Functionality, Usability, and Acceptability Assessment of the Manual Coconut Charcoal Briquette Molder

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ABSTRACT

This study focuses on the development and assessment of a prototype manual coconut charcoal briquette molder. Designed to efficiently utilize coconut by-products and other waste materials, the prototype addresses the pressing need for accessible and cost-effective briquette production technology in rural and resource-limited areas. Constructed from stainless steel, the molder features a cylindrical canister, a rotating lever, a metal frame, an ejector, and a presser. Functionality, usability, and acceptability were evaluated through user feedback, yielding mean scores of 4.56, 4.68, and 4.57, respectively, all categorized as "Very High." Experimental results on the burning time of briquettes produced with varying levels of cornstarch binder indicated a significant difference between treatments ($\rho = 0.008$). Treatment 4, containing 25 grams of cornstarch, exhibited the longest burning time (mean = 68.60 minutes). These findings highlight the prototype's potential as a practical solution for sustainable waste management and renewable energy production.

Keywords: Prototype, Manual Briquette Molder, Usability, Functionality, Acceptability

INTRODUCTION

This study focuses on the prototype development of a manual coconut charcoal briquette molder, an innovative response to the challenges faced by the coconut industry in managing waste and producing renewable energy. Coconut (Cocos nucifera L.), often referred to as the "tree of life," is a vital agricultural commodity globally. In the Philippines, the second-largest producer of coconuts, production reached 3.41 million metric tons in the second quarter of 2023, reflecting steady growth (Philippine Statistics Authority, 2023). However, the industry faces significant challenges, including natural disasters, pest infestations, and the underutilization of coconut by-products such as shells, which often contribute to environmental waste (DOST, 2017).

As fossil fuel prices rise and environmental concerns grow, biomass fuel has gained attention as an eco-friendly alternative. Charcoal briquettes, derived from coconut shells, offer a sustainable solution for heating and energy needs. However, existing briquette molders are typically costly, technically complex, and geographically inaccessible, particularly in rural communities (UNIDO, 2015). Addressing these issues, this study aims to develop a manual briquette molder that is both cost-effective and user-friendly.

The importance of this prototype extends beyond waste management; it aligns with sustainable practices by reducing reliance on fossil fuels and promoting renewable energy. Charcoal briquettes are not only environmentally friendly but also provide economic opportunities for small-scale farmers and entrepreneurs. On an industrial scale, briquette molders have been shown to contribute to reducing waste and lowering carbon

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emissions (Arayata, 2022). However, limited access to affordable and efficient technology has hindered broader adoption in rural areas, highlighting a critical research gap.

This study addresses these challenges through the design and development of a manual coconut briquette molder. The prototype is intended to produce high-quality briquettes while being accessible to communities with limited resources. The study's objectives are twofold: (1) to evaluate the functionality, usability, and acceptability of the prototype, and (2) to determine the burning time of briquettes produced with varying levels of cornstarch as a binder. By addressing these objectives, the study aims to provide a practical and sustainable solution for coconut waste utilization, contributing to renewable energy production and economic development in resource-limited settings.

MATERIALS AND METHODS

Design and Prototype Development

The prototype was constructed using stainless steel components, including a cylindrical molder, rotating lever, metal frame, ejector, and presser. It was designed to produce 12 briquettes per operation, incorporating ergonomic and safety features for user convenience.

Data Collection

Data were gathered from 25 respondents, including farmers, agriculturists, and a mechanical engineer in Mati City. Respondents evaluated the prototype using a structured questionnaire validated by experts. The assessment criteria included functionality, usability, and acceptability, rated on a 5-point Likert scale.

Experimental Procedure

A completely randomized design (CRD) was employed to test the burning time of briquettes produced with varying levels of cornstarch binder (10g, 15g, 20g, 25g). Each treatment included five replicates, with 200g of charcoal powder and 250ml of water kept constant.

Statistical Analysis

Data were analyzed using Analysis of Variance (ANOVA) to identify significant differences in burning times among treatments ($\rho = 0.05$). Fisher's Least Significant Difference (LSD) test was applied for post-hoc comparisons.

