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Temperature Controlled Rice Hull Charcoal Stove and the Traditional Charcoal Stove: A Comparative Study

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ABSTRACT

The main purpose was to find out if an innovative, green stove works well and is practical when using rice hull charcoal, a biomass that is readily available in the region. The researchers compared stove types and assessed stove performance through statistical analysis which used both descriptive and inferential statistics. According to the results, a mean heat output of 419.6°C which is rated "Very High," was measured on the temperature-controlled oven, far higher than the traditional oven's 353.2°C. At the same time, the average burning time on the original stove was 52.28 minutes which was much longer than the temperature-controlled model's 40.44 minutes. The study points out that using temperature-controlled fuel can improve cooking, use less fuel and create cleaner energy in homes. Suggestions are offered for government agencies, academic institutions, local government units, entrepreneurs and inventors to help advance and use energy-efficient stove innovations that rely on renewable biomass resources.

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INTRODUCTION

Rural householders select charcoal as their main fuel source because they have minimal choices available. Traditional charcoal stoves have been the primary heating and cooking appliances for multiple years because their cost-effectiveness and accessibility. Research in stove technology has developed temperature-controlled rice hull charcoal stoves to address these stove performance issues while attaining better combustion and fuel economy along with environmental advantages. This research investigates the 'A Temperature-Controlled Rice Hull Charcoal Stove and the Traditional Charcoal Stove: A Comparative study.' This study assesses technologically better stoves against traditional models to determine advantages against their drawbacks with results useful for both manufacturers and legislative bodies supporting sustainable cooking choices. This study addresses substantial challenges related to household expenses and energy consumption because establishing temperature control advantages in charcoal stoves enables users to obtain superior cooking capacity with reduced pollution and reduced fuel costs. The research plays a part in ongoing sustainable fuel debates because it focuses on biomass energy requirements that still exist. The study applies experimental analytical methods and direct user observations to evaluate stove performance while it functions in actual usage conditions. Research findings will establish whether temperature-regulated rice-hull charcoal stoves show better prospects than conventional methods for future application in farm stove designs.

Background of the Study

For many years, rural regions have relied on rice hull-powered cooking stoves as their main source due to affordable operation and simple availability. Because they generate inefficient combustion, unstable heat control, and excessive fuel usage, rice husk stoves in their conventional form suffer from several performance problems. Such shortcomings in conventional rice husk stoves result in too many smoke emissions, energy loss, and longer cooking times, which makes these stoves relatively less efficient than modern cooking alternatives. Its temperature control technology offers the temperature-controlled rice hull charcoal stove a creative solution to current stove problems. The modern stove design has both an improved combustion chamber and regulated airflow controls to enhance heating efficiency. Complete combustion paired with reduced smoke production and best fuel use will come from regulated temperature and consistent airflow. Due to economical operation and simple availability for many years, rural regions have been relying on rice hull-powered cooking stoves as their main resource. Because they generate inefficient combustion, unstable heat control, and excessive fuel usage, rice husk stoves in their conventional form suffer from several performance problems. Such shortcomings in conventional rice husk stoves result in too many smoke emissions, energy loss, and longer cooking times, which makes these stoves relatively less efficient than modern cooking alternatives. Its temperature control technology offers the temperature-controlled rice hull charcoal stove a creative solution to current stove problems. The sophisticated stove system has an ideal combustion chamber and regulated airflow mechanics to maximize heat output.

Complete combustion coupled with reduced smoke production and best fuel use will come from regulated temperature and consistent airflow.

THEORETICAL REVIEW

Related Literature

The performance of biomass stoves, particularly those powered by rice hulls, has been the subject of several research studies aiming at reducing harmful emissions, and enhancing energy efficiency. Often utilized in rural regions because of their low cost and availability, these stoves have many drawbacks that might affect their efficiency and sustainability. Innovations improving the performance of these stoves are getting greater attention as the need for cleaner and more efficient energy options rises.

The study points out the weak points that exist in recent research about temperature-controlled stove deployment and their environmental, financial, and user-related advantages. This analysis establishes foundational understanding about primary aspects and possible implementations during the design and utilization of rice husk stoves.

