

**DEVELOPMENT OF AN AUTOMATED  
MUSHROOM PASTEURIZING MACHINE**

**ALYSSAMAE C. MENDOZA  
KHARL AIDAN D. RAYO**

An Undergraduate Thesis Submitted to the Faculty of the Department of Agricultural and  
Biosystem 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**



## BIOGRAPHICAL SKETCH

Kharl Aidan D.C. Rayo was born on April 16, 2002, in Mallorca, San Leonardo, Nueva Ecija, as the second of three children to Mrs. Annalie D.C. Rayo and Victor P. Rayo. His academic journey began at San Lorenzo Ruiz Diocesan Academy, where he completed his elementary education in the 2011-2012 school year. He then transferred to Our Lady of Fatima University, Cabanatuan Campus, for his secondary education, graduating in the 2019-2020 academic year.

He decided to continue his studies at Central Luzon State University, pursuing a Bachelor of Science degree in Agricultural and Biosystems Engineering, a field that aligns with his passion and his family's business. Despite facing challenges in college due to being a slow learner, he remains determined and dedicated to overcoming obstacles. He constantly strives to learn new things and enhance his skills to contribute meaningfully to his field and society, guided by his favorite verse, Philippians 4:6: "Worry about nothing; pray about everything."

He also aims to start a successful business related to his field and invent solutions to address the challenges faced by farmers and communities. He believes that by applying passion and giving his all to everything he does, he can achieve his goals.

## **BIOGRAPHICAL SKETCH**

Alyssa Mae C. Mendoza was born on August 13, 2001, in Cabanatuan City, Nueva Ecija. She was raised in a simple, happy, and God-fearing family. She is the first daughter of Mrs. Rochelle C. Mendoza and Mr. Referendo D. Mendoza.

She completed her secondary education at Carranglan National High School in 2018. After graduation, she continued her studies at St. Joseph School of San Jose City, Nueva Ecija, where she graduated in 2020.

She pursued a bachelor's degree at Central Luzon State University, majoring in Agricultural and Biosystems Engineering.

Her college life was well spent and full of challenging lessons that molded her into an educated person. Those years helped her build strong friendships with individuals who became her inspiration during her ups and downs. Her college experience was also fruitful because Ms. Mendoza was able to develop her capabilities and make her dreams possible.

## ACKNOWLEDGMENT

The researchers would like to extend their deep appreciation to everyone who kindly gave their time, support, and knowledge, making this study possible.

First and foremost, profound appreciation to their Thesis Adviser, Engr. Novalyn G. Delos Santos, for her vital leadership, guidance, and consistent support throughout the duration of this study. Her abilities and dedication have been key in setting the route of the study, offering essential feedback, and providing major discoveries.

Special thanks to Dr. Wendy C. Mateo and Dr. Marvin M. Cinense for their time and assistance in offering suggestions, comments, and recommendations.

Gratitude is also extended to the Dean of the College of Engineering, Dr. Roy Searca Dela Cruz, for his continued support and guidance to the students.

To their family, especially their parents, sincerest appreciation for their continuous support, both emotional and financial. Their support and advice have been priceless in negotiating the challenges faced throughout this study.

They also extend their gratitude to their friends for their never-ending support and understanding has been a source of strength along this journey.

Above all, thankfulness is extended to Almighty God for His blessings, strength, wisdom, and inspiration during this remarkable journey. This piece serves as an homage to the grace that has illuminated the path.

The researchers extend their gratitude to everyone who has played a role, no matter how large or small, in bringing this study to its conclusion. Through the peaks and lows of this journey, their support added a rich layer to the experience, making the challenges more bearable and the victories more joyous.

This thesis is a testament to the collective efforts of all those mentioned above. Sincere thanks are extended to everyone for being an integral part of this academic milestone.

## TABLE OF CONTENTS

	PAGE
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF APPENDIX FIGURES	xii
ABSTRACT	xiv
INTRODUCTION	1
Background of the Study	3
Statement of the Problem	4
Objectives of the Study	5
Significance of the Study	6
Scope and Limitation of the Study	7
Time and Place of the Study	
REVIEW OF RELATED LITERATURE	8
Mushroom	8
Spore germination	9
Colonization	9
Fruiting	9
Sporulation	9
Characteristic of the Different Edible Mushroom Varieties in the Philippines	10
Paddy straw mushroom	12
Oyster mushroom	12
Shiitake mushroom	12
Button mushroom	13
Ear mushroom	13
Milky mushroom	13
Reishi mushroom	13
King Tuber oyster mushroom	14
Lion's mane mushroom	14
Yellowish oyster mushroom	14

