

**DESIGN, FABRICATION, AND PERFORMANCE EVALUATION OF
MUSHROOM SUBSTRATE CHOPPER AND MIXING MACHINE**

LEMUEL B. DURAN


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
(AB Machinery and Power Engineering)**

JULY 2024

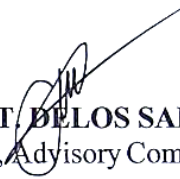
ACCEPTANCE SHEET

This undergraduate thesis entitled “**DESIGN, FABRICATION, AND PERFORMANCE EVALUATION OF MUSHROOM SUBSTRATE CHOPPER AND MIXING MACHINE**” prepared and submitted by **LEMUEL B. DURAN**, in partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AB Machinery and Power Engineering)**, is hereby accepted:


MAY A. CABRAL, M.Sc.
Member, Advisory Committee
6 - 25 - 2024
Date Signed


JOHN VINCENT A. NATE M.Sc.
Member, Advisory Committee

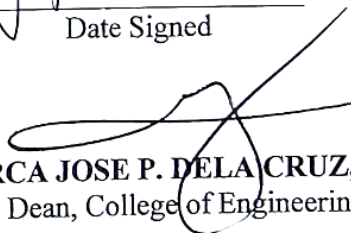
Date Signed


MARLON T. DELOS SANTOS M.Sc.
Chair, Advisory Committee
JUNE 24, 2024
Date Signed

Accepted as partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AB Machinery and Power Engineering)**:


JOHN PAULO C. SACDALAN, Ph.D.
Head, Department of Agricultural and Biosystems Engineering

Date Signed


ROY SEARCA JOSE P. DELA CRUZ, Ph.D.
Acting Dean, College of Engineering

Date Signed

BIOGRAPHICAL SKETCH

The author, Lemuel B. Duran, was born on March 1, 2002, in Capintalan, Carranglan, Nueva Ecija. He is the youngest of the four children of Mrs. Dakila B. Duran and Mr. Dante C. Duran.

His primary education was completed at Caanawan Elementary School in 2014. He pursued junior and senior high school education at Caanawan National High School and graduated in 2020 with high honors and academic excellence. He enrolled at Central Luzon State University in 2020, taking Bachelor of Science in Agricultural and Biosystems Engineering (BSABE). In 2022, he passed the interview and became a scholar of the Commission of Higher Education- Tulong Dunong Program Scholarship (CHED-TDP).

ACKNOWLEDGEMENT

Firstly, the researcher expresses his deepest gratitude to God for His provision and guidance throughout the entirety of this project. His grace provided him with the strength, wisdom, and perseverance needed to overcome challenges and achieve this milestone. He is also indebted significantly to the following individuals:

To the researcher's family, for the unwavering support that has been the cornerstone of his success, for endless encouragement, sacrifices, and trust in him to strive for excellence;

To his relatives from Tarlac who provided substrate materials essential for the research. Their contributions were invaluable and significantly impacted the progress of the work. Special thanks to the researcher's sisters, Deborah B. Duran and Aroma Joy B. Duran, for their financial support, which allowed him to focus on the studies without the additional burden of financial constraints;

To the researcher's thesis committee members: Engr. Marlon T. Delos Santos, Engr. May A. Cabral, and Engr. John Vincent A. Nate for their valuable comments and suggestions on the paper;

To Mariz O. Vergel De Dios for assisting in machine's performance testing and data gathering during the conduct of the study. Additionally, to John Paul Dizon, for his help with AutoCAD. His technical expertise and willingness to lend a hand greatly facilitated the design aspects of the work;

To Angelo's Workshop, Sir Angelo Babasoro, Sir James Babasoro, and Sir John Babasoro for fabricating the machine;

And lastly, to Mr. Jesus Sumibcay for helping with statistical analysis. It was his guidance and instruction that helped the researcher comprehend certain methodologies for the data analysis.

