Journal Renewable Energy & Mechanics (REM)
DOI: 10.25299/rem.2026.24667
Received 2025-09-01; Revised: 2026-03-17; Accepted 2026-03-31

Vol. 09 No.01 2026
E-ISSN: 2614-8315
P-ISSN: 2714-621X

Design and Development of Palm and Coconut Stick Saving Machine using an Adjustable Blade

Serano Gozali, Mustaza Ma'a*, Roni Novison, Agus Wijianto

Study Program of Mechanical Engineering, Department of Industrial Technology, Politeknik Caltex Riau, Jl. Umban Sari No. 1 Pekanbaru – Riau, 28265, Indonesia
*Corresponding author: mustaza@pcr.ac.id

ABSTRACT

Oil palm and coconut cultivation generate abundant biomass waste in the form of leaflets, yet their utilisation into economically valuable sticks is constrained by the inefficiency of manual separation and the limitations of machines employing fixed blades. This study aims to design and develop a stick shaving machine for coconut and oil palm leaflets by introducing an adjustable blade mechanism that adapts to variations in material dimensions. The prototype machine is powered by a 0.25 HP electric motor with a rubber-roller feeding system and tested at two blade gap settings (1 mm and 2 mm) under young, mature, and wet leaflet conditions. Experimental results indicate that the machine's production capacity for oil palm leaflets reached 11.16 kg/h, surpassing that of coconut leaflets (8.676 kg/h), due to differences in physical dimensions. Failure rate analysis demonstrated that a 1 mm blade gap was the most optimal configuration, yielding the lowest failure percentage (55%) when processing mature coconut leaflets and young oil palm leaflets. Furthermore, wet conditions increased the stiffness of oil palm midrib fibres, resulting in more stable cutting than wet coconut leaflets. In conclusion, the implementation of the adjustable blade mechanism empirically reduced stick damage while improving flexibility and efficiency in agricultural waste processing.

Keyword: oil palm; midrib waste; stripping machine, adjustable blade, agricultural waste utilisation

1. INTRODUCTION

Oil palm (*Elaeis guineensis*) and coconut are crucial plantation crops in Indonesia, contributing significantly to the national economy through vegetable oil production. However, the massive scale and high productivity of these plantations generate an immense amount of biomass waste, particularly in the form of fronds and leaflets, which are frequently abandoned and underutilised. Technological engineering efforts to manage plantation waste have been widely explored, ranging from mechanical chopping of palm fronds to reduce waste volume (Susilo et al., 2023) to advanced processing into alternating briquette energy. This includes the development of briquette dough mixers (Mustaza et al., 2025) and electric motor-driven briquette moulding machines equipped with specialised gearbox transmissions (Ma, Syachreffi, et al., 2025). Furthermore, oil palm and coconut leaves have substantial potential to be processed into high-value sticks for various handicrafts, thereby empowering local communities economically.

Despite its economic potential, manual separation of sticks from palm and coconut leaflets is highly inefficient and prone to ergonomic risks. To address this issue, the design of ergonomic workstations for leaf stripping has been proposed to improve worker posture and safety (Pawitra et al., 2025). In terms of mechanisation, the integration of roller mechanisms has proven successful in significantly increasing production capacity. Various studies have developed roller-based stick shaving machines, ranging from conventional machines (Valino Widodo, 2019) and a leaf-stick separator with a capacity of 7 kg/hour (Pardede et al., 2022) to specific palm stick shavers (Arsi & Two Nando, 2021) and electric motor-driven coconut leaf separators (Sutrisno et al., 2024). Recent advancements have even achieved highly efficient and economical designs capable of processing up to 1800 sticks per hour (Siregar et al., 2024).

