

**INFLUENCE OF ACOUSTIC WAVES ON THE SHELF LIFE QUALITY
OF BANANA (*Musa paradisiaca* L. *spp. sapientum* var. *lakatan*)**

DANISSE ANNE A. PATUNGAN

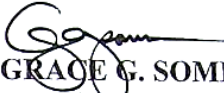
An Undergraduate Thesis Submitted to the Faculty of the Department of Agricultural
and Biosystems Engineering, College of Engineering, Central Luzon State
University, Science City of Muñoz, Nueva Ecija, Philippines
in Partial Fulfillment of the Requirements
For the Degree of

**BACHELOR OF SCIENCE IN AGRICULTURAL
AND BIOSYSTEMS ENGINEERING
(Agricultural and Bio-Process Engineering)**

JUNE 2019

ACCEPTANCE SHEET

This undergraduate thesis entitled, **INFLUENCE OF ACOUSTIC WAVES ON THE SHELF-LIFE QUALITY OF BANANA (*Musa paradisiaca* L. spp. *sapientum* var. *Lakatan*)**, prepared and submitted by **DANISSE ANNE A. PATUNGAN** in partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AGRICULTURAL AND BIO-PROCESS ENGINEERING)** is hereby accepted:


CAROLYN GRACE G. SOMERA, M.Sc.
Member, Advisory Committee

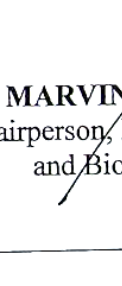
6/14/19
Date Signed


MELBA D. DENSON, M.Sc.
Member, Advisory Committee

6/14/19
Date Signed

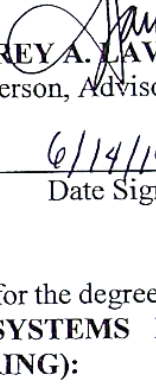

ANDRES M. TUATES, JR., M.Sc.
Co-chairperson, Advisory Committee

6/13/19
Date Signed



JEFFREY A. LAVARIAS, Ph.D.
Chairperson, Advisory Committee

6/14/19
Date Signed

Accepted as partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AGRICULTURAL AND BIO-PROCESS ENGINEERING)**:


MARVIN M. CINENSE, Ph.D.
Chairperson, Department of Agricultural
and Biosystems Engineering

6/14/19
Date Signed


VICTORINO T. TAYLAN, Ph.D.
Dean, College of Engineering

6/14/19
Date Signed

BIOGRAPHICAL SKETCH

The author, Danisse Anne Albay Patungan, was born on the 31st of August 1998 and lives in Poblacion North, Science City of Muñoz, Nueva Ecija. She is the eldest daughter of Mr. Roberto V. Patungan and Mrs. Imelda A. Patungan and twin sister of Danisse Grace A. Patungan.

In the year 2010, She finished her elementary education at Muñoz North Central School in Science City of Muñoz, Nueva Ecija. She took her secondary education at Muñoz National High School in Science City of Muñoz, Nueva Ecija.

She took up Bachelor of Science in Agricultural Engineering at Central Luzon State University in the year 2014 major in Agricultural and Bio-Process Engineering. She is a member of a collage-based student organization, Society of Agricultural Engineering Students - Philippine Society of Agricultural Engineering (SAGES-PSAE) Pre-professional Group since 2015. She was a player of Softball of the College of Engineering during intramurals year 2016 and Swimming on year 2017. She was also a university athlete of Swimming for the last two years of her study.

As an agricultural engineering student, she participated in various seminars and activities such as “The 67th PSAE Annual National Convention: Agricultural and Biosystems Engineers: Prime Movers for the Development and Management of Appropriate Engineering Technologies for Food Security” held on April 23-19, 2017 at Legazpi City Convention Center, Legazpi City, Albay, Bicol and the “The 21st PSAE-PPG Luzon Convention: Engaging PSAE-PPG towards Agricultural and Biosystems Engineering for Global Practice” held on December 12-14, 2017 at Central Luzon State University, Science City of Muñoz, Nueva Ecija.