TABLE OF CONTENTS

LIST OF FIGURES	ix
LIST OF TABLES	x
LIST OF APPENDIX FIGURE	xi
LIST OF APPENDIX TABLE	xii
ABSTRACT	xiii
INTRODUCTION	1
Background of the Study	1
Statement of the Problem	2
Objectives of the Study	2
Significance of the Study	3
Scope and Limitation of the study	3
Time and Place of the Study	4
REVIEW OF RELATED LITERATURE	5
Mushroom Cultivation	5
Substrate Materials and Additives	7
Mechanisms of the Mushroom Substrate Chopper Machine	7
Existing Technology and Practices on Mushroom Preparation Process	8
Experimental Study on Waste Shredder	8
Evaluate the Modified Chopper for Rice Straw Composting	9
Development and Performance Evaluation of Power-Driven Chopper	9
Analysis of the Design of the Palm Frond Chopping Machine as a Basic Ingredient for Animal Feed	11
Development and Redesign of Crop Residue Chopping Machine	11
Cost Analysis of the Machine	12
Depreciation	13
Salvage Value	13
Insurance	14
Total Fixed Cost	14
Repair and Maintenance	14
Total Annual Cost	14
Break-even Point	14
Payback Period	15
Custom Rate	15

METHODOLOGY	16
Conceptual Framework	16
Design Consideration and Criteria	17
Flowchart of Activities	18
Design of Machine	19
Design of Mushroom Substrate Chopper Components	19
Mixing Chamber	20
Volume of the Mixing Chamber	20
Hopper	21
Chopping Blades	21
Mixing Paddles	22
Diameter of Shafts used in mixer and chopper	22
Main Frame	24
Belt Length	25
Fabrication of Machine	26
Principle of Operation	26
Performance Testing and Evaluation	27
Preliminary testing	28
Preliminary Test Results	29
Blade's Ability to Cut	29
Determination of Mixing Paddle Orientation	29
Instruments and Materials for Evaluation	30
Preparation of Sample Materials	31
Data to be Gathered	31
Performance Indicators	32
Output Capacity	32
Chopping Efficiency	32
Chopped Length	33
Moisture Content	33
Interval of Collection	33
Mixing Rate	34
Experimental Layout and Design	34

Cost Analysis	35
Depreciation	35
Insurance	36
Interest on Investment	36
Total Fixed Cost	37
Electrical Cost	37
Repair and Maintenance	37
Total Variable Cost	38
Operating Cost	38
Total Annual Cost	39
Custom Rate	39
Payback Period	40
Break-even Point	40
RESULTS AND DISCUSSION	42
Mushroom Substrate Chopper Machine	42
Hopper	43
Blade Assembly	44
Mixing Chamber	45
Mixing Paddle Assembly	46
Electric motor Specification	47
Evaluated Performance Indicators	48
Output Capacity of the Chopper	48
Chopping Efficiency	50
Chopped Length	51
Interval of Collection on Mixing Rice Straw and Corn Stalks	52
Mixing Rate	52
Cost Analysis of the Machine	53
SUMMARY, CONCLUSION RECOMMENDATION	55
Summary	55
Conclusion	56
Recommendation	57
LITERATURE CITED	58

LIST OF FIGURES

FIGURE		PAGE
1	Conceptual framework of the study	17
2	Process flow chart of major activities of the study	18
3	Design of mushroom substrate chopper machine	19
4	Mixing chamber	20
5	Hopper and blade housing	21
6	Blade assembly	22
7	Paddle mixer	22
8	Process flow diagram of the machine	27
9	Experimental layout of the study	35
10	Mushroom substrate chopper and mixing machine	42
11	Hopper of the machine	44
12	Blade assembly of the machine	45
13	Mixing chamber of the machine	46
14	Mixing paddle assembly of the machine	47

LIST OF TABLES

TABLE		PAGE
1	Methods for fabricating the parts of the machine	26
2	Tools for evaluation process	30
3	Machine components and specifications	43
4	Electric motor specification	47
5	Means of chopper's output capacity at different operating speed of motor and substrates	48
6	Means of chopping efficiency at different operating speed of motor and substrates	50
7	Means of chopped length at different operating speed of motor and substrates	51
8	Summary of cost analysis	54