Furthermore, the optimisation of cutting mechanisms and power transmission systems remains a critical focus in agricultural machinery development. Alternative cutting methods, such as utilising thread as a cutting tool for stick shavers, have been investigated to evaluate stripping quality (Wang et al., 2023). Additionally, comprehensive performance analyses based on engine speed, energy consumption, and variations in leaf types have proven crucial in determining the optimal output quality of palm sticks (Wahyudi et al., 2026). The application of low-power electric motors (e.g, 0.25 HP to 1 HP) combined with precise transmission controls, such as gearboxes and variable speed drives (VSD), has been successfully implemented in other agricultural and industrial machines, including fan-shaped banana slicers (Panutan et al., 2025) and custom profile plate rolling machines (Ma, Prawira, et al., 2025). These studies provide a strong technical foundation, demonstrating that drive systems can be precisely adapted to produce the stable, efficient rotations required in stick shaving machines.

Although various stick shaving machine designs and their systems have advanced rapidly, the majority of current machines still use a fixed-blade cutting mechanism. The limited flexibility of these static blades frequently results in high failure rates, such as broken sticks or unclean stripping, when processing leaflets with different dimensional characteristics and structural stiffness, such as variations between palm and coconut leaves or between young and mature leaves. This technological gap necessitates the development of a more adaptive and universal shaving machine. Therefore, this study aims to design and develop an oil palm and coconut stick shaving machine by implementing an adjustable blade innovation. This adjustable blade dynamically adapts its cutting gap to the varying diameters of the midribs. This innovation is expected not only to effectively reduce biomass waste but also to significantly improve the flexibility, cutting stability, and overall efficiency of the stripping process compared to conventional fixed-blade designs.

2. METHODS

The development of the palm and coconut stick shaving machine was conducted through a systematic experimental engineering approach. The research procedure, as illustrated in the flowchart (Figure 1), began with a comprehensive literature review and a needs analysis to identify the limitations of existing stick-shaving machines. This was followed by the conceptual design of the adjustable blade mechanism and the fabrication and assembly of the prototype. The final stage involved empirical performance testing to evaluate the cutting success rate and production capacity across various leaflet conditions.

The conceptual design of the shaving machine relies on a mechanical feeding and dynamic stripping mechanism. The primary structure is supported by a rigid frame to minimise vibration during operation. The driving system is powered by an AC motor, which transmits torque to the main shaft via a pulley and V-belt (Figure 2).

