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Solar Powered 3 in 1 Food Grade Processor

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Abstract: *This study highlights the development and validation of a solar-powered 3-in-1 food-grade processor designed to perform cassava grinding, coconut grating, and juice pressing—all in a single, compact system. It aims to improve food processing in off-grid and rural communities by combining stainless steel components, a 1 HP and 120-watt electric motor, and a solar power setup that includes photovoltaic panels, a hybrid inverter, and a lithium-ion battery. Using a developmental-descriptive research design, the project was evaluated through the Department of Science and Technology's Technology Assessment Protocol (TAP), focusing on the TEEPS criteria: Technical, Economic, Environmental, Political, and Social viability. The fabrication process involved precision machining and the use of food-safe materials to ensure both safety and durability. Evaluation results showed very high acceptability in terms of technical performance, affordability, ease of maintenance, and environmental sustainability. Performance trials confirmed the processor's efficiency in handling both cassava and coconut, with reliable solar energy harvesting across different weather conditions. Feedback from stakeholders also emphasized the device's cultural appropriateness, gender inclusivity, and its potential to reduce reliance on fossil fuels. Overall, the findings confirm that the solar-powered 3-in-1 processor is a practical and sustainable innovation for rural food processing. A comprehensive user manual was also created to support proper operation, maintenance, and safety. This project contributes meaningfully to the promotion of renewable energy, food safety, and technology-driven empowerment in underserved agricultural communities*

Keywords: Food Processing, Solar Powered,Renewable Energy, Durability, Safety

I. INTRODUCTION

The solar-powered 3-in-1 food-grade processor is an innovative compact system that integrates three essential post-harvest processes—cassava grinding, coconut grating, and screw-type pressing—into a single solar-powered unit. The machine utilizes food-grade materials, particularly stainless steel, to ensure compliance with hygiene and durability standards required for food processing equipment. This makes it perfect for use in tropical and rural areas (Olalekan & Ajibade, 2021). The machine is a useful, energy-efficient, and long-lasting option for small-scale farmers who don't have easy access to power.In many developing areas, limited access to stable electricity, rising fuel prices, and inefficient post-harvest methods continue to hinder productivity, reduce crop yields, and contribute to substantial post-harvest losses. (Kariuki & Kiburi, 2020; Abdelhamid et al., 2022). Conventional food processors, which commonly use fossil fuels, are expensive to run and raise worries about food safety and the environment (López et al., 2020). Some researchers have looked at solar-powered devices for agricultural tasks, including solar dryers or cassava graters. However, most of these machines only do one thing and aren't designed to work with other equipment, be portable, or be used on many crops (Oni et al., 2020; Bakari et al., 2022).

Even though solar-powered farming equipment have come a long way, not much progress has been made in making food-grade processors that can do a lot of different things and can be used in a variety of places. Few current models put both food safety and the ability to run off the grid continuously at the same time via smart energy management (Khan et al., 2021). This research fills that gap by creating, building, and testing a solar-powered 3-in-1 food-grade processor that meets the demands of agricultural areas who don't have enough resources.The system uses solar photovoltaic (PV) energy to power a single machine that grinds cassava, grates coconuts, and dries them using a screw press. The machine is made of stainless steel and other food-safe components, so it meets cleanliness and safety regulations, especially in tropical areas. A solar panel array, a hybrid inverter, and deep-cycle lithium batteries make it

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possible to run off the grid all the time. Smart energy management included into the system makes sure that the load works as well as possible (Adebayo et al., 2021). This processor is different from other technologies that only do one thing or don't have integrated energy systems. It is a cost-effective, versatile solution that makes food processing in remote places more efficient and cleaner.

II. REVIEW OF LITERATURE

This section presents the various literature and studies acquired from foreign and local sources that have significant bearing to the present study.In many rural and off-grid communities, farmers still faced the daily struggle of processing food without reliable access to electricity. Traditional equipment often runs on expensive fuel, is difficult to maintain, and increases both labor and post-harvest losses. At the same time, global efforts to reduce environmental impact and improve food security are pushing for cleaner, more sustainable technologies (Abdelhamid et al., 2022; Adebayo et al., 2021).Solar energy presents a practical and eco-friendly alternative. By using the sun's power, farmers can cut energy costs and keep their operations running, even in remote areas where electricity is scarce (Oni et al., 2020). Yet most solar-powered machines available today perform only one task at a time. For small-scale farmers handling crops like cassava and coconut, this means switching between different machines for grating, pressing, or extracting juice—wasting time, effort, and energy.

