSTIC WAVES ON THE SHELF-LIFE QUALITY OF OKRA (*Abelmoschus esculentus L. Moench*)**

Adviser: JEFFREY A. LAVARIAS, Ph.D

Co-Adviser: ANDRES M. TUATES JR., Ph.D

Okra (*Abelmoschus esculentus L. Moench*), a widely used vegetable and possesses short shelf-life was treated with acoustic waves. This research study investigates the effects of acoustic waves on the shelf-life quality of okra. The objective was to assess the impact of acoustic wave treatment on key parameters related to okra's shelf-life, including surface color, firmness, and weight.

The okra samples were subjected to different durations of acoustic wave exposure: zero hours (controlled), four hours, and six hours. The samples were stored under two conditions: chilled and ambient. The effects of acoustic wave application were determined by measuring surface color, firmness, and weight.

Analysis of Variance (ANOVA) indicated that acoustic wave treatment had a significant effect on the shelf-life quality of okra. Compared to untreated samples, those exposed to acoustic waves exhibited minimal changes in surface color and maintained firmness over time in both chilled and ambient conditions. However, a significant difference in weight loss was observed only in the chilled condition. The shelf-life of acoustic wave-treated okra in the chilled condition extended up to 10 days while maintaining quality, whereas the untreated samples lasted for 8-9 days. In the ambient

condition, the shelf-life of acoustic wave-treated samples was 6 days, whereas the untreated samples lasted only 3-4 days.

This study contributes to our understanding of the potential benefits of acoustic wave treatment in preserving the shelf-life quality of okra. Further research is recommended to explore the optimal duration and intensity of acoustic waves for other crops.

Keywords: acoustic waves; okra,; shelf-life quality; surface color; firmness; weight loss

## LITERATURE CITED

- Ansari, A., Ahmad, E., Nazrussalam, N., & Singh, D. N. (2020). Evaluation of okra (*Abelmoschus esculentus* L. Moench) genotypes for important quantitative characters. *International Journal of Agricultural and Applied Sciences*, 1(1), 1–5. <https://doi.org/10.52804/ijaas2020.111>
- Artero, V. T., Cruz, F. J., Santos, V. M., & Bucayu-Laurent, J. P. (2016). Common, Tagalog, and Scientific Names of Fruits and Vegetables. Retrieved from [https://www.uog.edu/\\_resources/files/extension/Tagalog\\_Science\\_Names.pdf](https://www.uog.edu/_resources/files/extension/Tagalog_Science_Names.pdf)
- Asuncion, D., Lavarias, J., Tuates Jr, A., Somera, C. G., & Peneyra, R. (2020). Influence of acoustic waves on the shelf-life quality of broccoli (*Brassica oleracea* var. *italic*). *International Journal on Advanced Science, Engineering and Information Technology*, 10. Retrieved from [https://www.researchgate.net/publication/339817491\\_Influence\\_of\\_Acoustic\\_Waves\\_on\\_the\\_Shelf\\_Life\\_Quality\\_of\\_Broccoli\\_Brassica\\_oleracea\\_var\\_italic](https://www.researchgate.net/publication/339817491_Influence_of_Acoustic_Waves_on_the_Shelf_Life_Quality_of_Broccoli_Brassica_oleracea_var_italic)
- Bal, E. (2013). Effects of exogenous polyamine and ultrasound treatment to improve peach storability. *CHILEAN Journal of Agricultural Research*. 73 (4). <https://doi.org/10.4067/S0718-58392013000400016>
- Barett, D. M., Beaulieu, J., & Shewfelt, R. (2010). Color, Flavor, Texture, and Nutritional Quality of Fresh-Cut Fruits and Vegetables: Desirable Levels, Instrumental and Sensory M. Fruit and Vegetable Preservation Resources. Retrieved from <https://fruitandvegetable.ucdavis.edu/files/217117.pdf>
- Boyhan, G. E., Kelly, W. T., Krewer, G., & Taylor, K. (2009). Postharvest Handling and Transportation of Fruits and Vegetables. Retrieved from <https://esploro.libs.uga.edu/esploro/outputs/report/Postharvest-handling-and-transportation-of-fruits/9949316511502959/filesAndLinks?index=0>
- Braam, J., & G. Davis. (1990). In touch: plant response to mechanical stimuli. *New Phytol.* 165, 373–389.
- Brandenberger, Shrefler, Damicone, & Rebek. (2018). Okra Production. Oklahoma Cooperative Extension Service. Retrieved from <https://omni.okstate.edu/404/index.html>
- Cantwell, M. and T. Suslow. (2002). Okra: Recommendations for Maintaining Postharvest Quality. Retrieved from [https://postharvest.ucdavis.edu/Commodity\\_Resources/Fact\\_Sheets/Datastores/Vegetables\\_English/?uid=23andds=799](https://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/Datastores/Vegetables_English/?uid=23andds=799)