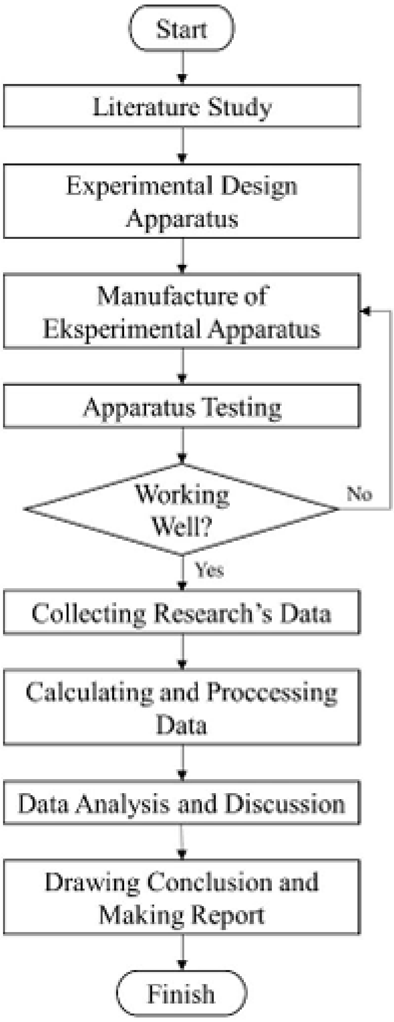

Figure 1. Flowchart

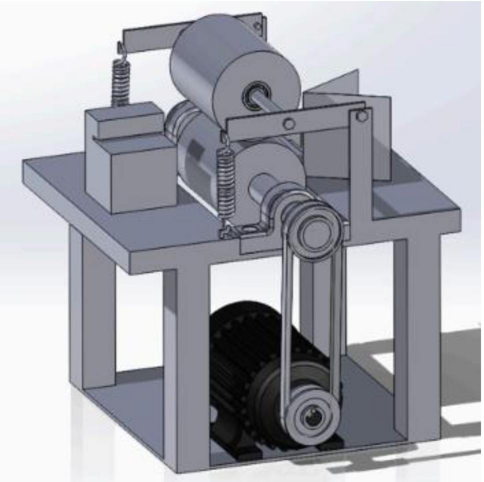

Figure 2. Mechanism design

For the feeding mechanism, the machine utilises rubber rollers to firmly grip and continuously pull the leaflets into the cutting zone. The primary innovation of this design is the cutting unit, which features two distinct blades: a fixed blade and an adjustable blade. The adjustable blade is mounted on a movable holder, with a tension spring that provides a continuous, adaptive clamping force. As the midrib enters the cutting zone, the tension spring stretches to allow the blade to slightly open for thicker diameters and instantly retracts to maintain pressure for thinner sections. This floating mechanism prevents the stick core from being crushed. Based on the material dimension, the tension spring was calibrated to provide a dynamic range from a minimum gap of 1 mm up to a maximum of 2 mm during the operational tests.

To ensure the mechanical reliability and safety of the prototype, a series of mathematical calculations was performed prior to fabrication. These engineering models determined the specific requirements for the shaft, motor, transmission system, and spring mechanism.

The main shaft must withstand the torsional load and forces generated during the stripping process. The allowable shear stress (τ_a). The shaft material was determined to ensure structural integrity:

$$\tau_a = \frac{\tau_b}{Sf_1 \times Sf_2} \qquad (1)$$

Where τ_a is the allowable shear stress (kg/mm^2), τ_b is the tensile strength (kg/mm^2), and Sf_1 , Sf_2. These are the safety factors.

The shaft force $\left(F_{pr}\right)$, which drives rubber rollers to pull the leaflets, is calculated based on the angular velocity (ω):

$$F_{pr} = m_{total} \times \omega^2 \times r \qquad (2)$$

Where F_{pr} is the shaft force (N), m is mass (kg), ω is angular velocity (rad/s), and r is the shaft radius (m).

To calculate the necessary driving power, the shaft speed (n_2) and shaft velocity (V) were determined:

$$n_2 = n_1 \frac{Dp_1}{Dp_2} \qquad (3)$$

$$V = 2\pi r_{total} n_2 \qquad (4)$$

Subsequently, the shaft power $\left(P_p\right)$ required to perform the operation was derived:

$$P_p = F \times V \qquad (5)$$

Where P_p is the shaft power (kW), F is the shaft force (N), and V is the shaft velocity (m/s).

Based on the required shaft power, the minimum specification for the electric drive motor (P_m) was calculated using a correction factor to account for operational load fluctuations:

$$P_m = f_c \times P_p \tag{6}$$

Where P_m is the required motor power (kW), f_c is the correction factor (typically 1.0 – 1.5), and P_p is the calculated shaft power (kW).

To achieve the desired rotational speed at the main shaft, the pulley ratio and the required belt length were calculated. Assuming negligible belt slip, the relationship between the driver and driven pulleys is expressed as:

$$\frac{n_1}{n_2} = \frac{Dp}{dp} \tag{7}$$

Where n_1 and n_2 represent the speeds of the driver and driven pulleys, respectively, while dp and Dp represent their respective diameters. The necessary v-belt length (L) was calculated using the distance between pulley centres (C):

$$L = 2C + \frac{\pi}{2}(dp + Dp) + \frac{1}{4C}(Dp - dp)^2 \tag{8}$$

Where L is the belt length (mm) and C is the centre-to-centre distance between the pulleys (mm).

The adjustable blade's performance relies on the proper tension of its integrated spring. The spring constant (K) was formulated to ensure sufficient clamping force without breaking the midribs:

$$K = \frac{F}{x} \tag{9}$$

Where K is the spring constant (N/m), F. Is the force applied based on mass and acceleration? $(F = m \times a)$. In this context, m represents the mass of the adjustable blade assembly (kg), and a is defined as the linear acceleration (m/s^2) of the blade assembly as it is dynamically displaced upwards by the varying thickness of the incoming midribs. Furthermore, x represents the change in the spring's length or displacement (m).