Production Status of Mushroom in the Philippines	15
Cultivation and Yield Performance	16
Different Substrate to be used in Cultivating Mushroom	17
Sawdust	18
Rice Straw	18
Traditional Mushroom Production	19
Existing Mushroom Pasteurizer in Mushroom Center	21
Steam Pasteurizer	23
Processing Parameters for Mushroom Pasteurizer in Machine	24
Temperature	24
Time	25
Humidity	25
Pressure	26
Machine Parameters for Mushroom Pasteurizer	26
Chamber Size	26
Heating System	26
Humidification System	27
Air Circulation System	27
PID Controller for Temperature Control	27
ESP32 Industrial	29
PETG	30
DS18B20	31
Process for Arduino Base Temperature Controller for a Mushroom Pasteurizer	32
METHODOLOGY	34
Design Consideration and Criteria	35
Design Conceptualization	37

Principle Operation	38
Electronic System Layout	39
Components of the Machine	40
Electrical Load Calculation Design	42
Preliminary Testing	47
Final Testing	47
Data Gathering	48
Performance of Automated Mushroom Pasteurizer	49
Time of the Pasteurization Operation (T)	49
Length of Colonization	49
Percent of Contamination	49
Data Gathering of the Automated Mushroom Pasteurizing Machine	50
Experimental Design of the Study	51
Material Cost Estimation	51
RESULTS AND DISCUSSION	52
Automated Mushroom Pasteurizer Description	52
Machine Setup of Automated Mushroom Pasteurizer	55
Microcontroller Setup on Mushroom Pasteurizer	56
Testing and Calibration of Pasteurizer	57
Inoculation setup of mushroom	58
Time, Temperature and Humidity During Operation	59
Percent of Contaminated Mushroom Fruiting Bags	61
Colonization Length	64
Material Cost Estimation	65
SUMMARY	67
CONCLUSION	69
RECOMMENDATION	70
LITERATURE CITED	71

## LIST OF TABLES

TABLE		PAGE
1	Optimal growing conditions for various mushrooms	10
2	Available varieties of mushroom cultivation in the Philippines	11
3	Capacity and Specification of Mushroom Substrate Pasteurizer	21
4	Capacity and Specification Steam Pasteurize	23
5	Specifications of the automated mushroom pasteurizing machine.	53
6	Contaminated mushroom fruiting bags during inoculation form each trial involves different hours of operation.	62
7	Table of Observations in Length of Colonization	64

## LIST OF FIGURES

FIGURES		PAGE
1	Mushroom Life Cycle	9
2	Volume of production of mushroom in the Philippines	16
3	Mushroom Pasteurizer Machine in Mushroom Center	22
4	Steam Pasteurizer	24
5	PID Controller	28
6	ESP32	30
7	PETG	31
8	DS18B20	32
9	Conceptual Framework of the Study	35
10	Design of Mushroom Pasteurizer Machine	38
11	Electronic System Layout	39
12	Equivalent Circuit	43
13	Small Signal Equivalent Circuit	43
14	NMOS Amplifier with Depletion Load Device	45
15	Driver Transistor Characteristics	45
16	Small Signal Equivalent Circuit	46
17	Automated mushroom pasteurizer chamber and its part	52
18	Set up of the Automated Mushroom Pasteurizer	55
19	Control Box of Pasteurizer	56
20	Testing and calibration of machine	57
21	Gathering of Data in the Mushroom Chamber	59

22	4-hours Graph of Temperature, Relative Humidity data	60
23	6-hours Graph of Temperature, Relative Humidity data	60
24	8-hours Graph of Temperature, Relative Humidity data	61
25	Visual inspection of the pasteurized mushroom fruiting.	62

## LIST OF APPENDIX FIGURES

FIGURES	PAGE
1 Automated mushroom pasteurizer chamber and its part (1=Lock, 2=Racks, 3=Sensor, 4=Cylindrical hinge, 5= Door, 6= Insulator)	79
2 Automated mushroom pasteurizer heating system and its part (7=Heating Coils, 8=Floating valve)	8
3 Automated mushroom pasteurizer control system and its and part (9=Outlet, 10=Braker, 11=Contactor,12=Riley, 13= Micro controller)	80
4 Buying of materials	84
5 Fabrication and assembly of the machine.	84
6 Installation of electrical and wirings.	85
7 Final Design of the Automated Mushroom Pasteurizer.	85
8 Collecting raw materials	86
9 Calibration of the machine	86
10 Soaking and composting of rice straw	87
11 Chopping and formulation of substrate	87
12 Bagging of substrate	88
13 Inserting the rings of the fruiting bags	88
14 Inserting the cotton waste	89
15 Loading of the Mushroom Fruiting bags	89
16 Unloading of the mushroom fruiting bags	90
17 Cooling of Fruiting bags	90
18 Seeding process	91
19 Final set up of T1 (4 hours)	91

