

**DEVELOPMENT OF ACTIVE ANTIOXIDANT AND ANTIMICROBIAL  
PACKAGING FILMS UTILIZING EXTRACTS FROM  
MANGO (*Mangifera indica* var. *carabao*) PEEL**

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An Undergraduate Thesis Submitted to the Faculty of the Department of Environmental  
Science, College of Arts and Sciences, 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 ENVIRONMENTAL SCIENCE  
(Environmental Chemistry)**

**JUNE 2019**

## ACCEPTANCE SHEET

This undergraduate thesis entitled "DEVELOPMENT OF ACTIVE ANTIOXIDANT AND ANTIMICROBIAL PACKAGING FILMS UTILIZING EXTRACT FROM MANGO (*Mangifera indica* var. *carabao*) PEEL," prepared and submitted by LILIANE M. SUAREZ, in partial fulfillment of the requirements for the degree of BACHELOR OF SCIENCE IN ENVIRONMENTAL SCIENCE, is hereby accepted.

  
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## **BIOGRAPHICAL SKETCH**

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## ACKNOWLEDGMENT

The author would like to express her earnest gratitude and appreciation to all of the individuals who generously supported in the completion of this proposal.

To Dr. Cesar V. Ortinero, the chairman of the Department of Environmental Science, her thesis adviser plus mentor, for his patience, guidance, ideas, trust and challenges for the development of the study.

To Dr. Danila S. Paragas, a faculty from the Department of Chemistry, her thesis critic for her never-ending support, suggestions, comments, encouragements, and offered a motherly care to the researcher from the beginning until the end of the study.

To Dr. Luzviminda S. Quito, the Department of Environmental Science Research Coordinator, for her assistance, comments, guidance, and unconditional efforts in reviewing the study.

To Christian G. Dela Cruz, Czelina Loren Ilagan, and Gemalyn Neuda, for all the concern, help, and tips they generously gave to all the struggling students of BS Chemistry and BSES during the conduct of their theses.

To the CAFES Fam, Jett Feliciano, Eddieson Canoza, John Wayne Villen, Neal Vincent Fernando, Jessah Mae Flores, Citadel Ariola and Al Owen Roy Ferrera, who saw the messiest parts but stood by her side all throughout the journey and made things bearable in times of difficulties and for keeping the researcher sane by supplying all the encouragement support, patience, midnight stories and laughter that fueled the author in finishing this study.

To Leira Mae Suarez and Aldrin Geronimo for the data processing and for selflessly giving all kinds of support this world could ever think of.

To her family, for the support and for always believing that she could do great things despite of her limitations and weaknesses.

Lastly, sincerest gratitude was given to all the people left unmentioned but helped and supported the researcher in any way that they could.

Above all, the Almighty God for always being the best in giving the wisdom, patience, peace, and for making the author find her purpose and strength.

To all of them, this humble piece of work is unreservedly dedicated.

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## ABSTRACT

**SUAREZ, LILIANE M.**, Department of Environmental Science, College of Arts and Sciences, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines, **JUNE 2019, DEVELOPMENT OF AN ACTIVE ANTIOXIDANT AND ANTIMICROBIAL PACKAGING FILMS UTILIZING EXTRACT FROM MANGO (*Mangifera indica* var. *carabao*) PEEL**

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Food packaging is one of the unswerving method in food containment to assure and control the factors that can affect the food safety, quality, and shelf life. The combination of antioxidant and antimicrobial property that the mango peel extract material is an excellent innovation in active packaging material in guaranteeing these factors. This study specifically aimed to develop an active antioxidant and antimicrobial packaging material utilizing extract from mango (*Mangifera indica* var. *carabao*) peel. The mango peel was subjected to maceration method with ethanol to obtain mango peel extract. The mango peel extract was subjected to different analyses such as DPPH Scavenging Radical Activity and Total Phenolic Content. The total phenolic content of the extract was 116.05 mg gallic acid equivalent (GAE)/g. The highest antioxidant activity recorded among the concentrations is 96.85% in 100ppm of the mango peel extract. The effective concentration in which the mango peel extract can scavenge the half of the DPPH radicals is 11.26 ppm. The films were characterized according to its weight, moisture, thickness and solubility and showed no significant differences among the varying concentrations. The films with 1000 mg extract of mango peel showed the highest DPPH radical scavenging activity at all periods and attained the highest percentage of 91.5423% at 420 minutes. The films with and

without mango peel extract showed no zone of inhibition implying the negative antimicrobial property. The extract can be commercially exploited as natural antioxidants. It can also be incorporated in products such as packaging films to enhance their antioxidant activity and help retard rancidity of food products.