LIST OF APPENDIX FIGURES

FIGURE		PAGE
1	Collection of rice straw and corn stalks from Tarlac	71
2	Drying of corn stalks	71
3	Drying of rice straw	72
4	Machine's frame	72
5	Mixing chamber	73
6	Mixing paddle	73
7	Detachable chopping blades	74
8	Fabrication of hopper and chopping chamber	74
9	Wheelset and stand	75
10	Door for mixing	75
11	Discharge outlet	76
12	Weighing the samples of rice straw	76
13	Weighing the samples of corn stalks	77
14	Feeding of corn stalks	77
15	Feeding of rice straw	78
16	Feeding of combined rice straw and corn stalks for mixing	78
17	Collection of mixed rice straw and corn stalks	79
18	Measuring the chop length of 30 samples of rice straw of each replicate	79
19	Measuring the chop length of 30 samples of corn stalks of each replicate	80

LIST OF APPENDIX TABLES

TABLE		PAGE
1	Data on chopper's output capacity (kg/h)	63
2	Analysis of variance on the chopper's output capacity at different rotating speed of motor and substrates	63
3	Data on chopping efficiency (%)	63
4	Analysis of variance on the chopping efficiency at different rotating speed of motor and substrates	64
5	Data on the chopped length of substrates (mm)	64
6	Analysis of variance on the precision of cut on corn stalks at different speed of the motor.	64

ABSTRACT

DURAN, LEMUEL B., Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Munoz, Nueva Ecija Philippines. **July 2024, DESIGN, FABRICATION, AND PERFORMANCE EVALUATION OF MUSHROOM SUBSTRATE CHOPPER AND MIXING MACHINE.**

Adviser: Marlon T. Delos Santos M.Sc.

Throughout the years, many have held mushrooms in high regard for its taste and health benefits it carries low calories and protein as well as a rich content of certain minerals and vitamins. However, its production remains low due to labor requirements, and intricate processes that consume a large amount of time such as chopping the substrate materials manually. Therefore, this study aims to address the concerns to establish the improvements and adjustments to be adopted for the mushroom substrate chopper and mixing machine. Its goal is to increase the work rate of the chopping mechanism on the rice straw and corn stalks. By addressing these inefficiencies. the study proposes to improve the efficiency and stability of mushroom production. The machine exhibited an average of 11.25 kg/h of output capacity on rice straw and 21.78 kg/h on corn stalks, with the mean chopping efficiency of 62.22 % and 61.44% from rice straw and corn stalks respectively, having a chopped length mean value of 251.24 mm and 260.37 mm of rice straw and corn stalks at varying operating speed of the motor. It also exhibited an average mixing rate of 27 kg/h with an interval of collection of 2 minutes and 12.84 seconds per 1 kilogram. Moreover, the custom rate and the operating cost of the machine were found to be Php13.16 per kg and Php10.13 per kg; respectively with a difference of Php3.03. Moreover, the payback period was computed to be 2.29 years and the break-even point was

Php 1,650.17 per year. Lastly, readjusting some of the parts of the machine is recommended to further improve its efficiency.

Keywords: output capacity; chopping efficiency; operating speed; mixing rate; chopped length

