

Sugarcane PeelPro

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Abstract

Sugarcane is a vital agricultural commodity widely used for sugar production and popular consumption, particularly in Southeast Asia where sugarcane juice is a culturally significant beverage. Traditional manual peeling of sugarcane, performed with knives, is labor-intensive, time-consuming, and poses safety risks to operators, especially small-scale vendors. This project presents the design, development, and testing of the Sugarcane Peel Pro, an automatic sugarcane peeling machine aimed at improving efficiency, safety, and sustainability for local vendors. The machine features a stainless-steel rotary blade powered by a 0.75 hp motor operating at 850 rpm, housed within a sturdy mild steel frame with ergonomic design elements such as a hand-fed slot, pressure rollers, and protective blade covers. It accommodates sugarcane stalks up to 30 mm in diameter, peeling each stalk within 45 to 60 seconds with an efficiency of 85% to 90%, while consuming low power (0.5 to 0.75 kWh). Manufactured through precision machining and MIG welding processes, the machine demonstrated reliable performance during testing, with smooth operation, stable blade balance, and effective safety features. While limitations remain regarding stalk shape adaptability and reliance on electricity, the Sugarcane Peel Pro effectively reduces labor intensity, enhances user safety, and minimizes material waste, providing a practical and cost-effective solution for small-scale sugarcane juice vendors. This innovation supports social and economic sustainability by promoting safer working conditions and increased productivity within local agricultural processing industries.

1. Introduction

Sugarcane is one of the most important agricultural commodities globally, serving as the primary raw material for sugar production. Beyond its economic value, sugarcane plays a significant role in daily human consumption as it is used in food, beverages, and even traditional medicine. In many Asian countries such as Malaysia, Thailand, India, and Indonesia, sugarcane juice is a popular street beverage and forms part of the local culture and small-scale entrepreneurship [1]. To produce high-quality juice, the peeling process of sugarcane is an essential stage as it removes the tough outer layer, allowing the inner stalk to be processed more efficiently and improving the overall taste of the extracted juice.

Traditionally, sugarcane peeling has been performed manually using knives, which requires a high level of skill, concentration, and physical strength. This manual process, although simple, is time-consuming, labor-intensive, and prone to safety risks [2]. Operators, especially elderly vendors, often face fatigue, muscle strain, and

the danger of hand injuries caused by sharp blades. Moreover, manual peeling results in inconsistent outcomes and material wastage, affecting both the efficiency of production and the profitability of sugarcane juice sellers. As market demand increases, the limitations of manual peeling methods hinder productivity and economic growth, particularly for small roadside businesses that depend heavily on manual labor [3].

The development of a mechanized sugarcane peeling machine offers a practical solution to these challenges. Automation in the peeling process can significantly increase efficiency, reduce injury risks, and ensure uniform peeling quality [4]. Mechanized systems can process larger quantities of sugarcane within a shorter time while minimizing physical strain on workers. This advancement aligns with the broader goal of promoting sustainability in small-scale industries through the integration of technology that is affordable, reliable, and environmentally friendly [5].

This project, known as the Sugarcane PeelPro, focuses on designing and developing a sustainable automatic sugarcane peeling machine that meets the needs of local vendors. The design emphasizes cost-effectiveness, user safety, and environmental sustainability. Economically, the machine aims to reduce operating costs and dependence on manual labor. Socially, it enhances user safety through ergonomic design features such as protective blade covers and simple operational controls, allowing even inexperienced users to handle it safely. Environmentally, it minimizes energy consumption and material waste by using locally sourced and durable materials.

Ultimately, the project seeks to create a user-friendly, efficient, and safe sugarcane peeling machine suitable for roadside sellers and small-scale entrepreneurs. The automation of the peeling process not only improves productivity but also contributes to social and economic sustainability by enabling workers to operate more efficiently and safely. The development of this machine represents a step forward in addressing the practical challenges faced by traditional sugarcane juice vendors while supporting innovation and local technological advancement within the agricultural processing sector.