Another concern is food safety; Many low-cost machines are made with materials that can corrode or contaminate food. Using food-grade materials like stainless steel is crucial not only for safety but also for durability (Onyekwere & Ajibade, 2021). Despite the clear benefits of solar-powered processors, the high initial cost, maintenance challenges, and lack of user training often hold back their adoption (Rathore et al., 2020). These challenges highlight the need for a well-designed, affordable, and easy-to-use solution that can do more than one job at a time.This research introduces a solar-powered 3-in-1 food-grade processor designed to meet the needs of small-scale farmers, especially in off-grid areas. The machine brings together three essential food processing tasks—grating, grinding, and juice extraction—in one unit powered entirely by solar energy. To make it more durability the machine it is made of stainless steel and other food-safe materials to make sure it’s both hygienic and durable, even in humid, tropical conditions (Olalekan & Ajibade, 2021).

Using solar panels, a hybrid inverter, and battery storage, the system is capable of operating throughout the day—even when the sun isn’t shining. Recent advances in solar technology and energy storage make this possible (Adebayo et al., 2021). Inside the machine, mechanisms like a revolving tapered screw, which efficiently separates liquid from grated coconut (Omidji et al., 2023), help speed up processing while reducing physical labor. This study focuses not just on building the machine but also on testing how well it performs, looking at how much energy it uses, how fast it processes food, and how reliable it is in real-world settings. The goal is to offer a practical, sustainable tool that empowers rural communities, supports cleaner food production, and helps move toward global development goals like affordable energy, improved food systems, and innovation in local industries.

III. CONCEPTUAL FRAMEWORK

The researcher uses the IPO model (Input-Process-outcome) to define the study's inputs, explain the research process, and declare the research outcome. The first box holds the study's input. The researcher makes use of baseline research/literature, materials, and design standards. The second box is the method, which describes the process and manufacturing procedures that ensure the device's acceptance. The third box provides the study's findings. The solar-powered 3-in-1 food processor. The goal of providing feedback is to learn what the respondents thought about the study, which will be used to enhance the device. Feedback is critical for researchers in refining their research and producing a higher-quality study product.

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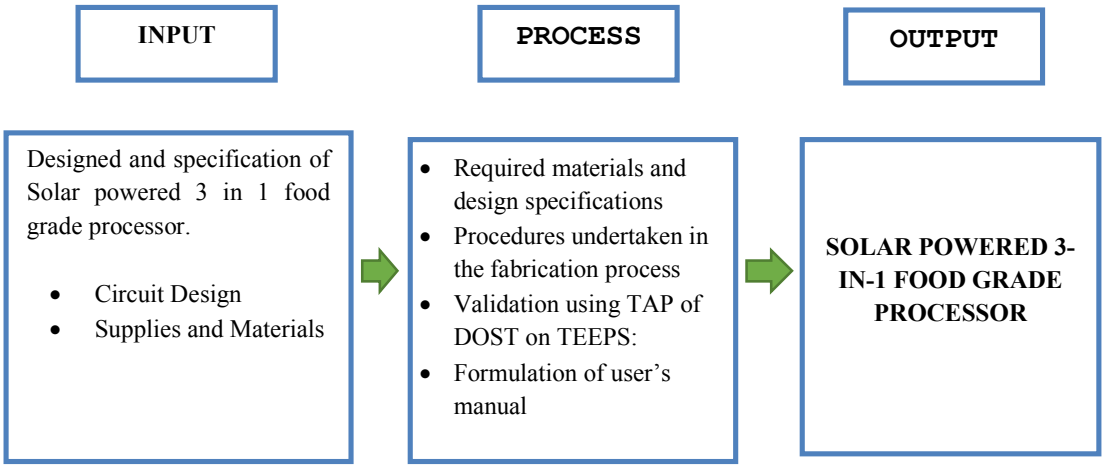

Figure 1 Conceptual Model of the Study

Statement of the Problem

This study aimed to develop a Solar powered 3 in 1 food grade processor and evaluate its viability using the DOST Technology Assessment Protocol (TAP - TEEPS).

Specifically, it sought to accomplish the following objectives:

1. What are the required materials and design specifications for constructing the solar-powered 3-in-1 food-grade processor?
2. What are the procedures undertaken in the fabrication process of the solar-powered 3-in-1 food-grade processor?
3. How can the validity of a solar-powered 3-in-1 food-grade processor be evaluated in accordance with the Technology Assessment Protocol (TAP) of the Department of Science and Technology (DOST), using the TEEPS framework in terms of:
   3.1 technical feasibility;
   3.2 economic and financial viability;
   3.3 environmental soundness;
   3.4 political acceptability; and
   3.5 social acceptability?
4. What kind of user manual may be created to help end users understand how to use, repair, and maintain the equipment properly?