ACKNOWLEDGEMENT

After a long run of struggle to meet the endpoint, success is almost at hand. The author wishes to express her profound gratitude and unending appreciation to the following people who in their own way or another have assisted, contributed and inspired them to make this simple piece of work a remarkable deed:

to Dr. Jeffrey A. Lavarias, chairperson of the advisory committee, and Engr. Andres M. Tuates Jr., co-chairperson of the advisory committee, for sharing his knowledge, guidance, full support in the conduct of the study, for their patience, for lending her some of the materials used during the conduct of the study, and for sparing their time for consultation due to their busy schedule;

to Engr. Carolyn Grace G. Somera and Engr. Melba D. Denson, members of the advisory committee, for their invaluable guidance, suggestions, comments and support which contributed to a significant improvement of the study;

to her loving parents, Roberto and Imelda Patungan, her twin sister Grace, her Aunt Myra, for all the hardship and sacrifice, for their unending support, morally, spiritually, and financially, for the unconditional love and care they have given her and for being the author's inspiration;

to her favorite person and number one fan, Christian Garcia, for the happiness, motivations, for being the shoulder to cry on when she lost the belief of finishing this thesis and also for being the author's inspiration;

to her closest friends, Art, Reñel, Hyleen, who unselfishly devoted their time, sweats, the never-ending support and bonding moments and memories which boosted her up and inspired her to continue on her pursue on the realization of this study;

to her teammates Geanne, Candace, Shaira and Ethyl for helping and giving her endless support during the conduct of the study;

to her thesis partners, Kimberly and Dominic, for supporting and giving her additional knowledge about this study and for all the days and night they have shared together guiding each other;

to the College of Engineering, especially the Department of Agricultural and Biosystems Engineering for sharing knowledge and concern to all students under their supervision;

to the Society of Agricultural Engineering Students - Philippine Society of Agricultural Engineers (SAGES-PSAE), partners for life, for the cheer ups, humors, love, and comradeship. The time spent with them can never be forgotten;

to all her BSABE 5 classmates who always pursued and encouraged her not to give up and continue to progress in times of hopeless days while doing all the requirements; and

to the Almighty God for His countless blessing, inspiration and guidance which gave courage and strength to the author to complete and pursue this study.

TABLE OF CONTENTS

	PAGE
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF APPENDIX TABLES	xii
LIST OF APPENDIX FIGURES	xiii
ABSTRACT	xiv
INTRODUCTION	1
Background of the Study	1
Statement of the Problem	3
Significance of the Study	4
Objectives of the Study	5
Scope and Limitation of the Study	5
Time and Place of the Study	6
REVIEW OF LITERATURE	7
Banana	7
Production of Banana in the Philippines	7
Morphological Description of Lakatan Banana	7
Maturity and Quality Indices of Banana	8
Maturity Indices of Banana	8
Quality Indices of Banana	9
Storage Requirements of Banana	10
Respiration and Ethylene Production of Banana	10
Responses to Ethylene	11
Physiological and Physical Disorders in Banana	11
Chilling Injury	12
Skin Abrasions	12
Impact Bruising	12

Storage	13
Purpose of Storage	13
Traditional Storage	14
Factors Affecting Storage	15
Temperature	15
Relative Humidity	15
Atmospheric Composition	16
Light and Other Factors	16
Acoustic Waves	17
Acoustic Absorption	17
Acoustic Waves on Plants	18
Measuring Sounds	18
Frequency	18
Decibel	19
Physicochemical Properties of Banana	19
Surface Color	20
Total Soluble Solid	20
Mechanical Property of Banana	21
Firmness	21
Shelf Life	21
Equipment in the Application of Acoustic Waves	22
Soundproof Chamber	22
Transducer	22
Sound Level Meter	23
Chiller	23
Equipment to Determine the Physicochemical and Mechanical Properties of Banana	24
Chromameter	24
Penetrometer	25
Refractometer	26