1.2 Literature Review

This section reviews previous studies and projects related to sugarcane peeling machines. The analysis focuses on the design concepts, working mechanisms, and materials used in earlier prototypes to identify their strengths and limitations. Understanding these previous developments provides a foundation for improving the design, efficiency, and usability of the proposed Sugarcane Peel Pro. A summary of relevant past projects is presented in Table 2.1.

Table 2.1 Different sugarcane peeling methods and machines developed over recent years

Project / Year	Motor Type	Blade Type	Body Material	Working Principle	Key Findings
Knife Sugarcane Peeling Machine (2020) [2]	Single Phase Motor	Knife Blade	Stainless Steel	Operates automatically; sensors detect the sugarcane to begin peeling. Waste peels are collected in a separate bucket.	Efficient peeling process; reduces human effort and maintains hygiene. Low cost but
Manual Peeling (2024) [6]	Manual	Knife Blade	Aluminium	Peeling is done manually using a knife; relies on human skill and energy.	time-consuming, inconsistent, and risky due to sharp tools.
Sugarcane Peeling Machine (2024)[7]	Three Phase Motor	Brush Blade	Mild Steel	Peeling performance depends on motor speed and sugarcane variety; automated process.	Improved efficiency and capacity; suitable for larger-scale operations.

The Table 2.1 summarizes key characteristics and findings from different sugarcane peeling methods and machines developed over recent years. It compares three projects by their motor type, blade design, body material, working principles, and observed outcomes. The 2017 Knife Sugarcane Peeling Machine utilizes a single-phase motor and stainless steel body with knife blades, employing sensors for automatic operation and waste collection, resulting in efficient peeling that reduces labor and improves hygiene. The 2022 Manual Peeling method relies solely on human skill and manual knife work with an aluminum body, which, while low cost, is time-consuming, inconsistent, and carries safety risks. The most recent 2024 Sugarcane Peeling Machine employs a three-phase motor with brush blades and a mild steel frame; its automated process varies with motor speed and

sugarcane type, delivering enhanced efficiency and higher capacity suitable for larger-scale use. This comparison highlights the evolution from manual to increasingly automated solutions, emphasizing improvements in productivity and safety.

Previous research projects share the same objective of simplifying and accelerating the sugarcane peeling process. The main differences lie in the type of motor used, blade design, and construction materials. Earlier designs like manual peeling rely entirely on human labor, while newer automated machines integrate motors and sensors to improve efficiency, safety, and hygiene. The findings highlight the need for a cost-effective, durable, and energy-efficient design suitable for small-scale vendors, which serves as the foundation for the development of the Sugarcane Peel Pro.

Sugarcane peeling technologies have developed slowly over time. The acceptable industrial solutions that are on the market are either too heavy or too expensive for the small-scale vendors. Recent studies have shown that although the use of stainless steel rotary blades will provide uniformity and improved speed of peel, the integration of motorised systems with safe machine circulation has proven to work well on food processing applications [8]. Studies have also shown that most of the existing models are either fully automated, or completely manual, therefore there are cost-effective semi-automated methods that do not exist [9].

2. Methodology

This section outlines the methods used in the design, development, and testing of the sugarcane peeling machine. The methodology covers the step-by-step process from material selection and machine fabrication to assembly and performance testing. It also includes the evaluation of machine efficiency, safety, and ease of operation. Each stage was carefully planned to ensure the machine meets its intended purpose of improving the sugarcane peeling process while remaining simple, affordable, and suitable for small- to medium-scale use.

The block diagram in Fig. 3.1 illustrates the functional workflow of the sugarcane peeling machine system. It begins with the Electric Input Source, which provides the power supply to operate the machine. This power is directed to the Motor System, which converts electrical energy into mechanical energy to drive the system. The motor is connected to a Belt Drive, which transfers rotational motion to the Rotary Blade, ensuring smooth and efficient power transmission. The rotary blade serves as the core component of the machine, performing the Peeling Process by effectively removing the outer layer of the sugarcane. The peeled waste is then collected in the Waste Collection Bin, a removable container designed for easy handling and disposal. Additionally, the machine includes a Control Panel with Stop Button for user interaction, allowing the operator to control the machine and stop it promptly for safety or operational purposes. This systematic and modular design ensures the machine operates efficiently, safely, and conveniently for the user.