Upon completion of the fabrication process, the machine's performance was empirically evaluated based on two primary metrics: production capacity (kg/hour) and cutting failure rate. The experimental variable included the type of material (oil palm vs coconut leaflets) and its physical condition (young, mature, and wet). To standardise the wet condition, the leaflets were completely submerged in clean water at ambient room temperature for 12 hours (overnight) prior to the shaving process. This procedure was strictly implemented to ensure uniform moisture absorption across all tested samples. Furthermore, the machine was tested under two different adjustable blade gap configurations (1 mm and 2 mm) to determine the optimal setting. The failure rate was explicitly calculated as the percentage of broken or improperly cleaned sticks generated during the shaving process. Providing quantitative data to identify the most stable and efficient operational parameters.

3. RESULT AND DISCUSSION

Based on the production capacity test, the machine exhibited significantly different performance when processing two distinct materials (Figure 3). The shredding capacity for oil palm leaflets reached 11.16 kg/h, equivalent to a production rate of 3.1 g/s. In contrast, coconut leaflets recorded a lower capacity of 8.676 kg/h, or approximately 2.4 g/s. The higher production capacity observed in oil palm leaflets is fundamentally attributed to their relatively shorter physical dimension compared to coconut leaflets. This morphological characteristic enables the machine's internal pulling mechanism to process oil palm leaflets more quickly. Thereby directly enhancing the overall daily output.

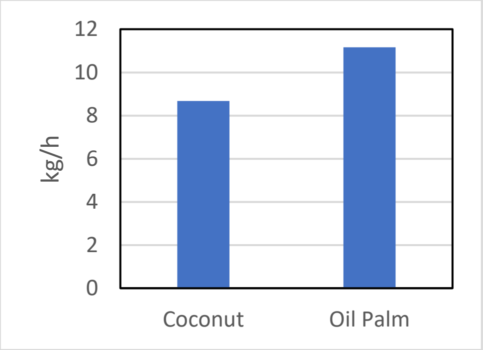

Figure 3. Capacity

Failure rate evaluation, defined as broken or improperly cleaned sticks, was conducted by comparing cutting performance at blade gaps of 1 mm and 2 mm under both young and mature leaflet conditions.

For coconut leaflets, mature leaves processed with a 1 mm blade gap yielded the lowest failure rate of 55%, outperforming young leaves at the same gap (60%). However, the failure rate increased sharply to 75% (mature) and 80% (young) when the machine operated with a 2 mm blade gap. The optimal cutting performance for mature coconut leaflets at a 1 mm gap (55%) can be explained mechanically by their material properties. Mature coconut midribs possess higher lignin content, resulting in greater fibre stiffness and core density compared to young leaflets. When forced through the narrow 1 mm gap, this dense core provides strong, stable counterpressure against the blade. This allows the blade to cleanly shear off the epidermis without crushing or snapping the stick core. In contrast, young coconut leaflets lack this internal stiffness, causing them to bend or get crushed under the same blade pressure (Figure 4).

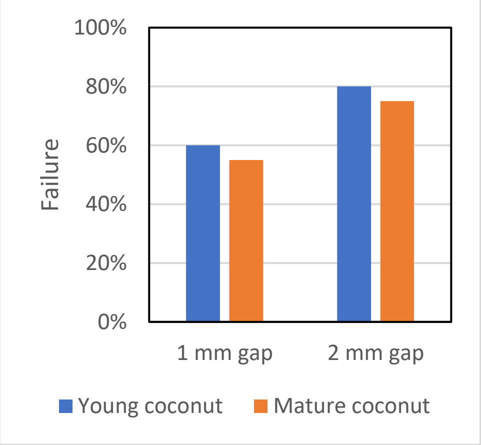

Figure 4. Failure of coconut leaflets

Conversely, the analysis of oil palm leaflets revealed a different mechanical phenomenon. The lowest failure rate (55%) was achieved with young oil palm leaflets processed at a 1 mm blade gap, while mature leaflets recorded a 60% failure rate. At a 2 mm blade gap, both young and mature oil palm leaflets exhibited equally high failure rates of 75%. Conversely, the oil palm leaflets exhibited different mechanical behaviour due to their inherently thicker, more rigid fibre structure. The lowest failure rate (55%) was achieved by young oil palm leaflets processed at a 1 mm blade gap. Mechanistically, mature oil palm midribs are highly lignified and excessively brittle. Forcing these grid-mature midribs through a narrow 1 mm gap generates excessive mechanical resistance, often leading to brittle failure (snapping or breaking of the stick). Young oil palm leaflets, however, possess an optimal balance of structural flexibility and sufficient core stiffness. This resilience allows them to absorb the comprehensive force of the adjustable blade and pass through the 1 mm gap smoothly while the epidermis is cleanly peeled (Figure 5).

