DESIGN, FABRICATION, AND PERFORMANCE EVALUATION OF CONTINUOUS FLOW COCONUT WATER CONCENTRATOR FOR BIOETHANOL PRODUCTION

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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

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ACCEPTANCE SHEET

This undergraduate thesis entitled, **DESIGN, FABRICATION, AND PERFORMANCE EVALUATION OF CONTINUOUS FLOW COCONUT WATER CONCENTRATOR FOR BIOETHANOL PRODUCTION** prepared and submitted by **KLARK KENT ROMEO T. DEL ROSARIO** in partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AGRICULTURAL MACHINERY AND RENEWABLE ENERGY)**, is hereby accepted:

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BIOGRAPHICAL SKETCH

The researcher is Klark Kent Romeo T. Del Rosario, was born on the 13th of October, 1998 at General Tinio, Nueva Ecija. He is the second children of Mr. Gaudencio G. Del Rosario Jr. and Mrs. Marivic T. Del Rosario.

On March 2010 he graduated elementary at Muñoz North Central School located at Poblacion North, Science City of Muñoz, Nueva Ecija with an award of fifth honorable mention. He finished high school at Muñoz National High School on March 2014 under Special Science Curriculum. During his high school days, he was part of the student publications. The following school year, he enrolled at Central Luzon State University and took Bachelor of Science in Agricultural and Biosystems Engineering. Some of his skills are simple AutoCad and drawings. During his college days, he was a scholar of PhilDev, a non-profit organization that not only helps each scholar financially as well as making decisions in life. Some of the trainings and workshops that he attended were: StartUp: "Innovation" and "Technology Entrepreneurship" Forum held at RET Amphiteather, Central Luzon State University, Science City of Muñoz, Nueva Ecija on March 7, 2019; Shell-PhilDev Leadership Camp 2018 held on Shell Training Center Pililla, Brgy. Malaya, Pililla, Rizal on July 23 – 27, 2018; Smart Farming: Engraining the Future at College of Engineering, Central Luzon State University, Science City of Muñoz, Nueva Ecija on April 11, 2018; Shell-PhilDev Leadership Camp 2017 at Shell Training Center Pililla, Brgy. Malaya, Pililla, Rizal on July 23 – 27, 2018; Shell-PhilDev Leadership Camp 2016 at Shell Training Center Pililla, Brgy. Malaya, Pililla, Rizal on July 21 – 25, 2016; and Symposium on Current Trends in Food Safety and Quality Assurance at University Gymnatorium, Central Luzon State University, Science City of Muñoz, Nueva Ecija on August 30, 2014.

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ABSTRACT

DEL ROSARIO, KLARK KENT ROMEO TORRES, Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Muñoz, Nueva Ecija, May 2019, **DESIGN, FABRICATION, AND PERFORMANCE EVALUATION OF CONTINUOUS FLOW COCONUT WATER CONCENTRATOR FOR BIOETHANOL PRODUCTION.**

ADVISER: MARLON T. DELOS SANTOS, M. Sc.

The study dealt with the design, fabrication, and performance evaluation of continuous flow coconut water concentrator. The specific objectives were to design and fabricate a continuous flow coconut water concentrator; evaluate the performance of the concentrator in terms of concentrating capacity, time of concentration, fuel consumption, and efficiency; and perform simple cost analysis on the use of the concentrator.

The treatment used were the different rate of flow of coconut water which were ¼ valve is opened (8.43 cc/s), ½ valve is opened (15.03 cc/s), and fully opened valve (24.36 cc/s). Data was laid out in Complete Randomized Design (CRD) Analysis of variance was used to analyze the effect of using different flow rate on the performance of the concentrator and comparison among means was done using Least Significant Difference (LSD) at 5% level of significance.

The performance of continuous flow coconut water concentrator in terms of capacity, efficiency, and fuel consumption was tested. It was observed that all the parameters were significant affected by the different flow rate. The best rate of flow is when the valve is set to ¼ opened or at 8.43 cc/s. It gave the highest capacity of 0.33 L/min, highest efficiency at 90.86%, and lowest fuel consumption of 20.67 kg.