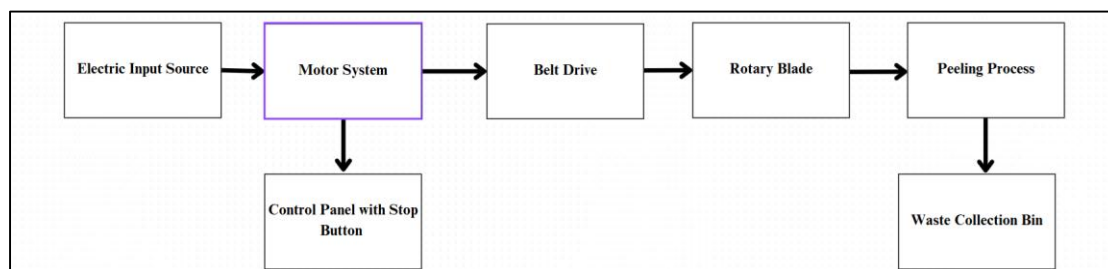


Fig. 3.1 Block diagram of Sugarcane PeelPro

2.1 Design and Material Overview

The sugarcane peeling machine was designed to remove the outer skin of sugarcane stalks efficiently and hygienically. The overall design consists of four main subsystems:

- Rotary Brush Mechanism – performs the peeling operation.
- Structural Frame – supports and holds all components.
- Motor and Transmission System – provides rotational motion to the brushes.
- Waste Collection Bin – collects the removed sugarcane peel.

Material selection was a critical step to ensure the durability, efficiency, and safety of the machine. The following factors were considered:

- Strength and rigidity for load-bearing components.
- Corrosion resistance for parts exposed to moisture and sugarcane juice.
- Ease of fabrication and maintenance.
- Compliance with food processing standards for components in contact with sugarcane.

Table 3.1 *Materials used in Sugarcane PeelPro*

Component	Material	Reason for Selection
Rotary Brush Shaft	Stainless Steel	Corrosion resistance and hygiene
Bristles	Nylon (hard grade, 0.5 mm)	Abrasive yet non-damaging to sugarcane surface
Frame	Mild Steel Square Tubes	Strength, availability, and ease of welding
Pulley & Belt	Cast Iron and Rubber	Durability and efficient power transmission
Waste Bin	Stainless Steel Sheet	Easy cleaning and resistance to corrosion

Table 3.1 presents the materials selected for key components of the sugarcane peeling machine along with their justifications. Stainless steel is used for the rotary brush shaft and waste bin due to its corrosion resistance, hygiene, and ease of cleaning. The nylon bristles, with a hard grade of 0.5 mm, provide an abrasive yet gentle surface suitable for peeling without damaging the sugarcane. The frame is constructed from mild steel square tubes, chosen for their strength, availability, and weldability. Cast iron and rubber are used for the pulley and belt system, ensuring durability and efficient power transmission. Overall, the material selection emphasizes strength, hygiene, and long-term reliability.

2.2 Fabrication and Assembly Procedures

The fabrication of the sugarcane peeling machine involved a series of processes, including brush fabrication, frame construction, motor installation, and assembly of the waste collection system. Each process was carefully executed to achieve the desired performance, precision, and safety standards.

The rotary brushes served as the primary peeling component of the machine. Each brush measured 120 mm in diameter and 400 mm in length. Nylon bristles of hard grade (0.5 mm thick) were mounted on cylindrical steel shafts using keyed hubs to ensure stability during rotation. Two brushes were installed parallel to each other on stainless steel shafts and secured firmly with high-tensile bolts. The spacing between the brushes was made adjustable to accommodate sugarcane stalks of different diameters. This configuration allowed the brushes to gently abrade and remove the sugarcane skin without damaging the inner layer, ensuring both effectiveness and product quality.