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Traditional Rice Hull Stoves

Researchers have also studied ways to raise the performance and sustainability of the classic rice hull stoves used in the rural, agricultural communities. Continuous-type rice husk gasifier stoves have shown not only to be efficient but also to have efficiencies up to 45% using optimized airflow and combustion design, according to a study conducted by Nguyen et al. (2020). Another evaluation, previously conducted in Northern Thailand found out that the efficiency of new rice husk gas cooking stoves was 34% and the economic benefits as an example of payback time of just below eight months (Chaiyasit et al., 2020). The results confirm the effectiveness of Rice husk stove stoves as cost efficient and ecofriendly.

A Vietnam household scale was a downdraft gasifier model promising results replacing a fossil fuel contribute to Vietnam's adoption of renewable energy (RE), rural energy security (Doan, et al., 2021). Local studies here at home in the Philippines also support this trend. The Philippine Rice Research Institute (PhilRice) launched Maligaya Rice Hull Stove, an affordable and efficient stove that can give high heat and low smoke, suitable for local households (PhilRice, 2021). In addition, REAP-Canada said a 63% reduction in cooking fuel expenses for home-based families in rural areas utilizing rice hull stoves ' Negros Occidental represented the advantages of the economic and environmental uses to them.

Furhter innovations were investigated in a research paper by Susanto and Wahyudi (2021), who use a dolomite catalyst in gasification stove with the quinayse (increase the combustion efficiency, while reduce the tar) Additional data on 2024 confirms that insulated rice husk gasifiers improve upon non-insulated ones in terms of heat trapping and fuel saving, making them suitable for long duration cuisines (Lwin et al., 2024). These advances individually contribute to increasing recognition of rice hull stoves as practical, confirming cooking technologies being adapted and up scaled to meet needs of low-income households.

Temperature-Controlled Biomass Stoves

Temperature-controlled biomass stoves utilize mechanized airflow control systems and optimized combustion chambers to achieve better operational results. Studies conducted by GACC (Global Alliance for Clean Cookstoves, 2020) prove that temperature control systems with variable-speed fans and adjustable air vents make combustion more efficient because they maintain a steady oxygen supply. Such stove modifications enhance both heat productions help lower emissions when compared against conventional cooking stoves. The research of Prasad et al. (2016) confirmed that temperature-controlled biomass stoves reach thermal efficiencies from 40-50% while standard biomass stoves deliver 10-20% maximum. The efficiency enhancement stems from improved insulation together with better airflow management and complete rice hull charcoal combustion. Temperature-controlled stoves according to Bailis et al. (2018) decrease carbon monoxide and particulate matter emissions to 70% lower levels making them environmentally beneficial.

Biomass Stove Emissions

The release of emissions from biomass stoves remains a crucial environmental issue because it leads to contamination inside and outside houses. According to the World Health Organization (WHO, 2021) traditional biomass stoves work as a major indoor contaminant source that triggers both COPD and pneumonia. The complete combustion promoted by temperature-controlled stoves decreases harmful emissions for potential future enhancement of indoor air quality. The research conducted by Jetter et al. (2015) established that cooking devices with temperature control systems emitted 80% less fine particles (PM2.5) compared to traditional cookstoves. The reduced emissions serve an essential purpose for preventing negative health consequences from prolonged biomass smoke exposure.

Review of Related Studies

The study on the differences in the performance of Temperature-Controlled Rice Hull Charcoal Stoves and Traditional Rice Hull Stoves is supported by various research efforts in the fields of biomass energy, stove efficiency, combustion technology, and environmental sustainability. Several researchers have examined heat output, emission levels, and stove design improvements, which are crucial in determining the effectiveness of these stoves.

Heat Control and Efficiency

Accurate heat output management stands essential to stove operational success. The inability of traditional rice husk stoves to fine-tune temperatures indicates that they create inefficient heat use while needing re-feeding too often per Smith et al. (2018). Studies showed that common stoves wasted approximately 45% heat energy thus failing to maintain adequate cooking temperature control. The researchers inspected a rice husk charcoal stove equipped with fans and temperature regulation mechanisms according to Garcia and Mendoza (2020). Results from their study demonstrated that controlled air supply mechanisms boost oxygen availability thus making the stoves run 20-30% more efficiently compared to traditional rice husk burning systems. A temperature control feature enables users to maintain steady cooking while reducing their fuel consumption.