Keywords: mango peel, antioxidant property, antimicrobial property, *Mangifera indica* var. *carabao*

## LITERATURE CITED

- Abdullah, N., Abdullah, A., Zulkifli, K., Aziman, N., Kamarudin, W. & Saidatul, S. (2012). Assessment on the antioxidant and antibacterial activities of selected fruit peels. *International Journal of ChemTech Research*, 4(4), 1534–1542.
- Adilah, A. N., Jamilah, B., Noranizan, M. A., & Hanani, Z. A. (2018). Utilization of mango peel extracts on the biodegradable films for active packaging. *Food Packaging and Shelf Life*, 16, 1–7.
- Ahvenainen, R. (Ed.). (2003). Active and intelligent packaging: An introduction. In R. Ahvenainen (Ed.), *VTT Biotechnology* (pp. 5-21). Cambridge, United Kingdom: Woodhead Publishing Ltd.
- Ajila, C. M., & Prasada Rao U. J. S. (2013). Mango peel dietary fibre: composition and associated bound phenolics. *Journal of Functional Foods*, 5(1), 444–450.
- Ajila, C. M., Bhat S. G., & Prasada Rao U. J. S. (2007). Valuable components of raw and ripe peels from two indian mango varieties. *Food Chemistry*, 102, 1006–1011.
- Ajila, C. M., Naidu, K. A., Bhat, S. G., & Rao, U. J. S. P. (2007). Bioactive compounds and antioxidant potential of mango peel extract. *Food Chemistry*, 105, 982–988. <https://doi.org/10.1016/j.foodchem.2007.04.052>
- Ashwar, B. A., Shah, A., Gani, A., Shah, U., Gani, A., Wani, I. A., ... Masoodi, F. A. (2014). Rice starch active packaging films loaded with antioxidants- development and characterization. *Starch*, 67, 1–29. Retrieved March 31, 2018, from <https://www.researchgate.net/publication/269287672>
- Balasundram, N., Sundram, K., & Samman, S. (2006). Phenolic compounds in plants and agri-industrial by-products: Antioxidant activity, occurrence, and potential uses. *Food Chemistry*, 99(1), 191–203. <https://doi:10.1016/j.foodchem.2005.07.042>
- Berardini, N., Knödler, M., Schieber, A., & Carle, R. (2005). Utilization of mango peels as a source of pectin and polyphenolics. *Innovative Food Science & Emerging Technologies*, 6(4), 442–452. <https://doi:10.1016/j.ifset.2005.06.004>
- Brody, A., Bugusu, B., Han, J., McHugh T. & Sand, C. K. (2008). Innovative food packaging solutions. *Journal of Food Science*, 73(8), 107–116.
- Chen, J. & Brody, A. L. (2013). Use of active packaging structures to control the microbial quality of a ready-to-eat meat product. *Food Control*, 30(1), 306–310. <https://doi:10.1016/j.foodcont.2012.07.002>

- Day, B. P. F. (2008). Active packaging of food. In J. Kerry & P Butler (Eds.), *Smart Packaging Technologies for Fast Moving Consumer Goods* (pp. 1-18). Hoboken, New Jersey: John & Wiley Sons, Ltd.
- De Abreu, D. A. P., Losada, P. P., Maroto, J., & Cruz, J. M. (2011). Lipid damage during frozen storage of Atlantic halibut (*Hippoglossus hippoglossus*) in active packaging film containing antioxidants. *Food Chemistry*, 126(1), 315–320. <https://doi:10.1016/j.foodchem.2010.10.048>
- Department of Science and Technology - Food and Nutrition Research Institute (DOST-FNRI). (2016). Philippine Nutrition Facts and Figures 2015: *Updating of Nutritional Status of Filipino Children and Other Population Groups Overview*. FNRI Bldg., DOST Compound, Gen. Santos Avenue, Bicutan, Taguig City, Metro Manila, Philippines.
- Diblan, S., & Kaya, S. (2018). Antimicrobials used in active packaging films. *Food and Health Journal*, 4(1), 63–79. <https://doi.org/10.3153/JFHS18007>
- Dobrucka, R. & Cierpiszewski R. (2014). Active and intelligent packaging food – research and development – a review. *Polish Journal of Food and Nutrition Sciences*, 64(1), 7–15.
- El-Kholy, K. H. F., Solta, M. E., Abd El Rahman, S. A. E., El-Saidy, D. M., & Foda, D. S. (2008, October 12-14). *Use of some agro-industrial by products in Nile tilapia fish diets*. Paper presented at the 8<sup>th</sup> International Symposium on Tilapia in Aquaculture, Cairo Egypt. Retrieved from <http://docplayer.net/37877124-Use-of-some-agro-industrial-by-products-in-nile-tilapia-fish-diets.html>
- Falusi, V. O., Adesina, I. A., Aladejimokun, A. O., & Elehinafe, T. R. (2017). Phytochemical screening and antibacterial activity of methanolic extracts of ripe and unripe peels of mango (*Mangifera indica* L.). *Journal of Applied Life Sciences International*, 14(3), 1–7.
- Gontard, N., Duchez, C., Cuq, J. L., & Guilbert, S. (2007). Edible composite films of wheat gluten and lipids: water vapour permeability and other physical properties. *International Journal of Food Science & Technology*, 29(1), 39–50. <https://doi:10.1111/j.1365-2621.1994.tb02045.x>
- Huff, K. (2009). *Active and Intelligent Packaging: Innovations for the Future* (Master's thesis). Virginia Polytechnic Institute and State University, Virginia, USA.

