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PERFORMANCE OF SEVERAL COCONUT COIR PEELING TOOLS FOR PEELING EFFICIENCY IN COCONUT PRODUCTION CENTERS

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ABSTRACT

In Indonesia, coconuts play a crucial role, and peeling them is essential for their utilization. Traditionally, coconuts were peeled manually using tools like machetes, but with the advancement of technology, machines are now being used to expedite the process. This study evaluated the performance of various coconut peeling machines in coconut production centers. The research methodology employed a combination of observational and descriptive approaches. Each peeling tool, including the traditional lewang, machete, and modern peeling devices, was tested using 150 samples of mature coconuts, ten nuts per trial using each of the three methods, and five replicates. The data collected was organized into tables and graphs to provide a descriptive analysis. The comprehensive study spanned over two months and took place at the Laboratory of the Indonesian Palm Crops Instrument Standard Testing Institute (IPALMSTI), situated in the agricultural lands beneath the coconut trees in the North Minahasa District, North Sulawesi Province, Indonesia. The study's findings revealed that, utilizing a modern coconut coir peeling machine reduced the peeling time significantly to 7.45 seconds, with a successful peeling rate of 241.48 nuts per 30 minutes. It was evident from the results that the optimization of peeling machines can have a substantial impact on productivity. Moreover, there is potential for enhancing the traditional lewang tool through ergonomic improvements or material enhancements to improve its performance. Considering these results, governments should consider providing subsidies to smaller coconut producers to facilitate the adoption of machine peeling tools. This initiative could enhance productivity and create new employment opportunities within the industry. The traditional lewang tool, with an average time of 9.48s, is relatively efficient but can be further improved. Ergonomic enhancements or material upgrades can reduce fatigue and increase speed. Providing ergonomic training for traditional tool users can also enhance efficiency. Governments or organizations can subsidize farmers or smaller producers to adopt machine peeling tools. Future solutions should merge technology with cost-effectiveness to benefit small-scale farmers.

Key words: Coconut, peeling machine, coconut coir, agricultural engineering, efficient

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INTRODUCTION

Coconut is a valuable plant in Indonesia. All parts of the coconut fruit (coir, shell, meat, and water) are beneficial. Coconut coir is the most significant part (35%) of coconut fruit compared with other components such as meat (28%), endocarp (12%), and coconut water (25%) [1]. Coconut coir is becoming interesting for development into a functional product with commercial value [2]. Coconut fiber, part of coconut coir, has become a raw material for the car industry, such as upholstery, dashboards, door trims, and coco beds and furniture [3].

The shell is the thin brown layer outside the fruit. It contains a hard layer of lignin, cellulose, methoxyl, and various minerals. The composition of these ingredients differs depending on the type of coconut. The shell's complex structure is due to its high silicate ($SiO2$) content [4]. The shell weight is around 15-19% of the coconut's total weight [5]. Separating coconut coir from the shell is a crucial procedure in coconut processing. Coconut farming communities or business owners commonly perform this task. The traditional approach uses tools such as crowbars, lewangs, sticks, and machetes for peeling [5]. Technological innovation aims to facilitate the process for farmers and contribute to lowering production costs, increasing yields, and reducing yield losses so that, in the end, it will increase farming income [6].

Currently, some coconut farmers or entrepreneurs still use the manual (traditional) method of peeling the coconut coir from the coconut shell using a lewang tool [7]. The lewang is made of steel and installed vertically, about ± 80 cm above the ground, with the lewang facing upwards. The manual coconut peeling process is considered to have a high risk of work accidents and requires a workforce, and special skills because it uses sharp lewangs [8]. However, coconut peeling is performed manually, and the peeling cost reaches Rp.350-Rp.500 (0.023-0.033 USD) per coconut [9]. This cost is often considered high, becoming an obstacle for the owners and entrepreneurs of Copra and other coconut derivative products. It affects the cost of peeling and reduces farmers' incomes [10]. Coconut peeling machines are widely used, and motor power is used for propulsion. The main component of the coconut coir peeling machine is a frame that supports the components contained in the machine [11]. A paring knife is a component for peeling coconut coir. The motor, one of the machine's most critical components, is the knife's driving component, and the transmission is a link between the motor and the coco peeling knife [12].