- Chowdhury, E. K., H. S. Lim, & H. Bae. (2014). Update on the effects of sound wave on plants. School of biotechnology, Yeungnam University, Gyeongsan 712- 749, Korea. Department of Applied Biology, Chungnam National University, Daejeon 305-764, Korea. <https://doi.org/10.5423/RPD.2014.20.1.001>
- Department of Agriculture (Philippines). (2020). Development of okra varieties for local and export markets shows promising results. Retrieved from <https://bar.gov.ph/index.php/media-resources/news-and-events/437-development-of-okra-varieties-for-local-and-export-markets-shows-promising-results>
- Department of Agriculture (Philippines). (2021). Philippines to start export of okra to Korea. Retrieved from <https://www.da.gov.ph/philippines-to-start-export-of-okra-to-korea/>
- D'Auria, M. (2021). Increase of the shelf-life of vegetables. *International Journal of Research Studies in Science, Engineering and Technology*, 8 (2), 9-11. <https://doi.org/10.22259/2349-476X.0802002>.
- Dhall, R. K., Sharma, S. R., and Mahajan, B. V. C. (2012). Development of post-harvest protocol of okra for export marketing. *Journal of Food Science and Technology*, 51(8), 1622–1625. <https://doi.org/10.1007/s13197-012-0669-0>
- DOST-PAGASA. (2022). Climate of the Philippines. *PAGASA*. Retrieved from <https://www.pagasa.dost.gov.ph/information/climate-philippines>
- El-Shaieny, A.-H. A. H., Abd-Elkarim, N. A. A., Taha, E. M., & Gebril, S. (2022). Bio-Stimulants Extend Shelf Life and Maintain Quality of Okra Pods. *Agriculture*, 12(10), 1699. <https://doi.org/10.3390/agriculture12101699>
- Finger, F. L., Della-Justina, M. E., Casali, V. W. D., & Puiatti, M. (2008). Temperature and modified atmosphere affect the quality of okra. *Scientia Agricola*, 65(4), 360–364. <https://doi.org/10.1590/S0103-90162008000400006>
- Finn, J. (2021). How Is Color Measured? Calculating Delta E - ALPOLIC®. Retrieved from <https://www.alpolic-america.com/blog/how-is-color-measured-calculating-delta-e/>
- Fogarty, E. (2022). What is an acoustic wave? All the Science. Retrieved from <https://www.allthescience.org/what-is-an-acoustic-wave.htm>
- Habtamu, F. G., Ratta, N., Desse Haki, G., Woldegiorgis, A., & Beyene, F. (2015). Nutritional Quality and Health Benefits of “Okra” (*Abelmoschus esculentus*): A