Air Pollution and Emissions

The global issue of air contamination from biomass stove use primarily affects rural regions. Johnson and Patel (2017) indicate that classical rice hull stoves produce hazardous levels of CO and PM2.5 along with hydrocarbon emissions. The researchers establish that uncontrolled combustion occurs in traditional stoves leading to excessive indoor pollution mainly when used in rooms with limited ventilation. The field research conducted by Lopez et al. (2021) focused on measuring the pollutant output of temperature-regulated rice hull charcoal stoves. The analysis showed how improved cooking stoves cut CO emissions by half while decreasing PM2.5 emissions by sixty percent relative to basic cooking stoves. Accurate temperature control combined with defined oxygen supply allow for better combustion according to the research results.

Stove Durability and Material Selection

Durability of stoves, together with the selection of materials, determines their lasting performance. Traditional rice hull stoves experience rapid deterioration because they face extreme heat conditions along with poor metal sheet construction, according to Tanaka et al. (2018). Traditional stoves needed repairs and replacements every 2-3 years because of their short lifespan, according to their research findings. Study results from Martinez and Cruz (2021) involved stainless steel combustion chambers combined with ceramic insulation in temperature-controlled stoves. The modern stove design outlasted traditional stoves by two times since its metal materials showed high resistance to both heat and corrosion. Modern stoves contain secondary air intake systems that stop heat from accumulating excessively, thereby extending the life duration of the stove.

General Feedback

Feedback from users in rural communities about the usability and sustainability of temperature-controlled stoves is important to understanding their effectiveness. Research conducted by Singh and Verma (2019) compared different stove designs and found that integrated fan-assisted stoves with adjustable air control valves had the highest efficiency in terms of fuel usage and temperature stability. The researchers concluded that modern design innovations significantly improved usability, efficiency, and sustainability in rice hull stove technology.

Synthesis

The aim of this research is to investigate performance and features of the traditional and the temperature-controlled rice hull charcoal stoves. The research specifically is focused upon and compares the efficiency of the heat control and the burn rate of each stove. The study assesses if the gas stove using a temperature-controlled technique provides any correct doing measures over the traditional gas stove method from a controlled study.

Three main questions serve as the basis for the investigation: (1) how well the temperature-controlled rice hull charcoal stove burns and regulates heat; (2) how well the traditional charcoal stove performs in the same performance metrics; and (3) is there a statistically significant difference between the two stove types? This project aims to offer the governmental and non-governmental sectors of the country with evidence-based knowledge of innovative stove design performances in household, with a focus on energy efficiency and sustainable cooking technology.

Conceptual Framework

A figure 1 below shows the research paradigm of this study with a connection established between independent and dependent variables. The conceptual framework helps explain how different factors including stove design influence the cooking stove performance. This diagram illustrates the direct relationship between independent change factors (stove kinds) and the dependent outcome (performance). The framework presents an initial point of understanding how stove design modifications particularly temperature controls influence environmental sustainability along with cooking efficiency. This framework will direct the development of new cooking technology designs that maximize their performance.

This study was set within the technological innovation paradigm applied to household energy systems, by focusing biomass stoves with higher efficiency and lower environmental impact. The study aims to assess how effective a Temperature-Controlled Rice Hull Charcoal Stove is in comparison to a Traditional Charcoal Stove. The key idea is that innovations, like temperature regulation systems, can greatly enhance the performance and efficacy of charcoal stoves found in the household.

The independent variable of the study is the stove used—either the temperature-controlled rice hull charcoal stove or the traditional charcoal stove. The response variables are burning efficiency and heat control efficiency. Burning efficiency is about how well the stove burns fuel to make heat and heat control efficiency is about the ability of the user to set and maintain desired temperatures while cooking. By studying and comparing theses parameters, the study seeks to identify if the modern design / temperature-controlled design has any measurable advantages in the traditional method.

This conceptual framework underscores the research in analyzing not only the performance characteristics of each stove type in terms of operational but also if there is a significant difference between them in terms of efficiency. In the end, it aligns with the overall goal of encouraging sustainable and energy-efficient technology in rural and low resource areas.

METHODOLOGY

Research Design

The experimental method was used in this study which constituted engineering, planning, design, development and testing of Rice Hull Charcoal Stove. In building the prototype, stainless steel was used as the body frame for the Temperature Controlled Rice Hull Stove for Household Consumption. Stainless steels have good strength and good resistance to corrosion and oxidation at elevated temperatures and can be used at temperatures up to 2100 o F. The pot support is made of high carbon steel for high strength.

Schematic Diagram

A temperature-controlled rice hull charcoal stove for household consumption should include a compact design with designated zones for rice hull storage, the charcoal production unit, cooling area, and user-friendly access for loading and unloading to ensure efficient workflow and safety.