20	Final set up of T2 (6 hours)	92
21	Final set up of T3 (8 hours)	92
22	Coding of the System	93

## LIST OF APPENDIX TABLES

<b>TABLES</b>	<b>PAGE</b>
1 Experimental Design of the Study	75
2 Cost estimate of Fabrication	75
3 Cost of Operation	78
4 Troubleshooting Manual	83

## ABSTRACT

**RAYO, KHARL AIDAN D., MENDOZA, ALYSSA MAE C.,** Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines, **JULY 2024, DESIGN FABRICATION AND DEVELOPMENT OF AUTIOMATED MUSHROOM PASTEURIZING MACHINE**

Adviser: NOVALYN G. DELOS SANTOS, M.Sc.

As one of the high valued crops in the world, mushroom production for both commercial and research purposes starts to grow. The purpose of this research work was to design, fabricate, and automate a mushroom pasteurizer under Arduino-platformed control systems. Through optimization of the mentioned pasteurization parameters—temperature, relative humidity, the box-like design of the pasteurizer had dimensions 1000 mm × 1000 mm × 1300 mm, with a capacity to hold 125 mushroom fruiting bags, and was fitted with an Arduino-based controller to maintain set conditions within it.

Conducted at the College of Engineering Farm, Central Luzon State University (CLSU), researchers enhanced traditional pasteurization methods by adding a temperature and humidity controller. Sensors ensured consistent temperature and humidity distribution, achieving optimal ranges of 90-96 degrees Celsius and 93-96% relative humidity.

The study examined the effects of three pasteurization durations (4, 6, and 8 hours) on mushroom growth. Findings showed that an 8-hour pasteurization period yielded the best results, with the lowest contamination rate of 14.4% and the longest colonization averaging 14.8 cm over three weeks. The developed system, incorporating an ESP board, heating coils, and relays, successfully automated the pasteurization

process, improving efficiency and consistency in mushroom production.

Keywords: Pasteurize, Temperature, Relative Humidity, Mushroom

## LITERATURE CITED

- Abound, A. K. (2005). Potential of water hyacinth in ruminant nutrition in Tanzania.
- Akbar, T., Gunawan, I., & Utama, S. (2020). Prototype System of Temperature and Humidity Automatic in Oyster Mushroom Cultivation using Arduino Uno. *Journal of Physics*.
- Alc, B., & Raja, B. (n.d.). Performance Test of Substrate Pasteurization using Evacuated Tube Collector Solar Water Heaters. Retrieved from <http://conference.ioe.edu.np/ioegc2014/papers/IOE-CONF-2014-03.pdf>
- Bisoyi, S. K., & Chatterjee, S. (2014). A review on paddy-straw mushroom production and incidence of contestant molds. *International Journal of Current Microbiology and Applied Sciences*, 3(1), 254-265.
- Bermuli, J. E., Irawati, W., & Tammu, R. M. (2022). THE EFFECT OF PASTEURIZATION STAGE ON THE PRODUCTION OF STRAW MUSHROOM (VOLVARELLA VOLVACEA, BULL. EX. FR./SING.). *BIOLINK (Jurnal Biologi Lingkungan Industri Keschatan)*, 8(2), 242–256.
- Dharsini, S. P., Dharshini, R., & Aravind, P. (2014). Application of various PID controller tuning techniques for a temperature system. *International Journal of Computer Applications*.
- Chang, H., Jeon, S.W., Cosadio, A.L., Icalina, C.L., Panganiban, R., Quirino, R.A., & Song, Y. (2014). Status and Prospect of Mushroom Industry in the Philippines. *JPAIR Multidisciplinary Research*, 16, 1-1.
- Cherry Lyu(Sensor Manufacturer. (2023, September 11). Introduction In the realm of temperature sensing, the “esp01s ds18b20” module has become synonymous with precision and reliability. This article delves into the fascinating world of NTC (Negative Temperature Coefficient) thermistors and their applications, with a particular focus on the DS18B20 digi. Retrieved March 22, 2024.
- Chang, H., Jeon, S., Cosadio, A., Icalina, C., Panganiban, R., Quirino, R., & Song, Y. (2014, March). Status and Prospect of Mushroom Industry in the Philippines.
- Darko Hercog, Tone Lerher, Mitja Truntič, & Oto Težak. (2023). Design and Implementation of ESP32-Based IoT Devices. *Sensors (Basel)*, 23(15), 6739–6739.