- Hutton, T. (2003). *Food Packaging: An introduction. Key topics in food science and technology*. Chipping Campden, Gloucestershire, UK: Campden and Chorleywood Food Research Association Group.
- Kanatt, S. R. & Chawla, S. P. (2017). Shelf life extension of chicken packed in active film developed with mango peel extract. *Journal of Food Safety*, 38(1), 1-12. <https://10.1111/jfs.12385>
- Kessler, M., Ubeaud, G., & Jung, L. (2003). Anti- and pro-oxidant activity of rutin and quercetin derivatives. *Journal of Pharmacy and Pharmacology*, 55(1), 131–142. <https://doi:10.1211/002235702559>
- Kittiphoom, S. (2012). Utilization of mango seed. *International Food Research Journal*, 19(4), 1325–1335.
- Kuganesan, A., Thiripuranathar, G., Navaratne, A. N., & Paranagama, P. A. (2017). Antioxidant and anti-inflammatory activities of peels, pulps and seed kernels of three common mango (*Mangifera indica* L.) varieties in Sri Lanka. *International Journal of Pharmaceutical Sciences and Research*, 8(1), 70-78. <https://10.13040/IJPSR.0975-8232>
- Labuza, T. P. & Breene, W. M. (1988). Applications of active packaging for improvement of shelf-life and nutritional quality of fresh and extended shelf-life foods. *Journal of Food Processing & Preservation*, 13(1), 1-69. <https://doi.org/10.1111/j.1745-4549.1989.tb00090.x>
- Mango Production Worldwide*. (2015, April 21). Retrieved from <https://mango-trees.blogspot.com/2015/04/mango-production-worldwide.html>
- Morais, D. R., Rotta, E. M., Sargi, S. C., Schmidt, E. M., Bonafe, E. G., Eberlin, M. N., ... Visentainer, J. V. (2015). Antioxidant activity, phenolics and UPLC–ESI(–)–MS of extracts from different tropical fruits parts and processed peels. *Food Research International*, 77, 392–399. <https://doi:10.1016/j.foodres.2015.08.036>
- Mukherjee, S.K.. (1997). *Introduction: Botany and importance. The Mango; Botany, Production and Uses*. New York City, USA: CAB International
- Muscat, D., Adhikari, B., Adhikari, R., & Chaudhary, D. S. (2012). Comparative study of film forming behaviour of low and high amylose starches using glycerol and xylitol as plasticizers. *Journal of Food Engineering*, 109(2), 189–201. <https://doi:10.1016/j.jfoodeng.2011.10.019>
- N.E.M Business Solutions*. (2009). Retrieved from <http://nem.org.uk/Rancidity.htm>