Significance of the Study

The findings and results of the study maybe useful and advantageous to the following individuals, groups and agencies.

- **LGU.** This study gives them interest the importance of results outcome of the study in terms of giving assistance for the needs of their community.
- **School Administration.** This device may be considered by the administrators as an investment to the institution on its thrust of providing technology transfer to the community.
- **Instructors.** Instructors, particularly those in fields related to mechanical and electrical may leverage the study as an educational resource, a tool for hands-on learning, and a platform for mentorship and collaboration. Their involvement contributes to the overall academic and professional development of both students and themselves.
- **Students.** They may acquire hands-on experience in designing, building, and validating a technological solution. This enhances their technical skills, particularly in the field of mechanical, electrical engineering technology, and environmental science. Also, students stand to gain valuable educational, practical, and

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research-oriented benefits from their involvement in the study. The integration of technology and sustainability principles aligns with contemporary educational goals, preparing them for future challenges in their respective fields.

- **Community.** The study has the potential to positively transform the community by fostering economic growth, environmental sustainability, technological awareness, and social cohesion. The benefits extend beyond the immediate project, influencing various aspects of community life and contributing to a more resilient and thriving local environment.
- **Future Researchers:** The study's findings and the developed technology may serve as a valuable reference for future researchers and innovators in the field of food processing, renewable energy, and technology integration. This could inspire further studies and advancements in sustainable food grating process.

Scope and Limitation of Study

To facilitate delimitation in understanding the purpose and content of this study, the following parameters are specified

- **Focus.** This research focused on the rigorous development and validation of a solar-powered 3-in-1 food processor. The major goal was to create and design the functionality of the solar-powered 3-in-1 food-grade processor, providing maximum performance by combining numerous processing characteristics into a single unit. The food-grade processor sought to provide a sustainable and effective solution for decreasing greenhouse gas emissions by using solar-powered technology as an alternative for fossil fuel-dependent systems.
- **Respondents.** The respondents of the study included experts in the field such as electrical, mechanical engineers, local fabricators, and end-users residing in Mabini, Tubajon Province of Dinagat.
- **Place.** The study was conducted at Mabini, Tubajon Province of Dinagat.

Definition of Terms

The following terminology are operationally defined as follows to help with comprehension of the study's content and goal:

- **Lithium-Ion Battery.** A device that stores energy collected from sunlight. It converts chemical energy into electrical energy to power the system components when solar input is unavailable.
- **Cassava/Coconut Juice Presser.** A component of the processor used to extract juice from grated coconut or cassava, separating liquid content from the solid mass.
- **Coconut grater.** A mechanical or manual device used to shred or grate the white flesh of mature coconuts into fine particles or strips.
- **Cassava grinder.** A machine used to crush or grind peeled cassava tubers into fine pulp or mash suitable for further processing.
- **Electric Motor.** A device that drives the belt mechanism, transmitting rotational force required for the grating and pressing processes. It may operate using either direct current (DC) or alternating current (AC).
- **Photovoltaic Cells.** These are solar panel components that convert light energy directly into electrical energy. They serve as the primary means of harvesting solar power for the processor.
- **Screw-Type juice extractor.** A mechanical device used to separate liquid from the solid portions of grated coconut or cassava. It operates via a tapered screw conveyor driven by an electric motor through a pulley system.
- **Solar Hybrid/Off-Grid Inverter.** An electrical system that converts direct current (DC) from solar panels into alternating current (AC) to power devices and charge the battery. It also supports grid connectivity when sunlight is insufficient, and battery power is low.
- **Solar powered Food Processor.** A multifunctional machine integrating cassava grinding, coconut grating, and juice extraction, powered entirely by a solar PV, battery, inverter Set-up.