- Review. *International Journal of Nutrition and Food Sciences*, 4(2), 208. <https://doi.org/10.11648/j.ijnfs.20150402.22>
- Hardenburg, R.E., A.L. Watada, & C. Wang. (1986). The commercial storage of fruits, vegetables and florist and nursery stocks. Retrieved from <https://www.ars.usda.gov/is/np/CommercialStorage/CommercialStorage.pdf>
- Hassanien, R. H., Hou, T., Li, Y., & Li, B. (2014). Advances in Effects of Sound Waves on Plants. *Journal of Integrative Agriculture*, 13(2), 335–348. [https://doi.org/10.1016/S2095-3119\(13\)60492-X](https://doi.org/10.1016/S2095-3119(13)60492-X)
- Hellesund, S. (2019). Measuring the speed of sound in air using a smartphone and a cardboard tube. *Physics Education*, 54(3), 035015. <https://doi.org/10.1088/1361-6552/ab0e21>
- Karmakar, P.K. (2011). Acoustic wave. *Acoustic Wave: From Microdevices to Helioseismology* (2<sup>nd</sup> Edition), 78-122. <https://doi.org/10.5772/17765>.
- Kim, J. Y., Lee, J.-S., Kwon, T.-R., Lee, S., Kim, J.-A., Lee, G.-M., Park, S.-C., & Jeong, M.-J. (2015). Sound waves delay tomato fruit ripening by negatively regulating ethylene biosynthesis and signaling genes. *Postharvest Biology and Technology*, 110, 43-50. <https://doi.org/10.1016/j.postharvbio.2015.07.015>
- Mamaril, H. J. U., & Rosales, R. J. G. (2018). Productivity of Okra (*Abelmoschus esculentus* L. cv. *Smooth Green*) Using Application Frequency of Vermicompost Tea. *International Journal of Research in Agricultural Sciences*, 5, 78-83. Retrieved from <https://journals.indexcopernicus.com/api/file/viewByFileId/529763>
- Mohanta, T.P. (2007). Sound wave in plant growth regulation: a review of potential biotechnological applications. *The Journal of Animal Plant Science*. 28(1). Retrieved from <http://www.thejaps.org.pk/docs/v-28-01/01.pdf>
- Mopera, L. E. (2016). Food Loss in the Food Value Chain: The Philippine Agriculture Scenario. *Journal of Developments in Sustainable Agriculture*, 11, 8-16. Retrieved from [https://www.jstage.jst.go.jp/article/jdsa/11/1/11\\_8/\\_pdf](https://www.jstage.jst.go.jp/article/jdsa/11/1/11_8/_pdf)
- Mota, W. F. da, Finger, F. L., Cecon, P. R., Silva, D. J. H. da, Corrêa, P. C., Firme, L. P., & Mizobutsi, G. P. (2010). Postharvest conservation and quality of okra submitted to different temperatures and storage forms. *Horticultura Brasileira*, 28(1), 12–18. <https://doi.org/10.1590/S0102-05362010000100003>

- Musa, A. (2018). Sorting and Grading of Fruits and Vegetables in Basic ways. Basic Agricultural Study. Retrieved from <https://agriculturistmusa.com/sorting-and-grading-of-fruits-and-vegetables/>
- Nishani, S., Deshpande, S., & Gundewadi, G. (2017). Use of acoustics as non-destructive techniques: a review. *International Journal of Current Microbiology and Applied Sciences*, 6(6). Retrieved from <https://www.ijcmas.com/6-6-2017/Shrikrishna%20Nishani,%20et%20al.pdf>
- Paclibare, C. O., Lavarias, J. Jr., Andres, A., Somera, C. G., & Peneyra, R. (2019). Influence of acoustic waves on the shelf-life quality of white oyster mushroom (*Pleurotus florida*). *International Journal on Advanced Science, Engineering and Information Technology*, 9, 2122. <https://doi.org/10.18517/ijaseit.9.6.8365>
- Patel, N., Patel, N. L., & Sangani, S. L. (2016). Effect of post-harvest treatments, packaging materials, and storage conditions on the shelf life and quality of okra. *International Journal of Agriculture Sciences*, 8(52), 2601–2605.
- Philippine Statistics Authority. (2021). Crop Statistics of the Philippines 2016-2020. Retrieved <https://psa.gov.ph/sites/default/files/Crops%20Statistics%20of%20the%20Philippines%202016-2020.pdf>
- Philippine Statistics Authority. (2021). Supply Utilization Accounts, Philippines, 2018-2020. Retrieved from [https://psa.gov.ph/sites/default/files/SUA-2018-2020-ao13Nov\\_ONS-signed.pdf](https://psa.gov.ph/sites/default/files/SUA-2018-2020-ao13Nov_ONS-signed.pdf)
- Philippine Statistics Authority. (2023). Crop Statistics of the Philippines 2017-2021. In *Crops Statistics of the Philippines - National and Regional* (ISSN: 2012-0478). <https://psa.gov.ph/sites/default/files/Crops%20Statistics%20of%20the%20Philippines%202017-2021.pdf>
- Phimolsiripol, Y., & Suppakul, P. (2016). Techniques in Shelf-life evaluation of food products. *Reference Module in Food Science*. <https://doi.org/10.1016/B978-0-08-100596-5.03293-5>
- Phornvillay, S., Prongprasert, N., Wongs-Aree, C., Uthairatanakij, A., & Srilaong, V. (2020). Physio-biochemical Responses of Okra (*Abelmoschus esculentus*) to Oxidative Stress Under Low Temperature Storage. *The Horticulture Journal*, 89 (1) 69-77. <https://doi.org/10.2503/hortj.UTD-105>
- Post-Harvest Management Protocols. (n.d.). Maturity Indices of Okra. Retrieved from <https://www.cclrc.in/fruits-vegetables/Okra.pdf>