- Narayanan, A., Neera, Mallesha, & Ramana, K. V. (2013). Synergized Antimicrobial Activity of Eugenol Incorporated Polyhydroxybutyrate Films Against Food Spoilage Microorganisms in Conjunction with Pediocin. *Applied Biochemistry and Biotechnology*, 170(6), 1379–1388. <https://doi:10.1007/s12010-013-0267-2>
- Percival, S. S., Talcott, S. T., Chin, S. T., Mallak, A. C., Lounds-Singleton, A., & Pettit-Moore, J. (2006). Neoplastic Transformation of BALB/3T3 Cells and Cell Cycle of HL-60 Cells are Inhibited by Mango (*Mangifera indica* L.) Juice and Mango Juice Extracts. *The Journal of Nutrition*, 136(5), 1300–1304. <https://doi:10.1093/jn/136.5.1300>
- Prior, R. L., Wu, X., & Schaich, K. (2005). Standardized Methods for the Determination of Antioxidant Capacity and Phenolics in Foods and Dietary Supplements. *Journal of Agricultural and Food Chemistry*, 53(10), 4290–4302. <https://doi:10.1021/jf0502698>
- Ramos, M., Jiménez, A., Peltzer, M., & Garrigós, M. C. (2012). Characterization and antimicrobial activity studies of polypropylene films with carvacrol and thymol for active packaging. *Journal of Food Engineering*, 109(3), 513–519
- Reis, L. C. B., de Souza, C. O., da Silva, J. B. A., Martins, A. C., Nunes, I. L., & Druzian, J. I. (2015). Active biocomposites of cassava starch: The effect of yerba mate extract and mango pulp as antioxidant additives on the properties and the stability of a packaged product. *Food and Bioprocess Processing*, 94, 382–391. <https://doi:10.1016/j.fbp.2014.05.004>
- Robertson, G. L. (Ed.). (2006). *Food packaging: Principles and practice* (2<sup>nd</sup> ed.). Boca Raton, Florida: CRC Press.
- Rooney, M. L. (Ed.). (1995). *Active Food Packaging*. Manhattan, New York City: Springer US.
- Rossi-Márquez, G., Han, J. H., García-Almendárez, B., Castaño-Tostado, E., & Regalado-González, C. (2009). Effect of temperature, pH and film thickness on nisin release from antimicrobial whey protein isolate edible films. *Journal of the Science of Food and Agriculture*, 89(14), 2492–2497. <https://doi:10.1002/jsfa.3751>
- Salmieri, S., Islam, F., Khan, R. A., Hossain, F. M., Ibrahim, H. M. M., Miao, C., ... Lacroix, M. (2014). Antimicrobial nanocomposite films made of poly(lactic acid)-cellulose nanocrystals (PLA-CNC) in food applications—part B: effect of oregano essential oil release on the inactivation of *Listeria monocytogenes* in mixed vegetables. *Cellulose*, 21(6), 4271–4285. <https://doi:10.1007/s10570-014-0406-0>

- Sogi, D. S., Siddiq, M., Greiby, I., & Dolan, K. D. (2013). Total phenolics, antioxidant activity, and functional properties of “Tommy Atkins” mango peel and kernel as affected by drying methods. *Food Chemistry*, *141*(3), 2649–2655. <https://doi:10.1016/j.foodchem.2013.05.053>
- Sultana, B., Hussain Z., Asif M., & Munir, A. (2012). Investigation on the antioxidant activity of leaves, peels, stems bark, and kernel of mango (*Mangifera indica L.*). *Journal of Food Science*, *77*(8), 849–852.
- Sun, X. (2014). *Development of Active Packaging with Antimicrobial Activity*. (Master’s thesis). Wayne State University, Michigan, USA.
- Svensson, A. (2004). *Active Food Packaging - Materials and Interactions* (Doctoral dissertation). Karlstad University, Karlstad, Sweden. Retrieved from <https://intelliflex.org/wp-content/uploads/Active-Packaging-food-material-interaction.pdf>
- The Green Book*. (2018). Retrieved from <https://www.greenbook.org/case-study/fresh-food-packaging-opportunity-assessment-to-promote-revenue-growth>
- Tunchaiyaphum, S., Eshtiaghi M. N., & Yoswathana, N. (2013). Extraction of bioactive compounds from mango peels using green technology. *International Journal of Chemical Engineering and Applications*, *4*(4), 194–198.
- Velioglu, Y. S., Mazza, G., Gao, L., & Oomah, B. D. (1998). Antioxidant activity and total phenolics in selected fruits, vegetables, and grain products. *Journal of Agricultural and Food Chemistry*, *46*(10), 4113–4117
- Vermeiren, L., Devlieghere, F., van Beest, M., de Kruijf, N., & Debevere, J. (1999). Developments in the active packaging of foods. *Trends in Food Science & Technology*, *10*(3), 77–86. [https://doi:10.1016/s0924-2244\(99\)00032-1](https://doi:10.1016/s0924-2244(99)00032-1)
- Wikipedia*. (2019, April 21). Retrieved from <https://en.wikipedia.org/wiki/Biocomposite>
- Yam, K. L., Takhistov, P. T., & Miltz, J. (2005). Intelligent packaging: concepts and applications. *Journal of Food Science*, *70*(1), 1-10. <https://doi.org/10.1111/j.1365-2621.2005.tb09052.x>
- Zhang, S., Kim, N., Yokoyama, W., & Kim, Y. (2018). Effects of moisture content on mechanical properties, transparency, and thermal stability of yuba film. *Food Chemistry*, *243*(15), 202–207. <https://doi.org/10.1016/j.foodchem.2017.09.127>