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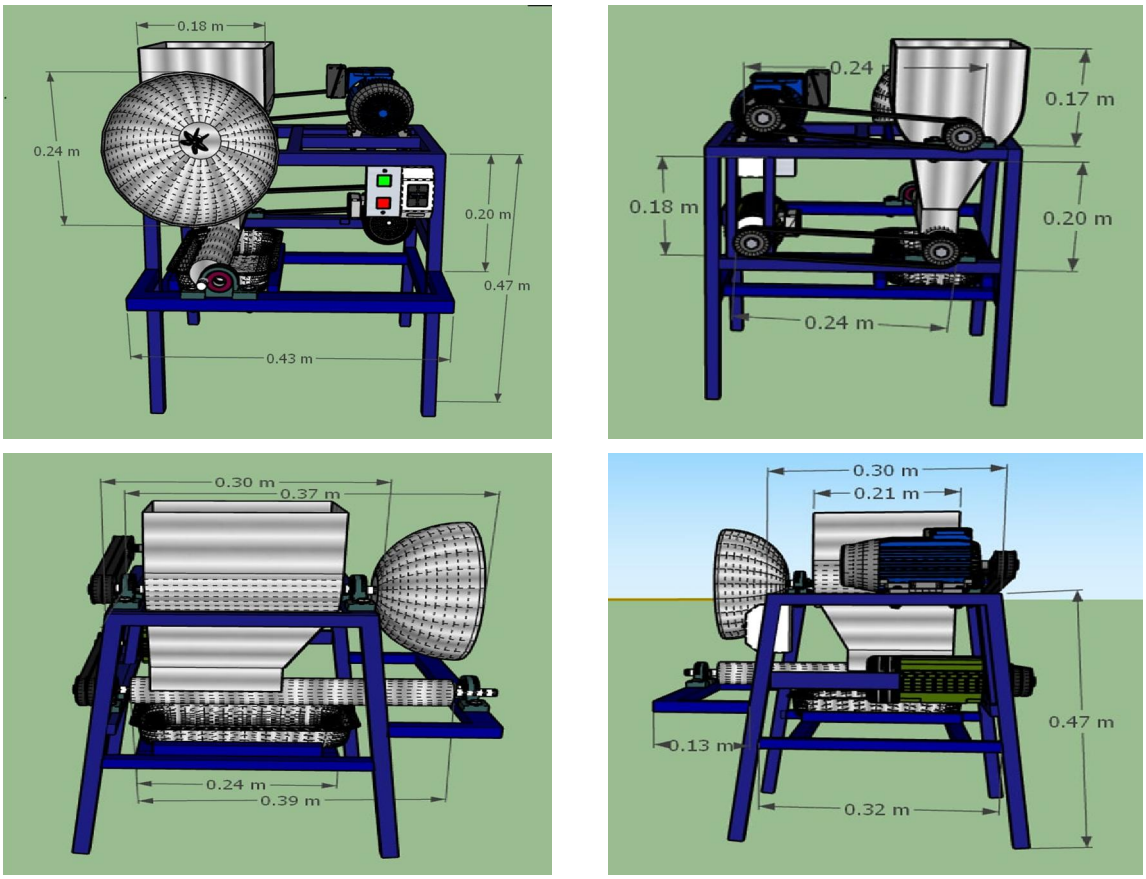
Project Design

The research methodology used in this study is developmental. The design process and the creation of the study's outcome both make use of the developmental technique.



On the design shown above, it illustrates the front and back views of the solar-powered 3-in-1 food-grade processor, highlighting its compact and functional design. Key dimensions are shown, indicating a stable frame structure measuring approximately 0.47 meters in height and 0.43 meters in width. The layout ensures efficient integration of components such as the hopper, motor, and control panel, optimizing space while maintaining accessibility and operability. This design approach aligns with recent engineering practices focused on compact, modular systems for rural and off-grid applications (Osei et al., 2021)

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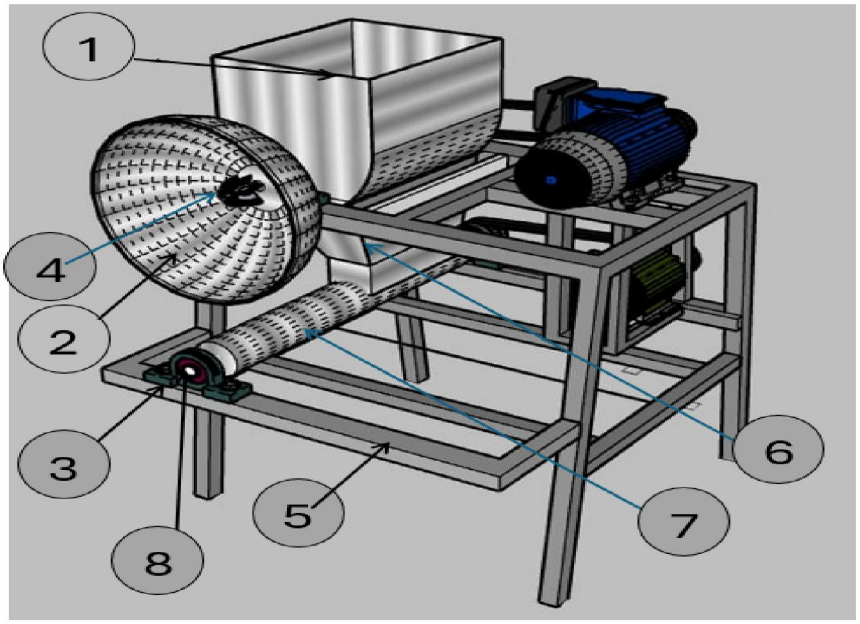