METHODOLOGY	27
Conceptualization of the Study	27
Materials and Instrumentation	28
Preparation of the Set-up	29
Soundproof Chamber	29
Collection of Raw Materials	32
Banana	32
Exposure to Acoustic Waves and Storage of Banana	32
Determination of Physicochemical Properties of Banana	33
Surface Color	33
Total Soluble Solid Content	35
Determination of Physicochemical Properties of Banana	36
Firmness	36
Evaluating the Shelf Life of Banana	37
Evaluating Optimum Hours of Exposure to Banana	38
Statistical Design	38
Statistical Layout	39
RESULTS AND DISCUSSION	40
Physicochemical Properties of Banana	40
Surface color	40
Total soluble solid	42
Mechanical Property of Banana	45
Firmness	45
Shelf life	47
Optimum Hours of Exposure to Banana	49
SUMMARY, CONCLUSION AND RECOMMENDATION	51
Summary	51
Conclusion	52
Recommendations	53

LITERATURE CITED	54
APPENDICES	58
Appendix Tables	59
Appendix Figures	67

LIST OF TABLES

TABLE		PAGE
1	Description of numerical ratings for banana quality	9
2	Materials and Instrumentation	29
3	Change in color ΔE of banana samples at 9 th day of cold storage (13°C)	41
4	Total soluble solid content of banana samples at 9 th day of storage (13°C)	44
5	Change in firmness of banana samples at 9 th day of cold storage (13°C)	47

LIST OF FIGURES

FIGURES		PAGE
1	Fully ripe and overripe Lakatan Banana	8
2	Banana Maturity Indices	9
3	Frequency of sound	19
4	Conceptual framework of the study	28
5	Schematic diagram of soundproof chamber	30
6	Sound transducer	31
7	Sound level meter	32
8	Samples Used	32
9	Chromameter	34
10	Penetrometer	35
11	Pocket Refractometer	36
12	Banana ripeness scale and color palette	37
13	Statistical layout of the study	39
14	Changes in Hunter 'b' values of banana fruit surfaces during storage at 13°C after sound treatment	40
15	Total soluble solid content changes in banana fruits during storage at 13°C	
16	Firmness of banana fruit during storage at 13°C after acoustic wave treatment	45
17	Comparison of fruit surface color change in response to various sound treatments in banana stored at 13°C.	48

LIST OF APPENDIX TABLES

APPENDIX TABLES		PAGE
1	Surface color of banana samples stored at chiller (13°C)	59
2	Change in color (ΔE) at 9 th day of storage of banana samples	61
3	Analysis of variance on the change in color of banana samples at 9 th day of storage	62
4	Comparison among means on the color of banana samples at 9 th day of cold storage	63
5	Firmness of the banana samples stored at chiller (13°C)	63
6	Change in firmness at 9 th day of storage of banana samples	64
7	Analysis of variance on the change in firmness of banana samples at 9 th day of storage	64
8	Comparison among means on the firmness of banana samples at 9 th day of storage (13°C)	65
9	Total soluble solid content of the banana samples stored at chiller (13°C)	66
10	Comparison among means on the total soluble solid contents of banana samples at 9 th day of storage (13°C)	66
11	Analysis of variance on the change in total soluble solid content of banana samples at 9 th day of storage	66

LIST OF APPENDIX FIGURES

APPENDIX FIGURES		PAGE
1	Banana samples used	67
2	Exposure of banana samples in acoustic waves at three chambers simultaneously.	67
3	Measuring the surface color of banana	68
4	Instrument used for measuring the pulp firmness of banana	68
5	Measuring the total soluble solid content of banana	69
6	Banana samples stored at chiller	69

ABSTRACT

PATUNGAN, DANISSE ANNE ALBAY, Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Muñoz, Nueva Ecija, **JUNE 2019, INFLUENCED OF ACOUSTIC WAVES ON THE SHELF LIFE QUALITY OF BANANA (*Musa paradisiaca* L. *spp. sapientum* var. *lakatan*).**

Adviser: JEFFREY A. LAVARIAS, Ph.D.

Co-adviser: ANDRES M. TUATES JR., M.Sc.