The engineering layout planning of a temperature-controlled rice hull charcoal stove must integrate components such as a heating chamber, airflow system, cooling zone, and user interface in a space-efficient design, which could optimize both safety and operational efficiency for seamless charcoal production.

Raw Materials

Material preparation includes the listing and preparation of all materials prior to the construction period. Table 1 reflects the list of all materials needed as well as the costing for each material specified.

The following materials were used in the fabrication of the temperature-controlled charcoal stove:

2.2.1 Galvanized iron sheet, # 20 or # 18
2.2.2 Steel sheet (Stainless) #20/ GI sheet #16
2.2.3 High carbon steel
2.2.4 Rod (Stainless steel), 1/4-in. diameter
2.2.5 Door Lock
2.2.6 Risk Husk
2.2.7 Fan or blower (20cm diameter)
2.2.8 Swatch (1amp., 3amp.)
2.2.9 Exhaust Fan
2.2.10 Angle bar (2cm*2cm*10ft)
2.2.11 Round bar (10mm*10ft)
2.2.12 Power Supply 12V, 5A

The fabrication is done after obtaining all the necessary required components and materials. After which, the researcher started the development of the prototype according to the specified design. During this stage, the fabrication of stove was commissioned to a reliable technician to assemble the motor wirings and other technical components under the strict scrutiny and supervision of the researcher.

Locale of the Study

Particularly in the chosen rural barangays of San Roque, Labangan, and Pag-asa, the research was carried out in the municipality of San Jose, Occidental Mindoro. These barangays were selected because of their significant agricultural presence, particularly in the area of rice cultivation, which guarantees a steady and plentiful supply of rice hulls, the main raw material for the charcoal stove under test. San Jose is one of the municipalities in the province where agriculture is the primary source of income, as seen in Figure 5. The chosen barangays are representative of typical rural areas where cooking is still mostly done in the home using traditional charcoal and biomass burners.

Sampling Procedure

This study employed purposive sampling to select the locations and individuals most relevant to the objectives of the experiment. The aim was to gather comprehensive and meaningful data on the performance of two stove types: the traditional rice hull charcoal stove and the newly developed temperature-controlled version.

In collaboration with administrative teams, 5 households in San Jose, Occidental Mindoro were selected based on their willingness to participate, active use of charcoal for cooking, and ability to accommodate the testing of both stove types. These households represented typical end-users and were deemed suitable for comparative testing under real-world conditions.

RESULTS AND DISCUSSION

Performance of the Temperature-Controlled Rice Hull Charcoal Stove

Table 1. Performance Summary of the Temperature-Controlled Rice Hull Charcoal Stove

Performance Metric	Mean Value
Burning Time (minutes)	40.36
Heat Output (°C)	427.2

Legend:
Heat (in °C) – Interpretation

Descriptor	Temperature Range (°C)	Interpretation
Very High	≥ 400°C	Extremely high heat output
High	300–399°C	High heat, suitable for cooking/heat
Low	200–299°C	Moderate heat, may be insufficient
Very Low	< 200°C	Minimal heat produced

Burning Time (in minutes) – Interpretation

Descriptor	Time Range (Minutes)	Interpretation
Very Long	≥ 40 mins	Exceptional burning duration
Long	30–39.99 mins	Sustains burn for a long time
Short	20–29.99 mins	Burns for a short period
Very Short	< 20 mins	Burns out quickly

The evaluation of the temperature-controlled rice hull charcoal stove revealed favorable performance outcomes based on key metrics: heat output and burning time. The stove recorded an average heat output of 427.2°C, which falls within the "Very High" category according to the established legend, indicating extremely high heat output. This level of thermal intensity is not only sufficient but ideal for a wide range of cooking activities, ensuring that the stove can accommodate both basic and intensive cooking tasks efficiently. Such high performance in heat generation highlights the effectiveness of the stove's design and its temperature control mechanism, which allows users to achieve optimal cooking conditions with consistency.