- Samira, A., Woldetsadik, K., & Workneh, T. S. (2011). Postharvest quality and shelf life of some hot pepper varieties. Retrieved from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3722400/>
- Santos, R. F. dos, Gomes-Junior, F. G., & Marcos-Filho, J. (2020). Morphological and physiological changes during maturation of okra seeds evaluated through image analysis. *Scientia Agricola*, 77(3). <https://doi.org/10.1590/1678-992x-2018-0297>
- Shen, D.-D., Li, X., Qin, Y.-L., Li, M.-T., Han, Q.-H., Zhou, J., Lin, S., Zhao, L., Zhang, Q., Qin, W., and Wu, D.-T. (2019). Physicochemical properties, phenolic profiles, antioxidant capacities, and inhibitory effects on digestive enzymes of okra (*Abelmoschus esculentus*) fruit at different maturation stages. *Journal of Food Science and Technology*, 56(3), 1275–1286. <https://doi.org/10.1007/s13197-019-03592-1>
- Taain, D., Jasim, A., Jameel, M., & Al-Hij, H. (2014). A study of storage behavior of okra fruits (*Abelmoschus esculentus* L. Moenth cv. Khnesri). *International Journal of Farming and Allied Sciences*. Retrieved from [https://www.researchgate.net/publication/311791428\\_A\\_study\\_of\\_storage\\_behavior\\_of\\_okra\\_fruits\\_Abelmoschus\\_esculentus\\_L\\_Moenth\\_cv\\_Khnesri](https://www.researchgate.net/publication/311791428_A_study_of_storage_behavior_of_okra_fruits_Abelmoschus_esculentus_L_Moenth_cv_Khnesri)
- Tanner, D. (2016). Impacts of storage on food quality. *Reference Module in Food Science*. Retrieved from <https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/shelf-life>
- Texture Analysis Professionals. (2018). Fruit Texture: How to assess skin strength and flesh firmness of whole fruits. Texture Analysis Professionals Blog: Fruit Texture: Retrieved from <https://textureanalysisprofessionals.blogspot.com>
- Watkins, C. B., & Nock J. (2012). Production guide for storage of organic fruits and vegetables. New York State Department of Agriculture and Markets, 10. Retrieved from [http://nysipm.cornell.edu/organic\\_guide/stored\\_fruit\\_veg.pdf](http://nysipm.cornell.edu/organic_guide/stored_fruit_veg.pdf)
- Watson, D., & Nasir, S. Z. (2019). What are Sound Transducers. The Engineering Projects. Retrieved from <https://www.theengineeringprojects.com/2019/09>