LITERATURE CITED

- Agricultural Machinery – Feed Mixer – Methods of Test. PAES 259:2011. Retrieved from <https://amtec.uplb.edu.ph/wp-content/uploads/2019/07/pns-paes-259-2011.pdf>.
- Agricultural Machinery – Feed Mixer – Specifications. PAES 258:2011. Retrieved from <https://amtec.uplb.edu.ph/wp-content/uploads/2019/07/pns-paes-258-2011.pdf>
- Agricultural Machinery – Granule Applicator– Specifications. PAES 165:2011. <https://amtec.uplb.edu.ph/wp-content/uploads/2019/07/pns-paes-165-2011.pdf>
- Agricultural Machinery – Hammer Mill – Specifications. PAES 216: 2004. Retrieved from <https://amtec.uplb.edu.ph/wp-content/uploads/2019/07/paes-216.pdf>
- Agricultural Machinery – Method of Sampling. PAES 103: 2000. Retrieved from <https://amtec.uplb.edu.ph/wp-content/uploads/2019/07/PAES-103-2000-Agricultural-Machinery-Method-of-Sampling.pdf>. Retrieved from <https://amtec.uplb.edu.ph/wp-content/uploads/2019/07/pns-paes-259-2011.pdf>
- Alexis. W. (2023). What is a Mixing Chamber? About Mechanics. <https://www.aboutmechanics.com/what-is-a-mixing-chamber.htm>
- Alrbaihat, M., (2022). A Review of Size Reduction Techniques Using Mechanochemistry Approach. Egyptian Journal of Chemistry. Retrieved from <http://ejchem.journals.ekb.eg/>
- Amer, M.A., Ali, ES.A.E. & Dawood, V.M. Modified and improved performance of local hammermill for mushroom residues chopping. Bull Natl Res Cent 46, 228 (2022). <https://doi.org/10.1186/s42269-022-00920-y>
- Awgichew, A. (2020). Development and Performance Evaluation of Power-Driven Chopper. Asian Journal of Applied Science and Technology, 4(4), 13-20.
- Baiomy, M. A., Kabeel, M. H. A., Arif, E. M., (2007). Development and Redesign of Crop Residue Chopping Machine. Agricultural Engineering Research Institute. 32 (9): 7307 - 7323, 2007,
- Balayo, S. A., Paca, R. M., Salmazan, A. L., & Mangorsi, Y. A. B. (2017). Design, Fabrication, and Evaluation of Forage Chopper Machine using three Different Diameter Pulleys. IJHSS .NET, 100.
- Bellettini, M. B., Fiorda, F. A., Maieves, H. A., Teixeira, G. L., Ávila, S., Hornung, P. S., Furigo, A., Junior, & Ribani, R. H. (2016). Factors affecting mushroom Pleurotus

- spp. Saudi Journal of Biological Sciences, 26(4), 633–646.
<https://doi.org/10.1016/j.sjbs.2016.12.005>
- Birn, A. (2022). 2. Seven Stages of Cultivation - Cornell Small Farms. Cornell Small Farms. <https://smallfarms.cornell.edu/projects/mushrooms/methods-of-commercial-mushroom-cultivation-in-the-northeastern-united-states/2-seven-stages-of-cultivation/>
- Broussard, W. (2023, April 21). North Spore. Common Contamination in Mushroom Cultivation. <https://northspore.com/blogs/the-black-trumpet/common-contamination-in-mushroom-cultivation>
- Edwards, W (2015). Estimating Farm Machinery Cost. Iowa State University of Science and Technology <https://www.extension.iastate.edu/agdm/crops/html/a3-29.html>.
- Elfatih, A., Arif, E. M., & Atef, A. E. (2010). Evaluate the modified chopper for rice straw composting. Journal of Applied Sciences Research, 6(8), 1125-1131.
- Edwards, W (2015). Estimating Farm Machinery Cost. Iowa State University of Science and Technology <https://www.extension.iastate.edu/agdm/crops/html/a3-29.html>.
- Fufa, B.K.; Tadesse, B.A.; Tulu, M.M. Cultivation of Pleurotus ostreatus on Agricultural Wastes and Their Combination. Int. J. Agron. 2021, 2021, 1465597.
- Fuglie, K. O. (2016). The growing role of the private sector in agricultural research and development world-wide. Global Food Security, 10, 29–38. <https://doi.org/10.1016/j.gfs.2016.07.005>
- Gaitán-Hernández, R., & Norberto Cortés, G. M. (2014). Improvement of yield of the edible and medicinal mushroom Lentinula edodes on wheat straw by use of supplemented spawn. Brazilian Journal of Microbiology, 45, 467-474.
- Goyal, R. (2014). Course: Farm Power & Machinery Management 3(2+1). (n.d). <http://ecoursesonline.iasri.res.in/course/view.php?id=13>
<http://ecoursesonline.iasri.res.in/course/view.php?id=13>
- Hanafí and A. S. Nurrohkayati, “Analysis of the Design of the Palm Frond Chopping Machine as a Basic Ingredient for Animal Feed”, PELS, vol. 3, Dec. 2022.
- Hashem, F. R., Ibrahim M.M., Nasr G.M. (2022). Modification of a machine for chopping rice straw using circular saw. Agricultural Engineering International: CIGR Journal, 24(4). <https://cigrjournal.org/index.php/Ejournal/article/view/7389/3981>
- IRRI Rice Knowledge Bank. (n.d.). Rice straw. <http://www.knowledgebank.irri.org/step-by-step-production/postharvest/ricebyproducts/ricestraw#:~:text=Characteristics%20of%20rice%20straw,of%20about%2015%E2%80%9318%25>