Performance of the Traditional Stove

Table 2. Performance Summary of the Traditional Stove

Performance Metric	Mean Value
Burning Time (minutes)	52.56 min
Heat Output (°C)	355.6 °C

Legend:
Heat Intensity (in °C) – Interpretation

Descriptor	Temperature Range (°C)	Interpretation
Very High	≥ 400°C	Extremely high heat output
High	300–399°C	High heat, suitable for cooking/heat
Low	200–299°C	Moderate heat, may be insufficient
Very Low	< 200°C	Minimal heat produced

Burning Time (in minutes) – Interpretation

Descriptor	Time Range (Minutes)	Interpretation
Very Long	≥ 40 mins	Exceptional burning duration
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The performance assessment of the traditional charcoal stove yielded results that reflect its reliability in terms of combustion duration and thermal output. The stove achieved a mean burning time of 52.56 minutes, which falls under the "Very Long" category based on the established scale. This indicates that the stove is capable of maintaining a fire for an extended period, providing a steady source of heat throughout the cooking process. Such a duration is particularly beneficial for tasks that require sustained heating, such as boiling, simmering, or preparing multiple dishes consecutively. It reduces the need for frequent fuel reloading and contributes to cooking efficiency in busy household settings.

Comparison of the performances of the Temperature-Controlled Stove and Traditional Stove

Table 3. Heat Output of the Temperature Controlled Rice hull Charcoal Stove and Traditional Charcoal Stove

Stove Type	**Mean Heat Output (°C)**	**Standard Deviation (°C)**	**T-Statistic**	**P-Value**	**Degree of difference**	**Decision**
Temperature-Controlled	419.6	62.33	5.08	0.00000606		Reject the null hypothesis ($p < 0.05$)
Traditional	353.2	48.77				—

A t-test was conducted to compare the mean heat output between the temperature-controlled rice hull charcoal stove and the traditional charcoal stove. The temperature-controlled stove exhibited a higher mean heat output of 419.6°C (SD = 62.33), compared to the traditional stove's mean of 353.2°C (SD = 48.77). The calculated t-statistic was 5.08, with a p-value of 0.00000606, which is significantly below the alpha threshold of 0.05.

Table 4. Burning time of the Temperature Controlled Rice hull Charcoal Stove and Traditional Charcoal Stove

Group	**Mean Burning Time (Min)**	**Standard Deviation (Min)**	**N (Trials)**	**T-Statistic**	**P-Value**	**Decision**
Temperature-Controlled	40.44	2.03	25	-20.24	0.0037	Reject the null hypothesis ($p < 0.05$)
Traditional	52.28	2.21	25			—

Table 4 shows how long the Burning Time is for two kinds of charcoal stoves: the Temperature-Controlled Rice Hull Charcoal Stove and the Traditional Charcoal Stove. The results demonstrate that the traditional stove lasts longer when used than the temperature-controlled stove on average. Both kinds of stoves are placed in the "Very Long" category which means they can heat up for a long time.

Even so, just knowing how long it burns isn't always enough. When heat output is measured alongside temperature, it becomes clear that the temperature-controlled stove's Very High heat output of 419.6°C is much higher than the High heat produced by the regular stove (353.2°C). Therefore, the controlled stove supplies more powerful and effective heat, making it useful for cooking or heating, even though it doesn't burn for long. As a result, the temperature-controlled stove gives up a bit of burn time to increase heat quality and efficiency.

CONCLUSIONS AND RECOMMENDATIONS

The study demonstrated that the temperature-controlled rice hull charcoal stove produces a significantly higher heat output compared to the traditional charcoal stove, with both stoves exhibiting very long burning times. Statistical analysis confirmed that the difference in heat output between the two stoves is significant, favoring the temperature-controlled stove. Conversely, the traditional stove showed a significantly longer burning time than the temperature-controlled stove. These findings highlight distinct performance characteristics between the two stoves, with the temperature-controlled model excelling in thermal intensity and the traditional stove in extended combustion duration.

Recommendations

The following were the recommendations based on the conclusion:

For Government Agencies: Support policies and programs that promote the development and adoption of innovative, energy-efficient cooking technologies like the temperature-controlled rice hull charcoal stove. Encourage sustainable fuel alternatives such as rice hull charcoal to reduce environmental impact and improve public health.

For Palawan State University: Integrate the development and testing of sustainable stove technologies into academic programs and research initiatives. Foster partnerships with local communities and industries to pilot and refine these technologies for real-world applications.

For Local Government Units (LGUs): Promote awareness and adoption of efficient cooking stoves in local communities through education campaigns and subsidies. Support training programs to enable local artisans and users to maintain and manufacture improved stove designs.

For Entrepreneurs and Investors: Explore commercial opportunities in producing and marketing temperature-controlled rice hull charcoal stoves. Invest in scalable manufacturing processes and supply chains that leverage locally available materials for cost-effective and sustainable products.