Coconut coir peeling can be performed semi-mechanically and semi-manually. Other semi-manual tools (not tested here) for peeling coconut coir include Sula (iron and wood), and even hoes, which can be used to peel coconut coir [7]. Sula is a traditional coconut peeler that has been used since time immemorial. Sula is made of iron and wood and resembles a sula eye [13].

Agricultural mechanization is vital for agricultural modernization, enhancing production, productivity, and efficiency. Although machines have long been used, further advancements are needed to improve their performance and competitiveness [8]. Implementing a coconut peeler as a technological development can boost productivity in the coconut industry. This machine is easy to operate, saves energy, and is safe to use, with a peeler capacity of 2 pieces per minute. Low cost and low energy use result in shorter peeling times, increased productivity of coconut peeling, and higher profitability [4]. Changes in perception and knowledge about converting conventional methods into machine technology have been successful. The functional testing results showed the best performance at a rotational speed of 14 rpm, with an average shell-peeling time of 20.96s per nut [14]. Similar research has been conducted using a coconut shell peeler machine in Naur Regency, Bengkulu [15]. The results show that peeling one coconut by machine takes an average of 15 seconds. This research not only measures the time taken to peel a coconut using the machine but also compares it with traditional manual peeling methods commonly used by locals. Since manual methods only focus on peeling and not grating, the comparison highlights the efficiency of the mechanized peeler tool which will be the easiest to operate, comfortable to operate, saves energy and is safe for use.

The development of agricultural mechanization in Indonesia cannot be separated from the local community's situation and strategic environmental conditions. It is necessary to approach the community's socio-cultural transformation system by considering each local culture's diversity. Therefore, to provide facilities and infrastructure, it is necessary to procure the necessary agricultural equipment through continuous technological innovation so that farmers can accept it. A machine work tool's capacity is the machine's ability to process and produce production materials in a particular time unit [16]. This research was conducted to thoroughly evaluate the performance and efficiency of various coconut peeling machines, including the lewang, machete, and peeling machine, to determine their impact on coconut production centers.

MATERIALS AND METHODS

The research method used in this study was carried out by testing the lewang, machete, and machine, with each test using 150 samples of old coconut nuts (10 nuts for each of three methods, and five replicates), and presenting the results in tables. The procedure for testing the performance of tools and machines was to prepare the semi-mechanized (automatic) and semi-manual (traditional) tools,

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prepare the coconut fruit, turn on the coconut coir peeling machine and ready the machete and lewang tools, and place the coconuts into the coir peeling machine or tool [17]. The tools used in this research were a coconut peeling machine from Indonesian Palm Crops Instrument Standard Testing Institute (IPALMSTI), a machete, lewang, digital scales, a digital camera, calculator, stationery, a stopwatch, and laptop. There are three main coconut peeling tools in Figures 1, 2, and 3 representing peeling machine, Lewang and Machete, respectively.