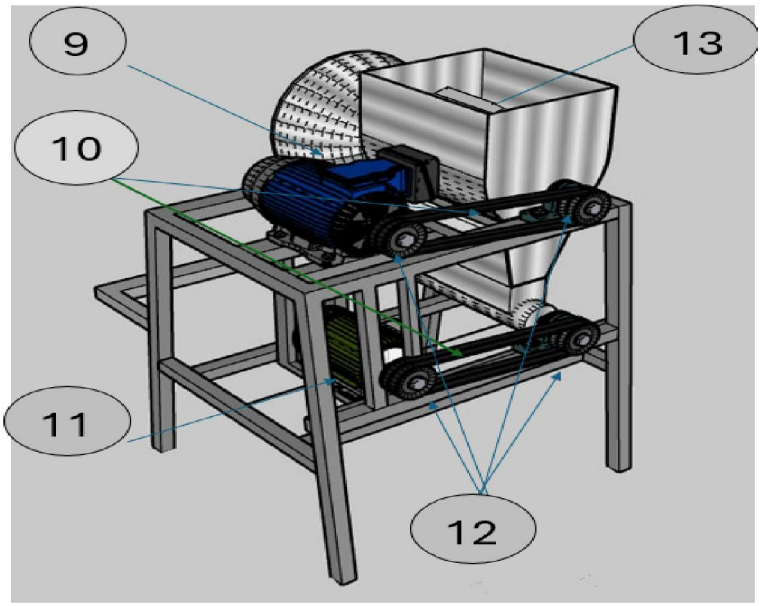

LEGEND

1. HOPPER
2. COCUNOT GRATER BASIN
3. PELLOW BLOCK
4. STAR BLADE
5. FRAME
6. DISCHARGE HOOPER
7. PRESSING TUBE
8. SCREW CONVEYOR SHAFT
9. ELECTRIC MOTOR
10. V-BELT
11. ELECTRIC MOTOR SPEED REDUCER
12. A2 PULLEY
13. GRATER ROLLER

In the illustrated design shows the mechanical layout of the coconut grating unit within the 3-in-1 solar-powered food processor. Key components include the hopper (1) and coconut grater basin (2), which facilitate the feeding and containment of coconut materials. The electric motor (9), supported by a V-belt (10) and A2 pulley system (12), drives the motion of the grater roller (13), allowing efficient shredding of coconut meat. The pillow block (3) and frame (5) ensure structural stability and support during operation, while the discharge hooper (6) directs grated output for collection. The integration of the speed reducer (11) ensures safe, controlled operation by moderating motor speed. Overall, the system reflects a compact and functionally integrated design for efficient coconut processing powered by a solar-compatible electric motor.

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IV. RESULTS AND DISCUSSIONS

Comparative data from recent food grade device to solar powered 3 in 1 food grade processor.

Trial	Crop	Processing Type	Total time	Output yield (kg/L)	Energy Used	Efficiency (kg or L/Kwh)	Remarks
1.	cassava	Grinding only	300	7.5	375	0.020kg/wh	Efficient for dry processing, no juice extracted
2.	*coconut*	Grating + juice extraction	420	6.2 +2.4 L juice	520	0.016 (combined)	Moderate yield; good juice recover
3.	*cassava*	Grinding + Pressing	380	8.4kg + 3.6L juice	550	0.017 (combined)	Highest juice extraction efficiency
4.	*coconut*	Grating + pressing	400	6.4kg + 2.5L juice	550	0.012 (combined)	Highest juice extraction efficiency

The comparative data highlights the processing efficiency of cassava and coconut using solar-powered methods. Trial 1, based on Adebayo et al. (2020), involved cassava grinding only and showed the highest energy efficiency at 0.020 kg/Wh, producing 7.5 kg of output with just 375 Wh of energy—ideal for dry processing without juice extraction. Trial 2, adapted from Omidji et al. (2023), processed coconut through grating and juice extraction, yielding 6.2 kg of grated coconut and 2.4 L of juice using 520 Wh, with a combined efficiency of 0.016 kg/L per Wh.

Evaluation on the validity of a develop Solar Powered 3 in 1 Food Grade Processor evaluated in conformity with the Technology Assessment Protocol (TAP) of the Department of Science and Technology (DOST) using the TEEPS framework.