RESULTS AND DISCUSSION

Table 1. Functionality Assessment

Criteria	**Mean**	**Level**
Highly functional	4.72	Very Functional
Molds 12 briquettes per minute	4.28	Functional
Reaches full press	4.68	Very Functional
Easy briquette extraction	4.72	Very Functional
Suitable for both left- and right-hand users	4.44	Functional
Overall	**4.56**	**Very Functional**

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The prototype demonstrated exceptional functionality, achieving an overall mean of 4.56, categorized as "Very Functional." Respondents highlighted the ease of operation and effectiveness in molding briquettes. Features such as the lever mechanism and ergonomic design contributed significantly to its high functionality score. These results are consistent with findings by Kithinji et al. (2017), who emphasized the importance of ergonomic and user-friendly designs in promoting technology adoption.

While the ability to mold 12 briquettes per minute received a slightly lower rating (4.28), it still falls within the functional category, suggesting room for optimization. The prototype's adaptability for both left- and right-handed users reflects its inclusive design, aligning with the goal of widespread usability (Njuguna et al., 2017).

Table 2. Usability Assessment

Criteria	**Mean**	**Level**
Easy to operate	4.84	Very Usable
Comfortable for prolonged use	4.24	Usable
Produces decent quantity per press	4.72	Very Usable
Provides safety	4.76	Very Usable
Portable	4.84	Very Usable
Overall	**4.68**	**Very Usable**

The usability evaluation yielded an overall mean of 4.68, categorizing the prototype as "Very Usable." Respondents particularly appreciated its portability and ease of operation, both scoring 4.84. These findings align with the principles outlined by Njuguna et al. (2017), who noted that portable and straightforward designs are critical for ensuring widespread adoption in rural areas.

However, comfort during prolonged use received a slightly lower score of 4.24, indicating potential areas for ergonomic improvements. Enhancing user comfort through design modifications, such as adjustable levers or padded handles, could further improve usability ratings. The prototype's safety features were also highly rated, underscoring its practical applicability in various operational settings (Ado et al., 2021).

Table 3. Acceptability Assessment

Criteria	**Mean**	**Level**
Accessible supplies and materials for components	3.44	Undecided
Reliable for longer operations	4.84	Very Acceptable
Operates in alignment with designated features	4.92	Very Acceptable
Appropriate tool for producing briquettes	4.80	Very Acceptable
Provides safety to users	4.88	Very Acceptable
Overall	**4.57**	**Very Acceptable**

The acceptability assessment revealed an overall mean of 4.57, reflecting a high level of user satisfaction. Key strengths identified include reliability (4.84) and alignment with designated features (4.92). These results

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affirm the prototype's ability to meet user expectations, as supported by similar findings in renewable energy technology studies (Aguilar et al., 2021).

The slightly lower score for accessibility of materials (3.44) highlights the need for locally available and affordable components. Addressing this limitation could further enhance the prototype's acceptability, particularly in resource-constrained areas.

Table 4. Burning Time of Briquettes

Treatment	**Mean Burning Time (minutes)**
T1 (10g)	62.20
T2 (15g)	65.00
T3 (20g)	67.00
T4 (25g)	68.60

ANOVA results ($\rho = 0.008$) confirmed significant differences among treatments. The longer burning time of T4 (25g of cornstarch) aligns with findings by Gana (2018), who observed improved combustion properties with increased binder concentration. The results suggest that higher binder levels enhance structural integrity, reducing porosity and prolonging burning duration.

Post-hoc analysis indicated significant differences between T4 and lower treatments (T1 and T2), further validating the effectiveness of the optimized binder concentration. These findings are crucial for applications requiring sustained energy output, such as household cooking and industrial heating (Chipangura et al., 2023).

CONCLUSION

The development and assessment of the manual coconut charcoal briquette molder highlight its potential to address critical challenges in coconut by-product utilization and renewable energy production. The prototype's high ratings for functionality (4.56), usability (4.68), and acceptability (4.57) reflect its capacity to meet user needs effectively. These results demonstrate that the manual briquette molder provides a viable solution for rural communities and small-scale entrepreneurs seeking cost-effective and sustainable alternatives for energy production. Moreover, the molder's simple design and portability make it particularly suitable for resource-limited settings (UNIDO, 2015).