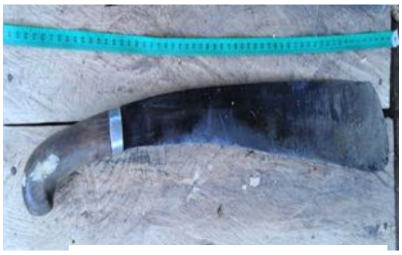

Figure 1: Machete

Figure 2: Lewang

Figure 3: Coconut Peeling Machine

Each tool serves a specific purpose in efficiently removing a coconut's outer layer (coir). The peeling machine is a mechanical device designed for automated peeling, making the process quicker and more convenient. The lewang is a handheld tool to pry the coconut meat away from the shell, facilitating easy extraction. The machete, a traditional and manual tool, is a large, sharp knife that cuts through the tough coconut coir. These tools have been developed and utilized across various cultures and regions where coconuts are a staple, showcasing the diversity of methods for extracting coconut meat. The material used in this research is coconut fruit (fruit weight varies between 1.250 – 2.250 kg with a fruit circumference of 52 cm - 66 cm). Using a stopwatch time measuring instrument, researchers manually tested the work time by peeling using a machete and lewang of human labor to determine the time generated for one coconut nut. An operator peeled the coconuts using the machine, and professional farmers peeled the coconuts using machetes and lewang. A comparative analysis was conducted by measuring the duration of the peeling process using a stopwatch set for 30 minutes, to obtain average peeling times. Peeling capacity can be calculated using the following formula.

$$\text{Peeling capacity} = \frac{Peeling\ Time\ (seconds).}{Testing\ Time\ (seconds)} \quad (1)$$

This formula can provide an overview of the efficiency or performance of a peeling process in the context of the time specified for testing.

RESULTS AND DISCUSSION

Before conducting the testing process, researchers compared the performance of several coconut coir peeling tools. First, the old coconut fruit was collected and placed in one place, with the age of harvesting coconut fruit being 11-12 months, and the type of coconut fruit originating from the Indonesian Palmae Research Center in Manado. The coconut fruit was prepared, and then the coconut coir was tested or peeled in the testing process using several coconut coir peeling tools: lewang, machete, and machine. Raw materials of old coconut fruit were prepared to be peeled on each tool test. The circumference of each coconut fruit per nut was measured, and each nut was weighed to obtain the uniformity of old coconut fruit, which was used as testing material. The results of the measurement of the use of coconut coir peeling tools on average from peeling ten coconuts are shown in Table 1. Lewang is a tool for peeling coconut coir. It is effective but complex for inexperienced users. In village communities, a machete is also used for peeling coconut coir.

Capacity of the coconut coir peeling tool

The performance of various coconut coir peeling tools was evaluated based on their peeling capacity and efficiency. The traditional lewang tool demonstrated an average peeling time of 9.48 seconds per coconut, resulting in a peeling capacity of approximately 190 coconuts per 30-minute period. The manual machete method showed a slower rate, with an average peeling time of 42.30 seconds per coconut, achieving a capacity of only about 43 coconuts per 30 minutes.

The most efficient was the electric-powered peeling machine, equipped with a high-speed engine (3000 RPM/220V). This machine performed significantly better, taking an average of 7.454 seconds per coconut, translating into a capacity of approximately 241 coconuts within the same 30-minute time frame. These results are presented in Table 1, highlighting the peeling capacities of each tool. A significant difference was observed in the measurement results of the average number of nuts peeled in 30 minutes using three tools: lewang, machine, and machete. The machine can peel the most, the lewang slightly less, and the machete considerably less. Other considerations, such as safety, effectiveness,

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and the quality of the result, also need to be considered when selecting the most suitable tool for a specific purpose.

Statistical data and standard deviation of peeling duration

The statistical analysis indicates a noteworthy variance in the standard deviation of peeling time (measured in seconds per nut) across the three tools, lewang, machete, and machine, at a significance level lower than 0.05. Given that the standard deviation reflects the extent to which the data is dispersed, this finding implies substantial differences in peeling times among the three methods. The average standard deviations of peeling time per nut for the lewang, machete, and machine methods were 0.02398 seconds, 0.0312 seconds, and 0.01806 seconds, respectively. Table 2 presents the statistical data with each method's means and standard deviations. These results provide insights into the efficiency and effectiveness of each seed peeling method.

Calculation of cost and energy efficiency

Coconut peeling machines, designed for mechanized husking, augur heightened productivity potential. The machine tested here is manufactured in Indonesia and is suitable for medium-to-large-scale operations. Their consistent performance can markedly curtail labor costs, increasing productivity. However, accounting for elevated initial costs and maintenance requisites is imperative. The lewang is cost-effective and low maintenance, suitable for small-scale operations, necessitating skilled labor and intermittent rest periods to ensure sustained productivity. Utilizing a machete requires skill and is fatiguing. Using a machete without proper skill and technique poses potential hazards, underscoring the significance of safety in operations. This consideration is paramount to safeguarding the operator's well-being [18].