- Dubey, D., Dhakal, B., Dhami, K., Sapkota, P., Rana, M., Poudel, N. S., & Aryal, L. (2019). Comparative study on the effect of different substrates on yield performance of oyster mushroom, GJBAHS
- Fungi Ally. (2020). Know When to Harvest Oyster Mushrooms for the Best Results. Retrieved from Know When to Harvest Oyster Mushrooms for the Best Results – Fungi Ally
- Gowda, N.A.N., & Kumaran, G.S. (2014). Design and development of a hot water paddy straw pasteurizer for mushroom cultivation. *Agricultural Mechanization in Asia, Africa and Latin America*, 45, 2, 11-18.
- Gowda, N.A.N., Kumaran, G.S., & Pandey, M. (2014). Performance Evaluation of Paddy Straw Pasteurizer for Mushroom Cultivation. *Agricultural Mechanization in Asia, Africa and Latin America*, 45, 3, 28-36
- Gupta, S., Kumar, S., Singh, R., & Summuna, B. (2020). Management of contaminants in mushroom spawn. *The Indian Journal of Agricultural Sciences*, 90(5), 1000-1003
- Jones, M., & Smith, J. (2023). The life cycle of mushrooms. *Mycology Today*, 35(1), 1217.
- Hòa, H. T., & Wang, C. (2015). The Effects of Temperature and Nutritional Conditions on Mycelium Growth of Two Oyster Mushrooms (*Pleurotus ostreatus* and *Pleurotus cystidiosus*). *Mycobiology*.
- Iconic Devices. (2023, July 19). ESP32-based Controllers for Innovative Automation and Monitoring Applications - NORVI Industrial Arduino. Retrieved March 21, 2024, from Programmable IoT Devices website: <https://norvi.lk/esp32-based-controllers-as-a-plc-for-automation-and-monitoring-applications/>
- Kyriakos Koritsoglou, Christou, V., Georgios Ntritsos, Georgios Tsoumanis, Tsipouras, M. G., Nikolaos Giannakeas, & Tzallas, A. T. (2020). Improving the Accuracy of Low-Cost Sensor Measurements for Freezer Automation. *Sensors*, 20(21), 6389–6389. <https://doi.org/10.3390/s20216389>
- Macias Gonzalez, A. A., Crespo Zafra, L. M., Bordons, A., & Rodriguez-Porrata, B. (2022). Pasteurization of Agricultural Substrates for Edible Mushroom Production. *Journal of Microbiology, Biotechnology and Food Sciences*, 12(1), e5729
- Mushworld. (2004). *Mushroom Grower's Handbook 1*.
- Nick. (2022, May 16). Pasteurizing Techniques in Mushroom Farming | Practical Growing.

- Orge, R.F., & Leal, L.V. (2018). Utilizing heat from rice hull biochar production for steam pasteurization of mushroom fruiting bags. *Cogent Engineering*, 5.
- Quimio, T. H. (2002). *Tropical Mushroom Cultivation*.
- Rai, R. D., & Arumuganathan, T. (2008). Post-harvest technology of mushrooms. National Research Centre for Mushroom (Indian Council of Agricultural Research). Retrieved from POST HARVEST TECHNOLOGY OF MUSHROOMS Technical Bulletin | Kyaw Kyaw Lin - Academia.edu
- Rogers, H. H., & Davis, D. E. (1972). Nutrient Removal by Water hyacinth. Retrieved June 20, 2011, from <http://www.jstor.org>.
- Sánchez, C. (2016). Modern aspects of mushroom culture technology. Retrieved March 11, 2024, from *Applied Microbiology and Biotechnology*.
- Selvi Sowmya, V., Dharsini, S. P., Dharshini, R., & Aravind, P. (2014). Application of various PID controller tuning techniques for a temperature system. *International Journal of Computer Applications*.
- Sayner, A. (2022, April 6). Complete Guide to Growing Mushrooms on Sawdust Blocks. GroCycle.<https://grocycle.com/growing-mushrooms-on-sawdustblocks/#:-:text=Final%20Thoughts->
- S.K. Barik, S. Dash, and P.K. Das. 2021. Monitoring and Automatic Control of Various Parameters for Mushroom Cultivation and Growing. *IOP Conference Series: Materials Science and Engineering*.
- Soriano, E., & Mangune, V. (n.d.). GROWTH IMPROVEMENT AND YIELD PERFORMANCE OF *Pleurotus* SPECIES USING DIFFERENT SUBSTRATE COMBINATIONS. Retrieved May 27, 2024, from <https://www.jetir.org/papers/JETIR2209168.pdf?fbclid=IwAR24Ws0L338ng5bLWkGJ5hYjhCn0oR6S4rk2jPwkcOvVwmNYfshsTlp731s>
- Thakur, M. P., & Singh, H. K. (2014). Advances in the cultivation technology of tropical mushrooms in India. *JNKVV Research Journal*, 48(2), 120-135.
- The Philippines Mushroom Industry Outlook 2022 - 2026. (2022).