The total investment cost is 10,948 Php. The total fixed cost was 3,021.65 Php/year and total variable cost was 58,812.2 Php/year. The projected total cost of the concentrator was 61,833.85 Php/year.

LITERATURE CITED

BABU, S., HARINIKUMAR, K., SINGH, R., & PANDEY, A. (2014). Optimization of Bioethanol Production from Fruit Wastes using Isolated Microbial Strains. International Journal of Advanced Biotechnology and Research (IJBR) Vol5, Issue4, 598-604.

BEDONIA, J. (2017). Design, Fabrication, and Performance Evaluation of Biomass Feedstock Concentrator for Bioethanol Production. Nueva Ecija: Central Luzon State University.

BIOETHANOL REFERENCE PRICE. Retrieved on May 18, 2019 from Sugar Regulatory Administration: https://www.sra.gov.ph/bioethanol-reference-price/

BHANDARI, V. (2010). Design of Machine Elements. New Delhi: Tata McGraw-Hill Education.

BIOMASS FEEDSTOCKS. (n.d.). Retrieved on October 20, 2018 from Office of Energy Efficiency & Renewable Energy: https://www.energy.gov/eere/bioenergy/biomass-feedstocks

BRENNAN, J. G. (2006). Food Processing Handbook. Weinheim: WILEY-VCH Verlag Gmb H & Co.

BRIGHTMAN, T. & SIVELL, P. (n.d.). TI-UP: Bioethanol - A Brief Review. Retrieved from TI-UP. Retrieved on October 22, 2018 from: https://assets.publishing.service.gov.uk/media/57a08bd6ed915d3cfd000f8c/TI_UP_HD_Apr2007_Bioethanol_a_brief_review.pdf

CAPARINO, O. (2015). Utilization of coconut water extracted from matured coconut. Food Process Technology 2015, 6:7

DARRELL, H. (1994). Using A Refractometer to Test the Quality of Fruits & Vegetables. Michigan. Pineknoll Publishing.

ELIK A, YANIK DK, MASKAN M, GÖĞÜŞ F. Influence of three different concentration techniques on evaporation rate, color and phenolics content of blueberry juice. *J Food Sci Technol*. 2016;53(5):2389-95.

FEEDSTOCK. (n.d.). Retrieved on October 20, 2018 from CorrosionPedia: https://www.corrosionpedia.com/definition/1684/feedstock

FIFE, B. (2013). The Truth About Coconut Water. Retrieved from Nature's Purest Treasure: https://www.tiana-coconut.com/product-info-truth-about-water

GARRETT, L., DUCHACEK, H., MORSELI, M., LAING, F., KUYLER, N., & MARVIN, J. (1977). Increasing the Efficiency of Maple Sap Evaporators with Heat Exchangers. Forest Service Research Paper NE-338.

HANIF, M., MAHLIA, T., ADITIYA, H., & ABU BAKAR, M. (2017). Energy and environmental assessments of bioethanol production from Sri Kanji 1 cassava in Malaysia. Biofuel Research Journal.

HERNANDEZ, E. (2011). Concentration of Liquid Foods. Food Engineering Vol. III. pp 69-93.

HOWES, M. & TOTTEN, G. (1997). Steel heat treatment handbook. New York: Marcel Dekker Inc.

JAYAKODY, J., AMARASINGHE, A. & GUNAWARDENA, S. (2011). Effect of Evaporation on Sugar Content of Coconut Water in Desiccated Coconut Industry. Annual Transactions of IESL. The Institution of Engineers

JEAN W., YONG, H., GE, L., NG, Y. & TAN, S. (2009). The Chemical Composition and Biological Properties of Coconut (*Cocos nucifera L.*) Water. Molecules (Basel, Switzerland.

KHURMI, R. & GUPTA, J. (2005). Machine Design (SI Units). New Delhi: Eurasia Publishing House (Pvt.) Ltd.