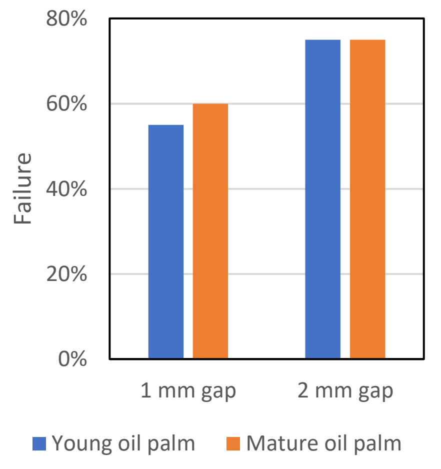

Figure 5. Failure of oil palm leaflets

Further testing involved soaked (wet) leaflets to assess the impact of material moisture on cutting stability. At a 1 mm blade gap, wet oil palm leaflets recorded a failure rate of 60%, performing better than wet coconut leaflets, which reached 65%. However, at a 2 mm blade gap, the failure rate of wet oil palm leaflets deteriorated sharply to 85%, while that of coconut leaflets remained at 75%. The superior performance of wet oil palm leaflets at the 1 mm gap (60%) is attributed to the structural changes induced by the standardised 12-hour water-soaking period. Overnight soaking acts as a plasticiser for the epidermal layer while swelling the internal fibres. For oil palm leaflets, this moisture absorption optimally enhanced the turgor and stiffness of the core, while softening the outer wet coconut leaflets absorbed too much moisture, causing their fibres to become overly pliable and prone to shredding or jamming under the blade's pressure (Figure 6).

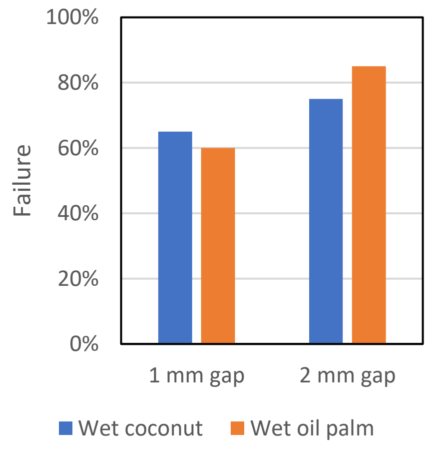

Figure 6. Soaked failure

Overall, the experimental data demonstrate that the innovation of adjustable blade gaps is crucial to determining the machine's success rate. Across all tested materials and conditions, a 1 mm blade gap consistently produced lower failure rates. Empirical evidence confirms that the 1 mm configuration provides superior cutting stability and precision compared to the widened 2 mm gap.

4. CONCLUSION

The design and development of a stick shaving machine featuring an adjustable blade mechanism has been successfully implemented to process coconut and oil palm leaflets. Experimental results demonstrated that the machine achieved a higher production capacity for oil palm leaflets (11.16 kg/h) than for coconut leaflets (8.676 kg/h) due to the palm leaflets' smaller physical dimensions. Furthermore, performance testing confirmed that a 1 mm blade gap significantly minimised failure rates, achieving its best performance (55% failure rate) when processing mature coconut leaflets and young oil palm leaflets, as it effectively leverages their specific fibre stiffness and structural resilience. The structural advantages of this optimal gap were also evident in wet conditions, particularly for soaked oil palm leaflets. Ultimately, the adjustable blade mechanism effectively accommodates the varying dimensional and physical properties of biomass waste, offering a highly flexible, practical, and efficient solution for agricultural stick production.