The structural frame was constructed using mild steel square tubes that provided the necessary support and rigidity for all the components. The tubes were cut to the required lengths using a power saw and then welded together to form a rectangular frame measuring 600 mm in length, 400 mm in width, and 700 mm in height. To enhance durability and prevent corrosion, the frame was sandblasted to remove impurities and coated with anti-corrosion enamel paint, giving it both strength and longevity in operation.

For the power transmission system, a 0.75 kW single-phase induction motor was installed on a steel baseplate. Vibration dampers were used to minimize noise and mechanical stress during operation. Power from the motor was transmitted to the brush shafts through a V-belt and pulley system designed with a 2:1 reduction ratio. This configuration produced an effective brush speed of approximately 700 revolutions per minute (rpm), which was found to be optimal for efficient peeling without causing excessive abrasion or loss of sugarcane flesh.

Finally, a waste collection bin was installed directly below the peeling area to collect the removed sugarcane peelings. The bin was fabricated from stainless steel and fitted with sliding rails, allowing it to be easily removed for cleaning and maintenance. This feature improved hygiene and facilitated smooth disposal of waste materials after each operation. Through these carefully planned fabrication and assembly procedures, the sugarcane peeling machine was successfully constructed to meet the design objectives of efficiency, safety, and ease of operation.

2.3 Testing Procedures

After the fabrication and assembly of the sugarcane peeling machine were completed, a series of performance tests were carried out to evaluate its functionality, efficiency, and reliability. The testing phase aimed to verify whether the machine operated according to design specifications and to identify any necessary adjustments to improve its performance.

Before testing, all moving components were inspected to ensure proper alignment and secure fastening. The rotary brushes were checked for uniform rotation, and the V-belt tension was adjusted to prevent slippage during operation. The machine was then connected to a single-phase power supply, and a no-load test was conducted to observe the smoothness of brush rotation and the stability of the frame under vibration.

For the performance test, freshly harvested sugarcane stalks of varying diameters were used. Each stalk was fed manually between the rotating brushes while the machine operated at the designed speed of 700 rpm. Observations were made on the peeling uniformity, time required per stalk, and the condition of the peeled surface. The waste bin was monitored to ensure efficient collection of removed peelings without blockages or spillage. The distance between the brushes was adjusted to achieve the best peeling results for different stalk sizes.

The efficiency of the machine was determined by comparing the time taken to peel a set number of stalks manually versus using the machine. The quality of peeling was assessed visually, focusing on the completeness of skin removal and the absence of excessive damage to the inner sugarcane layer. Additionally, safety and ease of operation were evaluated by monitoring vibrations, noise level, and user comfort during continuous operation. After several test runs, minor adjustments were made to optimize brush alignment and belt tension for smoother operation. The overall test results confirmed that the sugarcane peeling machine performed efficiently, producing cleanly peeled sugarcane in significantly less time compared to manual peeling. The machine was therefore considered suitable for small-scale processing and commercial applications with minimal maintenance requirements.

2.4 Final Design Approach

The sugarcane peeling machine design is compact and has an enclosed design that protects blades and the motor from dust, water moisture, and debris while keeping operators safe by limiting the possibility of exposure to moving components. The portability of the machine due to wheels allows users to access it in many locations, adding to its versatility and convenience. The solid foundation stabilizes the machine to help eliminate excessive vibration during operation and contributes to proper performance.

Additionally, the completely smooth and rounded exterior of the machine minimizes the build-up of dirt, which makes maintenance easy. The design optimizes sustainable waste management practices by including a small outlet that expels sugarcane peel waste from the machine into a removable container or harvesting bin. The machine utilizes durable materials, such as stainless steel, to resist corrosion and wear and extend the life of the machine while using fewer resources. The enclosed design also reduces sound and vibration and promotes a clean, quiet, and environmentally friendly machine operation.