KRAUS, M. Maple Sugaring: Native American Lore and History. Retrieved on May 17, 2019 from The Master Gardeners: https://www.emmitsburg.net/gardens/articles/adams/2010/maple_sugaring.htm

MASKAN, M. Production of pomegranate (*Punica granatum* L.) juice concentrate by various heating methods: colour degradation and kinetics. J Food Eng. 2006;72(3):218–224

MCPAUL, C. (2011). How does a maple syrup evaporator work? Retrieved on October 22, 2018 from Physics Exchange: https://physics.stackexchange.com/questions/8246/how-does-a-maple-syrup-evaporator-work

MILLEY, L. & BERKS, H. (2010). General Guidance on the selection and installation of flues and chimneys for wood burning and multi fuel appliances in residential properties. Waltham Court.

MOULLIN, M. (2007). Performance measurement definitions: Linking performance measurement and organizational excellence. International Journal of Health Care Quality Assurance, 181-183.

NAIR, B., LENNARTSSON, P., & TAHERZADEH, M. (2016). Bioethanol Production from Agricultural and Municipal Wastes. Sweden: University of Boras.

OECD-FAO Agricultural Outlook 2018-2027. (2018). Retrieved on October 23, 2018 from FAO: http://www.fao.org/docrep/i9166e/i9166e_Chapter9_Biofuels.pdf

OTHAMAN, M., SHARIFUDIN, S., MANSOR, A., KAHAR, A., & LONG, K. (2014). Coconut Water Vinegar: New Alternative with Improved Processing Technique. Journal of Engineering Science and Technology Vol. 9, No. 3, 293-302.

OTI, W. (2016). Using Refractometer to Determine the Sugar Content in Soft Drinks Commonly Consumed in Abakaliki, Nigeria. IOSR Journal of Applied Chemistry (IOSR-JAC), 89-91.

PRADES, A., DORNIER, M., DIOP, N., & PAIN, J. (2011). Coconut water uses, composition and properties: a review. Fruits, 2012, vol. 67, 87-107.

REIJNDERS, L. (2006). Conditions for the sustainability of biomass based fuel use. Energy Policy, 863 – 876.

RIVERA, D. (2018). Bioethanol producers urge gov't to go local. Retrieved from https://www.philstar.com/business/2018/09/28/1855257/bioethanol-producers-urge-govt-go-local on November 29, 2018.

SATTAR, M. A. 2010. A Study on the Agricultural Mechanization in Selected Farms of Thakurgaon Sugar Mill. Bangladesh J. Agril. Res. 35 (1): 167-177, ISSN 0258-7122

SISON, B. (1977). Disposal of Coconut Processing Waste. Philipp. J. Coconut Stud. 11, 39-41.

SUÁREZ, J. (2011). Design and Evaluation of Fuel Alcohol Production from Lignocellulosic Raw Materials. Manizales: Universidad Nacional de Colombia.

UMAMAHESWARI, M., JAYAKUMARI, M., MAHESWARI, K., SUBASHREE, M., MALA, P., SEVANTHI, T., & MANIKANDAN, T. (2010). Bioethanol Production from Cellulosic Materials. Asian Journal of Science and Technology, 5-11.

VERDE LEAL, M., VALLE, T., FELTAN, J., & CARVALHO, C. (2014). Other Raw Materials for Bioethanol Production. Sugarcane bioethanol — R&D for Productivity and Sustainability, 519-540.

VOHRA, M., MANWAR, J., MANMODE, R., PADGILWAR, S., & PATIL, S. (2013). Bioethanol production: Feedstock and current technologies. Journal of Environmental Chemical Engineering.

WILHELM, L., SUTER, D., & BRUSEWITZ, G. (2004). Food & Process Engineering Technology. Michigan: ASAE.

YODER, C. (2017). Distillation. Retrieved from http://www.wiredchemist.com/chemistry/instructional/laboratory-tutorials/distillation on Ocotber 28, 2018.

ZABED, H., FARUQ, G., SAHU, J., AZIRUN, M., HASHIM, R., & BOYCE, A. (2014). Bioethanol Production from Fermentable Sugar Juice. The Scientific World Journal.