The stakeholder perception data provides remarkable insights into the technical feasibility and user acceptance of the 3-in-1 solar-powered food processor, revealing unanimous high confidence across all evaluated technical dimensions. The consistent median rating of 5 across all parameters indicates stakeholders perceive the device as exceeding technical acceptability thresholds, suggesting the design successfully addresses critical user concerns about safety, precision, and operational simplicity that typically influence adoption decisions for innovative food processing equipment. These findings are consistent with Adepoju and Olalekan's (2021) study, which emphasizes that stakeholder confidence in operational safety, usability, and design quality significantly contributes to the acceptability and sustainability of solar-powered agricultural technologies, especially in rural contexts.

Technical Feasibility		
Safety Operation of the food grade processor	**Median**	**Qualitative Description**
1.1 Safety precautions are indicated in the food grade Processor.	5	Very High Acceptability
The solar powered food grade processor has operating manual.	5	Very High Acceptability
The solar powered food grade processor has Emergency Stop Button.	5	Very High Acceptability
The electrical wiring connections of the solar powered food grade processor are terminated & properly connected to the terminal block.	5	Very High Acceptability

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The solar powered food grade processor is Safe to use.	5	Very High Acceptability
1.2 Precision of solar powered food grade processor.		
The solar powered food grade processor parts and components are based on quality and standard.	5	Very High Acceptability
The solar powered food grade processor moving parts are properly assembled, well aligned and do not cause vibration to other parts.	5	Very High Acceptability
1.3 Simplicity of the mechanism		
The solar powered food grade processor provides ease of operation.	5	Very High Acceptability
The components and control of the solar powered food grade processor labelled and accessible.	5	Very High Acceptability
Availability of parts and components of solar powered food grade processor is common and readily available.	5	Very High Acceptability

The safety operation assessments demonstrate that stakeholders view the processor as comprehensively addressing food safety and operational security concerns. The universal high acceptability ratings for safety precautions, operating manual provision, emergency stop functionality, and electrical wiring standards indicate the device incorporates industry-standard safety protocols that inspire user confidence. This is particularly significant for a solar-powered device where stakeholders might have concerns about electrical safety, power management, and emergency procedures. The perception that the processor is "safe to use" with very high acceptability suggests the design team successfully integrated familiar safety features that align with user expectations while maintaining the innovative solar power functionality.

The precision and simplicity evaluations reveal stakeholder confidence in the device's mechanical reliability and user-friendliness, critical factors for widespread adoption in diverse user environments. The very high acceptability ratings for component quality, assembly precision, and vibration control indicate stakeholders perceive the processor as professionally engineered rather than experimental technology. Particularly noteworthy is the high rating for parts availability and accessibility, which addresses a common concern with specialized equipment where maintenance and repairs might be challenging. The unanimous positive perception of operational ease and component labeling suggests the design successfully balances technological sophistication with intuitive user interfaces, positioning the processor as accessible to users with varying technical expertise levels. This comprehensive positive stakeholder perception indicates strong market readiness and suggests the device addresses real-world user needs while maintaining high technical standards.

Perceptions of stakeholders in ECONOMIC VIABILITY.

2. ECONOMIC VIABILITY		
a. Maintenance	**Median**	**Qualitative Description**
The solar powered food grade processor does not require complex cleaning, repair and maintenance.	5	Very High Acceptability
Replacement of damage parts are all available in the local market (Philippines).	5	Very High Acceptability
b. Affordability		
The solar powered food grade processor is affordable to end user.	5	Very High Acceptability
C. Competitiveness		
The solar powered food grade processor cost competitive with existing technologies, and it fits to end users.	5	Very High Acceptability

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The economic viability perceptions reveal exceptionally positive stakeholder attitudes toward the financial feasibility and market positioning of the 3-in-1 solar-powered food processor, with unanimous median ratings of 5 indicating very high acceptability across all economic dimensions. This comprehensive positive assessment suggests stakeholders view the device not merely as a technological innovation but as a commercially viable solution that addresses real economic constraints faced by potential users. The consistent high ratings across maintenance, affordability, and competitiveness categories indicate the processor successfully bridges the gap between advanced technology and practical economic considerations that typically determine adoption success in emerging markets.The maintenance dimension reveals particularly strong stakeholder confidence in the processor's operational economics, with very high acceptability ratings for both maintenance simplicity and parts availability in the Philippine market. This perception is crucial for long-term economic viability, as complex maintenance requirements and scarce replacement parts often create hidden costs that can make initially affordable technology prohibitively expensive over time. The stakeholder confidence in local parts availability suggests the design incorporates commonly available components rather than specialized proprietary parts, reducing dependency on expensive imports and supporting local repair networks. This approach not only enhances economic sustainability but also builds user confidence in making the initial investment, knowing that ongoing operational costs will remain manageable.