The experimental findings further validate the effectiveness of the molder, with Treatment 4 (25 grams of cornstarch) producing briquettes with the longest burning time (mean = 68.60 minutes). This significant improvement in performance underscores the importance of optimizing binder concentrations to enhance briquette quality and efficiency. The results align with previous studies, such as Gana (2018), which emphasize the role of binder composition in prolonging burning times and improving energy output. These findings suggest that the molder, when paired with the appropriate binder mix, can produce high-quality briquettes that meet the demands of both household and industrial users.

By combining functionality, usability, and acceptability, this prototype contributes to sustainable waste management and renewable energy solutions. Future research should focus on further refining the design, exploring alternative materials, and conducting broader field tests to maximize its potential impact. The manual coconut briquette molder represents a practical innovation for sustainable energy and waste management, aligning with global goals for sustainability and economic resilience (Aguilar et al., 2021).

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Design

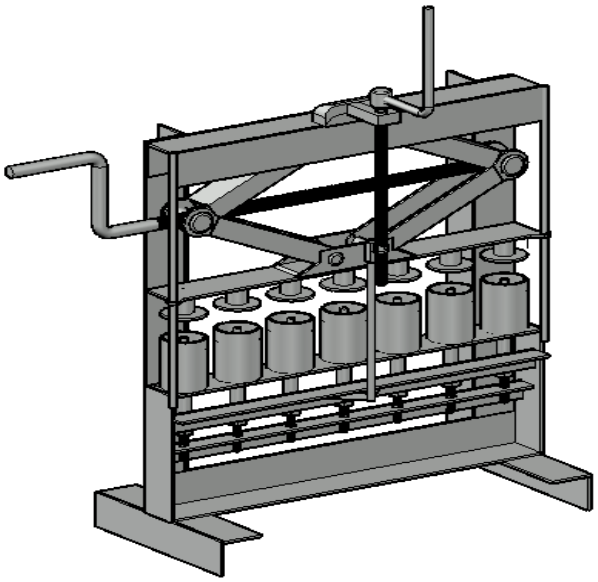

Figure 1. Perspective View

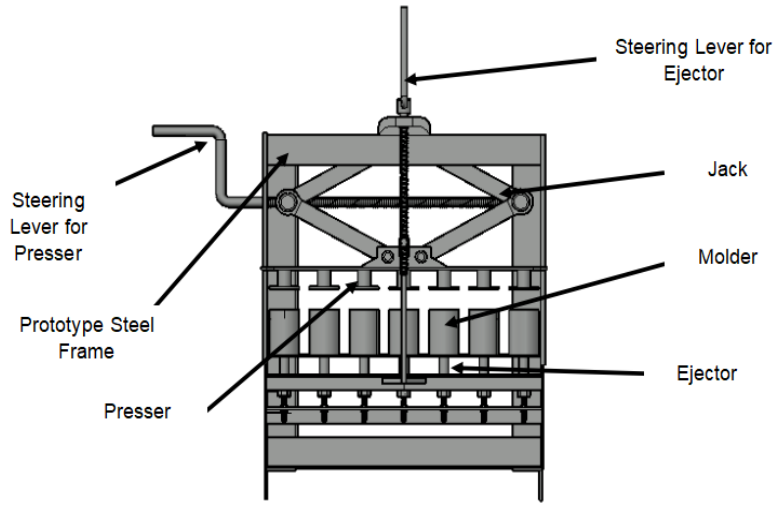

Figure 2. Major Components

RECOMMENDATIONS

1. Conduct further studies on the prototype's cost-efficiency and production rate.
2. Explore the use of alternative binders to enhance briquette performance.
3. Integrate a hydraulic pressing mechanism to improve efficiency.
4. Increase molder capacity to enhance production scalability.
5. Promote technology transfer and user training for wider adoption.

Ethical Considerations

This study adhered to ethical research standards by ensuring the voluntary participation of all respondents. Informed consent was obtained before conducting surveys and interviews, and participants were assured of

confidentiality and anonymity. Data collected were used solely for research purposes and stored securely to prevent unauthorized access. The study also adhered to ethical guidelines in handling sensitive information, ensuring no harm was caused to the participants during the research process.

Contributions of Authors

The authors contributed significantly to this study. Ivan L. Dujali led the conception and design of the prototype, as well as the analysis and interpretation of results. Venson B. Sarita played a key role in manuscript writing and revisions. All authors reviewed and approved the final manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest in the conduct and publication of this study.

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