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

Traditional tools like the machete and lewang are cost-effective for small-scale operations but less efficient for larger workloads. In contrast, the coconut coir peeling machine offers a faster and safer alternative, although it requires a higher initial investment and consistent power supply. Policymakers should consider ergonomic improvements or material enhancements to reduce fatigue and increase speed for those using traditional tools; ergonomic training can reduce physical strain and potentially increase the speed and efficiency of the peeling process. Governments or organizations can provide subsidies or financial aid to farmers or smaller producers to adopt machine peeling tools, enhancing overall productivity for facilities with a large volume of coconuts to process. Researchers and engineers face the challenge of designing an efficient, user-friendly, and affordable coconut peeling machine. Future solutions must merge advanced technology with cost-effectiveness to make modern machinery accessible to all farmers, bridging the gap between innovation and practicality.

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Conflicts of Interest
None.

Authors Contributions
Dedie Tooy participated in data interpretation and revised the article. **Frans Wetapo** participated in data collection and article writing. **Patrik Pasang**: Data collection and supervising the testing of tools. **Tineke Marlyn Langi**: Reviewing and editing the article.

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Table 1: Testing the capacity of some coconut coir peeling tools within 30 minutes

No	The types of coconut coir peeling tools	Peeling capacity Seconds/nut	Peeling capacity (nuts per 30 mins)
1	Lewang	9.48	189.873
2	Machete	42.30	42.553
3	Machine	7.454	241.481

Table 2: Statistical data and standard deviation of peeling duration

Peeling duration (seconds/nut) in five replications					
Lewang	**S. Dev**	**Machete**	**S. Dev**	**Machine**	**S. Dev**
9.48	0.01	42.30	0.011	7.454	0.012
9.32	0.0256	42.45	0.0225	7.340	0.0129
9.65	0.0289	42.20	0.01	7.592	0.0193
9.40	0.0064	42.60	0.09	7.421	0.0011
9.55	0.049	42.15	0.0225	7.667	0.045
Average					
9.48	0.02	42.30	0.03	7.454	0.01

REFERENCES

1. **Andrés GS, Sara Aguilar-Sierra SA and B Graziella** Morphological, physical, and chemical characterization of coconut residues in Ecuador. *Heliyon*. 2023**; 9(9)**: e19267 https://doi.org/10.1016/j.heliyon.2023.e19267

2. **Kumar N and D Kumar** Strength Properties of Coconut Shell as Coarse Aggregate in Concrete. *International J. of Computer & Mathematical Sciences IJCMS ISSN*. 2014; ***3*(5).**

3. **AlNouss A, Parthasarathy P, Shahbaz M, Al-Ansari T, Mackey H and G McKay** Techno-economic and sensitivity analysis of coconut coir pith-biomass gasification using ASPEN PLUS. ("Coir Pith Lignin as a Reliable Bio-Source for Carbonaceous Nano ...") *Applied Energy*, 2020; ***261***: 114350. https://doi.org/10.1016/j.apenergy.2019.114350

4. **Adeel S, Kiran S, Shahid M, Habib SR, Habib N and M Hussaan** Eco-friendly application of coconut coir (*Cocos nucifera*) extract for silk dyeing. *Environmental Science and Pollution Research*. 2022; **29:** 564–572. https://doi.org/10.1007/s11356-021-15669-6

5. **Singh P, Dubey P, Younis K and O Yousuf** A review on the valorization of coconut shell waste. *Biomass Conversion and Biorefinery.* 2022;1–11. https://doi.org/10.1007/s13399-022-03001-2