While implementing all these design features to contribute to overall sustainability, the design also places an emphasis on safety. The enclosed design emphasizes not encountering moving parts, stabilizing the machine while being used, and providing ergonomic aspects that reduce operator strain, resulting in a safe, sustainable, and efficient machine for sugarcane peeling. Fig. 3.2 illustrates the overall structure and key components of the sugarcane peeling machine, emphasizing its compact enclosed design, mobility, stability, waste outlet system, and safety features.

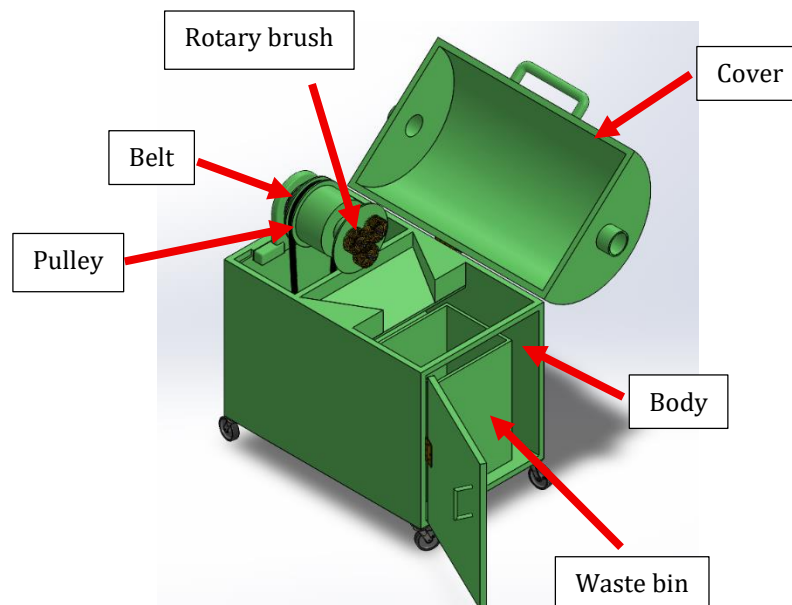


Fig. 3.2 Final design of Sugarcane PeelPro

3. Result and Discussion

The sugarcane peeling machine was built and tested to check how well it worked, how fast it peeled, and how safe and easy it was to use. During testing, it peeled sugarcane stalks of different sizes to see how reliable and consistent it was. The machine uses a hairpin blade powered by a 180-watt electric motor. It took about 45 to 60 seconds to peel each stalk. It removed 85% to 90% of the outer skin without harming the inner part. Each stalk produced about 18 to 25 grams of peel waste, which was collected in a removable bin. After many uses, the blades showed very little wear. The stainless steel stayed strong and in good condition. The machine used between 0.5 and 0.75 kWh of electricity per hour and made less than 70 decibels of noise, which is safe for small machines. Overall, the machine worked well and was much faster than peeling by hand. It improved hygiene by reducing

hand contact and produced very little waste. Its strong materials and simple design make it useful for farmers, juice sellers, and small businesses.

Table 4.1 *Peeling test*

Test	Time taken (second)
Peel 1	57
Peel 2	51
Peel 3	58

Table 4.1 shows the peeling test was conducted three times, with the recorded times being 57, 51, and 58 seconds respectively. On average, the machine took approximately 55 seconds to peel one sugarcane stalk, demonstrating consistent performance across all trials.

3.2 Detailed Design

The sugarcane peeling machine was carefully designed to optimize performance, safety, and durability. At its core, the machine features a fast-spinning rotary blade made of stainless steel, measuring 200 mm in width and 3 mm in thickness. This blade is powered by a 0.75 hp single-phase electric motor running at approximately 850 rpm—an ideal speed to effectively remove the tough outer skin of sugarcane while preserving the soft, edible inner layer. Power is transmitted smoothly through a pulley and belt system that requires minimal maintenance.

The structural frame is constructed from mild steel (MS) angle bars, providing robust support and stability during operation. To enhance durability and resistance to rust, the frame is coated with a specialized powder paint. The machine design incorporates a hand-fed slot for easy insertion of sugarcane stalks and a sloped guide to correctly position the stalks for peeling. Pressure rollers press the stalks firmly against the blade, ensuring even and consistent peeling. Beneath the blade, a stainless-steel waste bin collects the peelings; this bin is removable and requires regular emptying to maintain cleanliness. For user safety, the machine includes a clear acrylic blade cover to prevent accidental contact with the blade and is mounted on non-slip wheels to maintain stability while allowing mobility.