Banana fruits are highly demanded as nutritious and economically important fruit. However, they experience a different marketing problem (El-Naby, 2010). One of the limiting factors that influence the fruits' economic value is its relatively short shelf-life at ambient temperature, and most of the times, caused by postharvest processes such as handling and storage.

Acoustic waves is known for its desirable effects in extending the shelf life of a certain commodity during storage. Therefore it is seriously thought as to why these sound treatments which are reported to be effective for better storage of fruits could be tried for banana fruits and hence this study.

The study aimed to evaluate the influence of acoustic waves on the shelf-life quality of banana fruit. Specifically, the study would like to evaluate the effects of acoustic waves in the quality of banana in terms of surface color, firmness, total soluble solid content, and shelf life extension; and determine the optimum hours of exposure time of banana to acoustic waves that gives the longest shelf-life extension under refrigerated storage condition.

Half green half yellow banana were exposed to 1 KHz at 100 dB acoustic waves before storing in a chiller with temperature of 13°C. The banana fruits were exposed to acoustic waves at different durations: T1 (control treatment) – no exposure; T2 – 4 hours of exposure; T3 – 6 hours of exposure; and T4 – 8 hours of exposure. Banana fruits were evaluated in terms of surface color, firmness and total soluble solid content.

Results revealed that during storage, the surface color and firmness of banana fruits exposed for 6 hours was significantly better compared to other treatments. The skin color of banana in this treatment transitioned to brown at a slower rate. Additionally, the change in the firmness also slowed down. The shelf life of banana fruit exposed to 6 hours of acoustic waves lasted for 21 days before reaching unmarketable stage. Banana fruits which were not exposed to acoustic waves lasted only 9 days. The overall effect of 6 hours exposure time actually gave banana fruits an additional shelf life of 12 marketable days.

Keywords: banana; acoustic waves; shelf life

LITERATURE CITED

- ACMAS IN FRUIT PENETROMETER (2014). Fruit Penetrometer.
<http://www.acmasindia.com/blog/fruit-penetrometer>.
- ADIAHA, M. S. (2017). Complete Guide to Agricultural Product Processing and Storage. World Scientific News 81(1) (2017) 1-52.
<http://www.worldscientificnews.com/2017/07/WSN-811-2017-1-52.pdf>
- ADRIANO-ANAYA, M. D. L., KARINA, D., SALVADOR-FIGUEROA, M., VAZQUEZSHY, J. A., & Ov, I. (2012). Sensory and physico-chemical Quality of banana fruits Grand Naine grown with biofertilizer. African Journal of Agricultural Research, 7(33), 4620–4626.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5980282/>
- AGAR, LT., HESS-PIERCE, B., MASSANTINI, R., KADER, A.A. and (1999). Postharvest CO₂ and Ethylene Production and Quality Maintenance of Fresh-Cut Kiwifruit Slice. Journal of Food Science 64(3):433-440
- AMAGLO, H., ARAH, I. K., KUMAH, E.K., OFORI, H. (2015). Preharvest and Postharvest Factors Affecting the Quality and Shelf Life of Harvested Tomatoes: A Mini Review,” International Journal of Agronomy, vol. 2015, Article ID 478041, 6 pages, 2015. <https://doi.org/10.1155/2015/478041>.
- BIALE, J. AND YAUNG, R.E. (1981). Respiration and Ripening in Fruits Retrospect and Prospect. In: Recent Advances in the Biochemistry of Fruits and Vegetables. Friend, J. and Rhodes, M. J. C. (ed) Academic Press, London. ppl-39
- BRAAM, J. (2004). In touch: plant response to mechanical stimuli. New Phytologist., 165, pp. 373-389. Retrieved on data from web address: <https://doi.org/10.1111/j.1469-8137.2004.01263.x>.
- CHANG, W.H., AND HWANG, Y.J. (1990). Effect of Some Inhibitors on Carbohydrate Content and Related Enzyme Activity during Ripening of Taiwan Northern Banana Fruit. Acta Horticulturae 275:611-619.
[doi=10.1.1.1016.6613&rep=rep1&type=pdf](https://doi.org/10.1111/j.1469-8137.2004.01263.x)
- CRISOSTO, C. H., CRISOSTO, G. H. and METHENEY, P. (2003). Consumer acceptance of “Brooks” and “Bing” cherries is mainly dependent on fruit SSC and visual skin color. Postharvest Biol. Technol. 28:159–167.
<http://www.fruitandvegetable.ucdavis.edu/files/217117.pdf>