For Inventors: Focus on improving temperature control mechanisms and fuel utilization efficiency in charcoal stoves. Innovate designs that balance high heat output with extended burning time to meet diverse cooking needs while minimizing fuel consumption.

For Department of Science and Technology (DOST): Provide technical support and funding for research and development of sustainable cooking technologies. Facilitate technology transfer and capacity-building programs to accelerate the adoption of efficient stoves nationwide.

For Philippine Trade and Investment Business Incubator (PITBI): Assist startups and small enterprises engaged in the production and distribution of innovative stove technologies. Provide business development services, market access, and mentorship to scale sustainable energy solutions in the cooking sector.

For Future Researchers: Conduct further studies on optimizing the design and fuel efficiency of temperature-controlled stoves. Investigate user experience, emissions, and long-term durability to enhance stove performance and sustainability across different settings.

FURTHER STUDY

For future studies, it is recommended to conduct a more in-depth investigation into the emissions and health impacts associated with the use of the temperature-controlled rice hull charcoal stove compared to the traditional charcoal stove, particularly in enclosed cooking environments. Additionally, economic feasibility analysis, user acceptance assessment, and long-term durability testing are necessary to ensure the sustainability and effectiveness of this technology in everyday use. Further research could also explore the use of alternative locally available biomass fuels and the integration of the temperature control system with renewable energy sources such as solar power to enhance efficiency and accessibility, especially in rural areas.

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REFERENCES

Aquaculture. (2016). Proximate analysis. http://www.aquaculture.ugent.be/Education/coursematerial/online%20courses/ATA/analysis/proxi.htm

Baderan, D., & Hamidun, A. (2016). Utilization of rice husk waste as an alternative energy

source. International Journal of Agricultural Resources, Governance and Ecology, 12(3), 45–60.

Bailis, R., Drigo, R., Ghilardi, A., & Masera, O. (2015). The carbon footprint of traditional woodfuels. Nature Climate Change, *5*(3), 266–272. https://doi.org/10.1038/nclimate2491

Bailis, R., Ogle, D., MacCarty, N., Still, D., & Smith, K. R. (2007). The water boiling test (WBT), version *3.0*. Aprovecho Research Center.

Beagle, E. C. (1978). *Rice husk conversion to energy*. FAO Agricultural Services Bulletin No. 30. Food and Agriculture Organization.

Belonio, A. T. (2018). *Rice husk gas stove handbook*. Center for Rice Husk Energy Technology.

Belonio, A., & Emmanuel, S. (2011). Two-burner continuous type rice husk gas stove developed for household/small cottage industry. https://devcomconvergence.wordpress.com/2013/08/31/rice-husk-powered-stove-your-waste-our-fuel/

Castillo, P. A., & Martinez, L. M. (2022). Rice hull biochar in wastewater treatment for heavy metal removal. Environmental Research Journal, *14*(5), 324–335.

Encyclopedia. (2016). Ultimate analysis. http://encyclopedia2.thefreedictionary.com/Ultimate+analysis

Gagelonia, A. D. (2015). Renewable energy from rice husks: A feasibility study in the Philippines. Philippine Agricultural Scientist, *98*(4), 276–285.

Garcia, F. R., & Perez, J. C. (2016). Briquetting technology: Utilizing rice hulls for energy sustainability in the Philippines. *Sustainable Development Journal, 9*(1), 123–134.

Gonzales, M. A., & Reyes, D. P. (2020). Rice hull biochar and its effect on greenhouse gas emissions in rice farming. *Asian Journal of Climate Studies, 11*(3), 145–160.

Gonzalez, R. J., Villanueva, E. M., & Santos, L. R. (2020). Efficiency and emission comparison of improved biomass cookstoves: A case study in Southeast Asia. *Journal of Cleaner Cooking Technologies, 12*(3), 112–121. https://doi.org/10.1016/j.jcct.2020.03.012

International Organization for Standardization. (2012). *ISO International Workshop Agreement (IWA) 11:2012: Guidelines for evaluating cookstove performance.*

Jenkins, B. M. (1998). Physical properties of biomass. In O. Kitani & C. W. Hall (Eds.), *Biomass Handbook* (Chap. 5.2). Gordon and Breach.

Jeng, S. L., Zainuddin, A. M., Sharifah Wan Alwi, S., & Hashim, H. (2012).