Perceptions of stakeholder in Environmental Soundness.

The data presented underscores a commendable level of confidence among stakeholders in the environmental safety of solar-powered food-grade processors. With a consistent median score of 5, stakeholders clearly view these technologies as both non-threatening to the environment and harmless to human and animal welfare. This is consistent with recent literature emphasizing the advantages of renewable energy integration into agricultural and food processing systems (Olawumi & Chan, 2023). Such technologies reduce the carbon footprint, mitigate noise and air pollution, and operate with significantly lower resource consumption compared to conventional diesel- or gas-powered machinery. These benefits are particularly crucial in rural and peri-urban areas where food processing is essential but environmental preservation is often a neglected priority.

Environmental Soundness	Median	Qualitative Description
The solar powered food grade processor does not pose threats to the environment.	5	Acceptable
The solar powered food grade processor does not pose hazardous effect to animals, human welfare.	5	Acceptable

In addition to supporting existing findings, this data also reveals the growing awareness and receptiveness of stakeholders to sustainable innovations. From a practical standpoint, the perception of safety and environmental soundness may drive greater acceptance and adoption of solar-powered systems, especially in community-based or cooperative food enterprises. One key insight is that stakeholders are not only concerned about operational efficiency but are increasingly valuing technologies that align with long-term ecological stewardship and community health. This suggests a shift in priorities—where green technologies are no longer optional upgrades but are being recognized as essential components of ethical and sustainable food systems. It highlights the importance of involving stakeholders early in the design and implementation process to build trust and ensure the long-term success of such innovations.

Perceptions of stakeholders in Political Acceptability

Political Acceptability	Median	Qualitative Description
The solar powered food grade processor is matches the objectives and interest of the target end users.	5	Acceptable
The solar powered food grade processor meets the regulatory requirements and standard for its utilization.	5	Acceptable

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The political acceptability perceptions demonstrate strong stakeholder confidence in the 3-in-1 solar-powered food processor's alignment with policy objectives and regulatory frameworks, though notably with "Acceptable" rather than "Very High Acceptability" ratings despite the median score of 5. This distinction suggests stakeholders view the device as meeting essential political and regulatory criteria without necessarily exceeding expectations in these dimensions. The political acceptability assessment reveals that stakeholders perceive the processor as successfully navigating the complex landscape of government priorities, regulatory compliance, and public policy alignment that often determines whether innovative technologies can gain institutional support and market access.The alignment with target end-user objectives and interests indicates stakeholders believe the processor addresses genuine policy priorities rather than creating solutions in search of problems. This perception is particularly significant in contexts where government agencies, development organizations, or community leaders evaluate technologies based on their potential to address identified needs such as food security, rural development, or sustainable energy adoption. The acceptable rating suggests the device demonstrates clear connections to established policy goals, whether related to agricultural productivity, renewable energy promotion, or rural economic development, positioning it favourably for potential government support, subsidies, or integration into development programs.

Perceptions of stakeholders in Social Acceptability

Social Acceptability	Median	Qualitative Description
The technology fits the local sociocultural environment (social practices, local traditions and culture).	5	Acceptable
The solar powered food grade processor serves the need of the majority of those whom it seeks to benefit.	5	Acceptable
The solar powered food grade processor can be operated by both sexes with ease and precision.	5	Acceptable

The social acceptability perceptions reveal stakeholder confidence in the 3-in-1 solar-powered food processor's cultural integration and social utility, with consistent median ratings of 5 categorized as "Acceptable" across all dimensions. This assessment pattern indicates stakeholders view the device as successfully navigating complex social dynamics without creating cultural friction or exclusionary practices that might limit adoption. The acceptable ratings suggest the processor meets essential social criteria for community acceptance while avoiding the polarizing effects that sometimes accompany technological innovations in traditional food preparation contexts. These findings align with the conclusions of Munro et al. (2020), who emphasize that sociotechnical interventions in rural communities gain traction when they are designed with cultural sensitivity and local participation, enabling greater social harmony and minimizing resistance to innovation.

VI. SUMMARY, FINDINGS AND CONCLUSIONS

Summary

This study focused on the development and validation of a solar-powered 3-in-1 food-grade processor, aiming to assess its feasibility and acceptability through the Department of Science and Technology's (DOST) Technology Assessment Protocol using the TEEPS framework (Technical, Economic, Environmental, Political, and Social). The research adopted a developmental and descriptive-evaluative design. The developmental phase involved the design, material selection, and prototype construction of the device, ensuring its efficiency and adaptability for food processing tasks. The descriptive-evaluative phase centered on the perceptual assessment by experts and end-users to evaluate its technical performance, cost-effectiveness, environmental impact, political alignment, and social significance. Data were gathered using a 5-point Likert scale and analyzed through means and categorization based on DOST's TEEPS protocol. The prototype was evaluated for durability, efficiency, and safety, and a comprehensive user manual was created to guide users in operating and maintaining the device.