- DADZIE, B.K & ORCHARD, J.E., 1997. Routine Post-harvest Screening of Banana/plantain Hybrids: Criteria and Methods. Volume 2 of Inibap technical guidelines. Bioversity International, pp. 7–9
<https://books.google.com.ph/books?id=HAhmtUjc8g0C&dq>
- DOWNEY, L. (2018). How to tell if a banana has gone bad.
<https://www.livestrong.com/article/502059>.
- ELLYN, S. (2011). What are the health benefits of banana bread?. Retrieved on January 17, 2019. Accessed at <http://www.livestrong.com/article/268303-what-are-the-health-benefits-of-banana-bread/#ixzz2BVxmutdY>
- EL-NABY, S. K. M. A. (2010). Effect of postharvest treatments on quality aspect of Maghrabi banana fruit. *American-Eurasian Journal of Agricultural and Environmental Science*, 8(5), 582–587. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5980282/>
- FAO (2012). Food and Agriculture Organization of United Nations. Agriculture data base Prod STAT. Retrieved from <http://faostat.fao.org/site/339/default.aspx>
- FAO (2017). Food and Agriculture Organization. Section 7: Storage of horticultural crops.
[http://www.fao.org/WAIRdocs/x5403e/x5403e09.htm#controlledatmosphere\(c.a.\)](http://www.fao.org/WAIRdocs/x5403e/x5403e09.htm#controlledatmosphere(c.a))
- FERRIS, S., GAUHL, F., LAWRENCE, A., PASBERG-GAUHL, E., AND (1998). On-Farm Yield Loss Assessment of Black Sigatoka on Plantain and Banana. UTA Research Guide 67. Training Program, UTA, Ibadan, Nigeria. doi=10.1.1.1016.6613&rep=rep1&type=pdf.
- FFTC (Food and Fertilizer Technology Center), 2011. Postharvest Handling Losses in Different Asian Countries. Retrieved on February 2, 2019. Accessed at <http://www.ffc.agnet.org>.
- Food and Agriculture Organization (FAO). 2018. Banana Market Review 2017. Retrieved on January 10, 2019 from <http://www.fao.org/economic/est/est-commodities/bananas/bananafacts/en/#.XEn76FUzbIU>
<https://academic.oup.com/jxb/article/60/12/3311/522588>
- GHOSH R., MISHRA R.C., CHOI B., KWON Y.S., BAE D.W., PARK S.C. (2015). Corrigendum: exposure to sound vibrations lead to transcriptomic, proteomic and hormonal changes in Arabidopsis. *Sci. Rep.* 6:37484. 10.1038/srep37484