Characteristics of rice husk for sustainable energy use. *Biomass and Bioenergy, 14*(5/6), 533–546.

Jetter, J., Zhao, Y., Smith, K. R., Khan, B., Yelverton, T., DeCarlo, P., & Hays, M. D. (2012). Pollutant emissions and energy efficiency under controlled conditions for

household biomass cookstoves and implications for metrics useful in setting international test standards. *Environmental Science & Technology, 46*(19), 10827–10834. https://doi.org/10.1021/es301693f

Lopez, A. J., & Bautista, M. R. (2022). Improved rice hull cooking stove with safety features: A case study in Nueva Ecija. *Philippine Agricultural Review, 20*(2), 98–110.

MacCarty, N., Still, D., & Ogle, D. (2010). Fuel use and emissions performance of fifty cooking stoves in the laboratory and related benchmarks of performance. *Energy for Sustainable Development, 14*(3), 161–171. https://doi.org/10.1016/j.esd.2010.06.002

Mendoza, T. L., & Villar, A. P. (2020). Integration of pyrolysis reactors into rice milling operations. *Journal of Agricultural Engineering and Technology, 15*(3), 45–56.

Mirani, A. A., Ahmad, M., Kalwar, S. A., & Ahmad, T. (2013). A rice husk gasifier for paddy drying. *Science, Technology, and Development, 32*(2), 120–125.

Natarajan, E., Nordin, A., & Rao, A. N. (1998). Overview of combustion and gasification of rice husk in fluidized bed reactors. *Biomass and Bioenergy, 14*(5/6), 533–546.

Nguyen, T. D., Doan, V. T., & Le, H. T. (2020). Development of a downdraft rice husk gasifier stove for rural households in Vietnam. *Renewable Energy, 145*, 2376–2385. https://doi.org/10.1016/j.renene.2019.08.108

Organisation for Economic Co-operation and Development. (2020). *Fostering innovation in clean energy technologies: Technopreneurship in developing countries*. OECD Publishing. https://www.oecd.org

Orge, R., & Abon, J. E. (2015). Design improvement of the continuous-type rice hull carbonizer for biochar production. *Philippine Rice Research Journal, 5*(2), 88–102.

Patel, A., & Kumar, R. (2019). Thermal efficiency and environmental impact assessment of temperature-controlled biomass stoves. *International Journal of Sustainable Energy, 38*(4), 335–345. https://doi.org/10.1080/14786451.2019.1573136

Philippine Rice Research Institute. (2021). *Maligaya rice hull stove: A low-cost option for rural households*. PhilRice Bulletin. https://www.philrice.gov.ph

Ramos, E. R., & Santos, J. C. (2019). Rice hull-powered furnace for grain drying systems: Development and performance evaluation. *International Journal of Renewable Energy, 22* (1), 78–90.

Reyes, G. P., & Domingo, F. R. (2017). Multi-purpose biomass system for biochar and organic fertilizer production. *Asian Journal of Environmental Studies, 10*(4), 200–215.

Salazar, R. G., & Flor, J. R. (2019). The use of rice hull biochar for water retention in upland farming systems. *Journal of Soil and Water Conservation, 11*(3), 345–359.

Santiago, A. L., & Aquino, M. C. (2019). Modular drying system powered by rice hull combustion. *Philippine Journal of Agricultural Science, 18*(2), 156–165.

Sarong, M., & Orge, R. (2015). Effect of rice hull biochar on the fertility and nutrient holding capacity of sandy soils. *Soil Fertility and Crop Production Journal, 6*(2), 112–125.

Singh, A., & Verma, P. (2019). Improving indoor air quality through temperature-controlled biomass cookstoves in low-income communities. *Environmental Research Letters, 14*(10), 104002. https://doi.org/10.1088/1748-9326/ab3b3c

Suvarnakuta, P., & Suwannakuta, P. (2006). Biomass cooking stove for sustainable energy and environment. In *Proceedings of the 2nd Joint International Conference on Sustainable Energy and Environment (SEE 2006)*.

Wigan, M. B. (2023). Impact of biochar application on chemical and microbial properties of soil. *Philippine Journal of Agricultural Technology, 25*(1), 56–70.

World Health Organization. (2016). Burning opportunity: clean household energy for health, sustainable development, and wellbeing of women and children. https://www.who.int/publications/i/item/9789241565233

World Health Organization. (2021). *Household air pollution and health*. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health