REFERENCES

Arsi, F., & Two Nando, F. (2021). PERANCANGAN MESIN PENGOLAH LIMBAH LIDI KELAPA SAWIT MENGGUNAKAN COMPUTER AIDED DESIGN (CAD). *Jurnal Teknik Industri Terintegrasi (JUTIN)*, *4*(1), 53–59.

Ma, M., Prawira, Y., Novison, R., & Zaira, J. Y. (2025). *Experimental investigation of profile eye shape on plate bending : The role of rotational speed*. *6*(1), 91–100.

Ma, M., Syachreffi, M. I., Novison, R., Zaira, J. Y., & Nugraha, N. C. (2025). *The Effect of Funnel Angle on Density , Hardness , and Calorific Value in Briquette Pressing Machine*. *20*(1), 106–112.

Mustaza, M., Adli, M. A., Novison, R., & Wijianto, A. (2025). *Homogenization Of Bricket Dough : A Study On Horizontal Helical Ribbon Mixer*. *20*(1), 129–136.

Askeland, D. R. (1985). *The Science and Engineering of Material*. Alternate Edition. PWS Engineering. Boston. USA.

Panutan, D., Ma, M., Wijianto, A., & Novison, R. (2025). *Design and simulation of a fan-shaped banana cutting machine*. *6*(1), 101–108.

Pardede, F. A., Peranginangin, D., Sebayang, S., & Tarigan, K. (2022). RANCANG BANGUN MESIN SEBAGAI PEMISAH ANTARA DAUN DENGAN LIDI KELAPA SAWIT MENGGUNAKAN ROLL SEBAGAI PENARIK DENGAN

KAPASITAS 7 KG/JAM. *Teknologi Mesin*, *3*(2), 13–23.

Pawitra, T. A., Sitania, F. D., Sukmono, Y., Widada, D., & Wijaya, M. F. (2025). Implementasi tojok ergonomis bagi pekerja pada perkebunan kelapa sawit Ladeppung, Muara Badak. *KACANEGARA Jurnal Pengabdian Pada Masyarakat*, *8*(4), 425–432. https://doi.org/10.28989/kacanegara.v8i4.2855.

Siregar, Z. H., Ramadhan, A., & Syafputra, N. (2024). Rancang mesin peraut lidi kelapa sawit dengan menggunakan motor listrik kapasitas 1800 lidi/jam. *Jurnal Mekanova : Mekanikal, Inovasi Dan Teknologi*, *10*(2), 515–527.

Susilo, B., Siti Nurrohkayati, A., Haryo Pranoto, S., & Nugroho, A. (2023). Prototype Mesin Pecacah Pelepah dan Daun Kelapa Sawit Sebagai Pakan Ternak Alternatif Pengganti Hijauan. *Journal Technology Urgency Breakthrough in Engineering*, *2*(1), 29–36. http://ejournal.umm.ac.id/index.php/turbine

Sutrisno, Witjahjo, H., & Aziz, A. K. (2024). Rancang Bangun Alat Pemisah Daun Kelapa Dan Lidi Menggunakan Motor Listrik. *Jurnal Infotex*, *3*(1), 370–379.

Valino Widodo. (2019). *PERANCANGAN MESIN PERAUT DAUN LIDI KELAPA SAWIT MENGGUNAKAN ROLL SEBAGAI PENARIK* [Skripsi Sarjana]. UNIVERSITAS ISLAM RIAU.

Wahyudi, Indra Setiawan, Eduardus Dimas Arya Sadewa, Fattiya Hamada Sakti Isa Putri, Muhammad Rifa'i, Ibnu Ferianto, Nurani Adristi Bunga Nirvana, & Gusti Ivan Indie Mahardika. (2026). Design and performance analysis of a stick making machine to support the sustainability of palm oil leaf waste. *TEKNOSAINS : Jurnal Sains, Teknologi Dan Informatika*, *13*(1), 177–185. https://doi.org/10.37373/tekno.v13i1.2014

Wang, C., Song, C., & Song, J. (2023). Optimization and test of working parameters of cutting device of vegetable grafting machine. *Journal of Physics: Conference Series*, *2528*(1), 1–9. https://doi.org/10.1088/1742-6596/2528/1/012003