3.3 Product Specification

The compact dimensions of the sugarcane peeling machine, measuring 600 mm (length) × 500 mm (width) × 900 mm (height), allow it to be conveniently placed in confined workspaces such as small commercial kitchens or market stalls. Weighing approximately 40 kg to 45 kg, it strikes a balance between portability and operational stability.

The completed machine is shown in Fig. 4.1 which equipped with stainless steel rotary blades powered by a 0.75 hp, 220 V single-phase electric motor. The blade speed is maintained at a constant 850 rpm to optimize the peeling process, balancing efficiency and safety. The machine can accommodate sugarcane stalks up to 30 mm in diameter and is capable of peeling each stalk within 45 to 60 seconds, depending on size and hardness.

Peeling efficiency ranges from 85% to 90%, ensuring minimal waste. Power consumption is relatively low, between 0.5 to 0.75 kWh, making it suitable for small commercial vendors concerned with energy costs. The removable waste bin has a capacity of 8 to 10 liters and is designed for easy cleaning. Additional safety features include an emergency stop switch, a transparent blade shroud for visibility and protection, and non-skid rubber feet for secure anchoring during operation.



Fig. 4.1 *Sugarcane PeelPro machine*

3.4 Manufacturing Process

The manufacturing process began with the preparation of materials, primarily mild steel angle bars and stainless steel sheets, which were cut to size using power saws and shear machines. These materials formed the structural frame and blade components.

The frame was fabricated using Metal Inert Gas (MIG) welding, with careful control to minimize spatter and ensure a clean finish. Welded joints were ground flat to improve surface quality and facilitate precise assembly. The frame was then powder-coated to enhance corrosion resistance and aesthetics.

Blade components were fabricated from flat bars and required precision machining. The rotary blade and shaft were shaped using a lathe and further processed on a milling machine to achieve accurate alignment. Keyways were machined into the shaft for concentric rotation, and pulley slots were cut and aligned precisely to maintain correct belt tension.

The blade itself was laser-cut from stainless steel to exact dimensions and sharpened specifically for peeling. Heat treatment was applied to improve hardness and wear resistance, ensuring the blade's durability and consistent performance.

Assembly involved aligning and bolting fabricated components together, securing mechanical parts, and installing electrical systems including wiring and switches. Final electrical adjustments were scheduled to be performed by a qualified electrician upon delivery.

3.5 Testing

Upon assembly, comprehensive testing was conducted to verify the machine's functionality and performance. Technicians evaluated blade balance, ensuring smooth rotation without vibration. The power transmission system was checked for proper operation and noise levels were monitored to detect any mechanical issues.

Operational tests focused on the feed mechanism to confirm correct engagement and clearing during peeling. Adjustments were made where necessary to optimize the feeding system and overall machine responsiveness. The testing phase confirmed that the machine operates reliably, efficiently, and safely, meeting the design criteria established at the outset. Minor refinements were implemented based on test results to enhance durability and user safety, making the machine suitable for its intended small commercial use.

3.6 Limitations

Although the machine demonstrated good performance during testing, several limitations may affect its overall effectiveness in real-world applications. The machine operated most efficiently with sugarcane stalks ranging between 20 to 30 mm in diameter. When larger or smaller stalks were inserted, the peeling process became less consistent, leading to partial peeling or surface damage. This size limitation reduces its flexibility for farmers and vendors who handle sugarcane of varying thicknesses.

Additionally, the machine faced difficulties in peeling stalks that were curved, bent, or irregularly shaped. Such stalks often failed to maintain proper contact with the rotary brushes, resulting in uneven peeling and increased wastage. In practical settings where sugarcane is rarely uniform, this issue could lower productivity and require additional manual handling or pre-sorting of stalks.