- Kagan, J. (2024, February 24). Payback period explained, with the formula and how to calculate it. Investopedia. <https://www.investopedia.com/terms/p/paybackperiod.asp>
- Kumar, I. S., & Kumar, T. H. (2015). Design and Development of Agricultural Waste Shredder Machine. *International Journal of Innovative Science, Engineering & Technology*, 2(10), 164-172.
- Lembarki, N. (2018, March 9). Factors to be considered during Machine Design. <https://www.linkedin.com/pulse/factors-considered-during-machine-design-naoufal-lembarki>
- Lichao , X.,Yong, C., Rong, Z., Jing, Z., Ruie, Z., (2020). Design and Simulation of Chopping Device of Straw Returning Machine. *Journal of Physics: Conference Series* (Vol. 1748, No. 6, p. 062066). IOP Publishing.
- Marthiana, W., Arman, R., Mahyoedin, Y., & Wardiyanto, D. (2018). Design and production of rotary-type machine for chop up organic waste plantation. In *MATEC Web of Conferences* (Vol. 248, p. 01010). EDP Sciences.
- Rangel-Vargas, E., Rodriguez, J., Domínguez, R., Lorenzo, J. M., Sosa, M. S., Andres, S. C., Rosmini, M. R., Pérez-Álvarez, J. Á., Teixeira, A., & Santos, E. M. (2021). Edible Mushrooms as a Natural Source of Food Ingredient/Additive Replacer. *Foods*, 10(11), 2687. <https://doi.org/10.3390/foods10112687>
- Recent Advances in Mushroom Cultivation Technology and its Application (Volume - 2). (2022). <https://doi.org/10.22271/bs.book.48>
- Royse, D., Baars, J., Tan, Q., (2017). *Current Overview of Mushroom Production in the World*. John Wiley & Sons Ltd. Retrieved from <https://onlinelibrary.wiley.com/doi/10.1002/9781119149446.ch2>.
- Sarhadi, H. R., Ramezan, D., Zarabi, M. M., Pirnia, M., Nasiri Dehsorkhi, A., & Yousefshahi, B. (2021). Evaluation of physical and chemical properties of substrate components in the production process of Shiitake mushroom (*Lentinula edodes* (Berk.) Pegler). *Journal of Plant Production Research*, 28(3), 131-146. doi: 10.22069/jopp.2021.18521.2732
- Sayner, A. (2022). *A Complete Guide to Mushroom Substrates*. GroCycle. <https://grocycle.com/mushroom-substrate/>
- Schmidt, J. (2023, December 4). Break-even analysis. Corporate Finance Institute. <https://corporatefinanceinstitute.com/resources/accounting/break-even-analysis/#:~:text=Key%20Highlights,needed%20to%20cover%20total%20costs.>

- Shields, T. (2021, April 8). Understanding Mushroom Substrates - FreshCap Mushrooms. FreshCap Mushrooms. <https://learn.freshcap.com/growing/understanding-mushrooms-substrates/>
- Surupa, S. (2017, July 24). Control Systems for Machine Tools | Industrial Engineering. Engineering Notes India. <https://www.engineeringenotes.com/industrial-engineering/machine-tools/control-systems-for-machine-tools-industrial-engineering/22195>
- Upadhyay, R. C., & Singh, M. (2011). Production of edible mushrooms. Industrial Applications, 79-97.
- United States Department of Agriculture, Natural Resources Conservation Service, "Water Resources Handbook for Economics" (1998). All U.S. Government Documents (Utah Regional Depository). Paper 168.
- Ware, E., (2019, November 6). What is the nutritional value of mushrooms? <https://www.medicalnewstoday.com/articles/278858#benefits>