- GRIERSON, D. J., LIN, Z.F., ZHONG, S.L., (2009). Recent advances in ethylene research. *Journal of Experimental Botany*. Volume 60, Issue 12, August 2009, Pages 3311-3336 pp. 3311-3336.
- HARILL, R. (1998). Using a refractometer to test the quality of fruits & vegetables. Pineknoll publishing. <http://www.nutritionsecurity.org/PDF/Brix.pdf>
- HAUNG, R.Y., and SCOTT, K.J. ZHANG, D., (1993). Some Physiological and Biochemical Changes of "Green ripe" Bananas at Relative High Storage Temperatures. *Acta Horticulturae* 343:81-85 .
- HAYS, J. (2009). Bananas: their history, cultivation and production. Retrieved on January 10,2019 at <http://factsanddetails.com/world/cat54/sub343/item1577.html>
- HUBERT, O., LECHAUDEL, M., LUYCKX, A., (2016). Banana physiological post-harvest disorders: a review. *MOJ Food Process Technol.* 3(1):226–231. DOI: 10.15406/mojfpt.2016.03.00060. <https://www.hindawi.com/journals/ija/2015/478041/>
- JEONG, M. J. KIM, J. A., KIM, J. Y., KWON, T. R., LEE, G. M., LEE, J. S., LEE, S. I., PARK, S. C., (2015). Sound waves delay tomato fruit ripening by negatively regulating ethylene biosynthesis and signaling genes. *Postharvest Biology and Technology*, Volume 110, Pages 43-50. <https://doi.org/10.1016/j.postharvbio.2015.07.015>
- KADER, A. (1996). Banana: Recommendations for Maintaining Postharvest quality. http://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/Datastores/Fruit_English/?uid=9&ds=798 (Accessed January 19, 2019).
- KAYS, S. J. (1991). *Postharvest Physiology of Perishable Plant Products*. Nostrand Reinhold, New York. pp 1,229-247.
- KURTUS, R. 2009. Overview of Sound Waves. Retrieved on January 15, 2019. <http://www.school-for-champions.com/science/sound.htm#.Wd9mTGicZIU>.
- MISHRA, S., MOHAPATRA, D., & SUTAR, N. (2010). Banana and its by-product utilization: an overview. *Journal of scientific and industrial research*, 69(5):323-329. https://www.researchgate.net/publication/230650431_Banana_and_its_by-product_utilisation_An_overview.
- MOPERA, L. E. (2016). Food Loss in the Food Value Chain: The Philippine Agriculture Scenario. *Journal of Developments in Sustainable Agriculture* 11: 8-16. https://www.jstage.jst.go.jp/article/jdsa/11/1/11_8/_pdf

- MORTON, J. (1987). Banana. P. 29-46. In *Fruits of warm climates*. Julia F. Morton, Miami, FL. <http://www.hort.purdue.edu/necrop/morton/banana.html>
- PHILIPPINE STATISTICS AUTHORITY. Performance of Philippine Agriculture April to June 2017. Accessed at <http://psa.gov.ph.pdf>.
- NOVET, J. (2015). Look Inside Microsoft's Anechoic Chamber, Officially the Quietest Place on Earth. *VentureBeat*. Retrieved January 18 2019. Accessed at https://en.wikipedia.org/wiki/Anechoic_chamber
- RAO, C. G. (2015). *Engineering for storage of fruits and vegetables: cold storage, controlled atmosphere storage, modified atmosphere storage*. Academic Press, ISBN 0128033665 page 5. <https://books.google.com.ph/books?id=TbR7BgJ&on>
- RAPUSAS R.S., SERRANO E.P., 2010. Qualitative and Quantitative Loss Assessment of High Value Food Crops (mango, banana, calamansi, carrots, cabbage and onion). BPREUPLB. <http://www.bpreuplb.org/3/a-i3684e.pdf>
- ROBINSON, J. C., & SAÚCO, V. G. (2010). *Bananas and plantains*, Vol. 19. Cabi. <https://onlinelibrary.wiley.com/doi/pdf/10.1002/fsn3.591>
- SERRANO, E. P., 2006. Philippines In: *Postharvest Management of Fruit and Vegetables in the Asia-Pacific Region*. Japan: Asian Productivity Organization (APO). p. 216. <http://www.fao.org/docrep/014/mb060e/mb060e00.pdf>
- SHEWFELT, R. L. (2000a). Fruit and vegetable quality. In: *Fruit and Vegetable Quality: An Integrated View*. Shewfelt, R. L. and B. Bruckner (Eds.). Technomic Press, Lancaster PA, pp. 144–157. <http://www.fruitandvegetable.ucdavis.edu/files/217117.pdf>
- VERMA, L. R. (2000). *Postharvest Technology of Fruits and Vegetables: General concepts and principles*. Volume 1 of *Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation, and Waste Management*. Indus Publishing. Pp 96. <https://books.google.com.ph/books>