Another limitation is the machine's dependence on electricity for operation. This restricts its usability in rural or outdoor locations where power supply is unreliable or unavailable. As a result, the machine may not be suitable for field-based or small roadside vendors who lack access to consistent electrical sources.

Finally, while the machine includes basic safety features such as protective covers and stable framing, it still requires additional safety mechanisms to ensure secure operation, especially for untrained users or during large-scale continuous operation. Without these enhancements, the risk of minor injuries or mechanical accidents could limit its adoption in commercial or industrial settings.

4. Conclusion

In conclusion, the sugarcane peeling machine developed in this project successfully meets the objectives of efficient, safe, and durable operation for small-scale commercial use. The detailed design, incorporating a stainless-steel rotary blade powered by a 0.75 hp motor and supported by a sturdy mild steel frame, enables effective peeling of sugarcane stalks up to 30 mm in diameter. The manufacturing process, involving precise machining and careful assembly, ensured the production of a robust and reliable machine.

Performance testing demonstrated that the machine can peel each sugarcane stalk within 45 to 60 seconds, achieving a peeling efficiency of 85% to 90% with minimal waste. The machine's power consumption remains low, making it economically viable for small vendors. Additionally, safety features such as the acrylic blade cover, emergency stop switch, and non-slip feet contribute to secure operation.

While the machine showed excellent consistency and ease of use, some limitations were noted regarding stalk size and shape compatibility, as well as dependency on electrical power. Addressing these in future iterations

could broaden its applicability and improve user experience. Overall, the project successfully delivered a functional prototype that can enhance productivity and reduce labor in sugarcane peeling processes.

Building on the findings of this research, several areas for future exploration and development are recommended. One possible continuation of the project is the design and implementation of an auto-feeding mechanism, which would allow multiple sugarcane stalks to be processed in sequence with minimal manual handling. This addition would improve productivity and make the machine more suitable for medium- to large-scale operations. Further research is also recommended on blade optimization, specifically in the area of geometry, angle, and material composition, to enhance the machine's ability to handle irregular and curved stalks. Investigating alternative power sources, such as solar panels or integrated battery systems, would be beneficial for extending the usability of the machine in remote or off-grid locations. It is strongly advised to select a solid and more rigid metal structure, like mild steel box sections or reinforced stainless steel, for the main frame and structure of the sugarcane peeling machine.

During the testing process, some minor vibrations were present in the region of the machine's maintaining housing and bearings, this was largely compared to the total weight and structure of the machine. However, during operation over longer periods of time and particularly at the very high end of spinning speeds, it was felt these vibrations would not be critically damaging under continuous operation, but might affect some degree of long-term stability, comfort, and wear over time. If a larger, heavier structural material is incorporated, or there is an increase of frame thickness, this overall rigidity of the machine can be significantly improved. A more robust frame will also contribute to reducing operational noise and safety, by limiting machine movement during operation. This is especially of benefit if the machine is used in high output places or over long periods of time. In summary, this research constitutes a first step toward more efficient, accessible and scalable sugarcane processing, and lays the foundation for future developments in agricultural mechanization, particularly in regions of the world where mechanized processing would have significant socio-economic benefits.

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Conflict of Interest

This publication has no conflicts or issues regarding the data, as it relies on references from the internet and research.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Syed Luqmanulhakim Syed Abd Hamid, Afif Haziq Aszele, Muhammad Fuad Hasif Kasiman; **data collection:** Syed Luqmanulhakim Syed Abd Hamid, Afif Haziq Aszele, Muhammad Fuad Hasif Kasiman; **analysis and interpretation of results:** Syed Luqmanulhakim Syed Abd Hamid, Afif Haziq Aszele, Muhammad Fuad Hasif Kasiman, Nurmina Abdullah; **draft manuscript preparation:** Syed Luqmanulhakim Syed Abd Hamid, Afif Haziq Aszele, Muhammad Fuad Hasif Kasiman, Nurmina Abdullah. All authors reviewed the results and approved the final version of the manuscript

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