6. **Sujiono EH, Zabrian D, Dahlan MY, Amin BD and J Agus** Graphene oxide-based coconut shell waste: synthesis by modified Hummers method and characterization. *Heliyon*. 2020; **6(8)**. https://doi.org/10.1016/j.heliyon.2020.e04568

7. **Yusofe AYA, Chee HC, Ramesh S, Ali MY and Z Ibrahim** Design and engineering analysis of a coconut peeler machine. AIP Conference Proceedings. 2023; **2643(1).** https://doi.org/10.1063/5.0129406

8. **Ingle DAH, Damahe A, Rahangdale A, Chahande A, Wasnik B and B Tembhare** Literature Review on Coconut Peeling Machine. *International J. for Research in Applied Science and Engineering Technology*, 2022; ***10*(4).** https://doi.org/10.22214/ijraset.2022.41226

9. **Ganesh EN** Design and Modeling of Coconut PEELING Machine. *Computer J*. 2022; ***65*(7).** http://dx.doi.org/10.6084/m9.figshare.21271053

10. **Tooy D, Lantang D, Rantung RA, Rumambi DP, Longdong IA and HF Pinatik** Techno-Economic Study of Coconut Husks Decomposing Machine for Farmer Group Scale. *J. of Agriculture*. 2023;**2(2)**:212-223. https://doi.org/10.47709/joa.v2i02.#2668

11. **Banda YPA, Mulyono J and H Santosa** The design of the Coconut Peeling and Splitting Machine using TRIZ Method. *PROZIMA (Productivity, Optimization and Manufacturing System Engineering)*, 2022; **5(2)**. https://doi.org/10.21070/prozima.v5i2.1390

12. **Adhiatma A, Hidayat R, Gusviandra D, Rildiwan R, Zulnadi Z, Amrizal A and FY Batubara** Rancang Bangun dan Kinerja Mesin Pengupas Sabut Kelapa Muda (Design and Performance of Young Coconut Peeling Machine). *Agroteknika*. 2019; **2(2)**: 85-94. https://doi.org/10.32530/agroteknika.v2i2.40

13. **Herdiana A and S Riyadi** Perancangan Mesin Pengupas Tempurung Kelapa Menggunakan Software FEM (Coconut Shell Peeling Machine Design Using FEM Software). Technology National Seminar. 2022; ***6***. https://doi.org/10.31949/stima.v6i0.703

14. **Prasetiyo AB and AS Kartinasari** Analisis Struktur Desain Pisau Pengupas Tempurung Kelapa Menggunakan ANSYS 19.2 (Structural Analysis of Coconut Shell Peeling Knife Design Using ANSYS 19.2), National Seminar Research and Technology Innovation. 2022; ***1*(1)**.

15. **Harefa D and MKA Rosa** *Peningkatan Produktivitas Kelompok Petani Kelapa Desa Batu Lungun Melalui Pembuatan Alat Pengupas Kelapa Sederhana* (Increasing the Productivity of the Coconut Farmer Group in Batu Lungun Village by Making Simple Coconut Peeling Tools). *J. of Community Services*. 2021; **2(1).** https://doi.org/10.33369/tribute.v2i1.18029

16. **Prima F** Perancangan Alat Pengupas Sabut Kelapa Menggunakan Metode VDI 2221 (Design of a Coconut Coir Peeler Using the VD 2221 Method). *Inaque : Journal of Industrial and Quality Engineering*, 2021; **9(2).** https://doi.org/10.34010/iqe.v9i2.5147

17. **Anuar MAAC and AKA Rahim** To Design A Semi-Auto Coconut Peeling Machine. *Research Progress in Mechanical and Manufacturing Engineering*. 2022; **3(1):** 978-987.

18. **Fitra F, Azmi A, Marbun NJ and NA Fathurrozi** Study of Anthropometry and Ergonomics of Desk and Chair Design for Elementary School (Case Study: Public Elementary School 008 Purnama). *J. of Industrial Engineering Management***.** 2021. 170-175. https://doi.org/10.33536/jiem.v0i0.770