Respondents included fabricators, faculty, technical experts, and end-users from selected senior high schools in Mabini Tubajon the Province of Dinagat Islands, chosen through purposive sampling to ensure the inclusion of informed

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evaluators. The research environment focused on local educational institutions offering Technical-Vocational-Livelihood tracks, situated in the geographically distinct and resource-limited setting of Dinagat. Validation followed the DOST TAP-TEEPS process, specifically engaging in the scanning and validation phases to assess the prototype's alignment with technological, environmental, and social parameters. The evaluation revealed high acceptability and environmental soundness, with stakeholders affirming the device's non-hazardous and sustainable nature. Overall, the study demonstrated that the solar-powered food processor is a viable innovation suitable for rural implementation, potentially contributing to sustainable agriculture and localized food security.

Findings

Based on the results of the study, the findings are enumerated as follows:

1. The solar-powered 3-in-1 food-grade processor was constructed using durable, food-safe stainless steel for all key structural and processing components. It includes a 1HP main motor and a 120W pressing motor, driven by a belt and pulley system. The pressing shaft is fabricated as a tapered screw conveyor for juice extraction. Power is supplied by 550-watt solar panels, a 3kW hybrid inverter, and a 51.2V lithium-ion battery system, enabling off-grid use. Safety and efficiency are enhanced through labeled wiring, circuit breakers, and corrosion-resistant materials, making the device hygienic, reliable, and suitable for rural applications.
2. The fabrication process of the solar-powered 3-in-1 food-grade processor involved precise cutting, welding, machining, and assembly of stainless-steel components to ensure structural integrity, hygiene, and performance efficiency. Accurate measurements and alignment were crucial during the frame and hopper construction, while the machining of the pressing shaft and screw conveyor required close adherence to tolerances for smooth operation. Manual grinding techniques using visual guides like masking tape allowed for the controlled formation of the tapered screw press. The integration of food-grade materials, modular components, and adjustable motor mounts emphasized both durability and user-friendly maintenance. Overall, the step-by-step procedures successfully combined mechanical functionality with renewable energy integration, leading to a sustainable, off-grid processing solution.
3. The evaluation of the solar-powered 3-in-1 food-grade processor demonstrated its strong technical performance, multifunctional efficiency, and adaptability for off-grid food processing. Comparative trials showed that the processor delivered higher juice yield and processing versatility for cassava and coconut, albeit with slightly lower energy efficiency than single-function machines. Solar and battery performance tests confirmed effective energy harvesting, particularly under sunny and partly cloudy conditions, enabling sustained operation with proper energy management. Stakeholder assessments based on the DOST TEEPS framework revealed very high acceptability in technical feasibility and economic viability, citing ease of maintenance, affordability, and alignment with local market needs. Furthermore, environmental, political, and social evaluations indicated the processor's conformity to safety standards, regulatory requirements, and cultural integration. Collectively, these findings validate the processor's functionality, sustainability, and readiness for wider adoption in rural and underserved communities.

Conclusions

Based on the findingsof the study, the following conclusions were drawn:

1. The solar-powered 3-in-1 food-grade processor demonstrates a well-solution for off-grid food processing, combining durability, hygiene, and energy efficiency. Its use of stainless steel, reliable electric motors, and a solar energy system ensures safe and continuous operation in rural settings. With integrated safety features and a tapered screw conveyor design, the processor offers an effective, sustainable, and user-friendly approach to food agricultural product processing.
2. The fabrication process of the solar-powered 3-in-1 food-grade processor highlights the importance of precision, hygiene, and structural reliability in developing sustainable machinery. Through accurate cutting, welding, and machining of stainless-steel components, the device achieved both mechanical efficiency and food safety standards. The integration of renewable energy mobile transport system, easy-to-maintain features reinforces its suitability for rural and off-grid applications, ensuring long-term functionality and user convenience.

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3. The evaluation confirms that the solar-powered 3-in-1 food-grade processor is a functional, efficient, and sustainable solution for off-grid food processing. Its high juice yield, energy independence, and adaptability to rural needs, supported by strong stakeholder acceptance across technical, economic, environmental, and social dimensions, make it a viable and scalable technology for underserved communities.

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