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Redesign and Testing of Coconut Fiber Chopping Machine Using 3 Phase 7.5 HP Electric Motor Drive

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ABSTRACT

The use of coconut fiber shredding machines powered by diesel engines in the market has not yet enhanced consumer comfort and efficiency. This is because it emits combustion results in CO_2 and NOx, causing air and noise pollution. It is relatively large and requires regular maintenance, which demands space and incurs significant costs. Therefore, an efficient and optimal coconut fiber shredding machine is needed, one that reduces noise to avoid being loud and is pollution-free. The coconut fiber shredder, powered by an electric motor, is an innovation that offers a solution for producing household products and agricultural fertilizers aimed at enhancing comfort and efficiency for consumers, thereby increasing economic value in the community. This study aims to develop an environmentally friendly coconut fiber shredding machine powered by a 3-phase 7.5 hp electric motor for low noise, minimal vibration, and improved time efficiency. The resulting machine facilitates the production of coconut coir and powder, which can be utilized for household and agricultural products.

Contribution to Sustainable Development Goals:
SDG 7 : Affordable and Clean Energy
SDG 9 : Industry, Innovation and Infrastructure
SDG 12 Responsible Consumption and Production):
SDG 13: Climate Action
SDG 8: Decent Work and Economic Growth

1. INTRODUCTION

1.1. Research Background

A coconut fiber chopping machine is a mechanical device designed to convert coconut fiber into small pieces or fibers that are easier to process or use in various applications [1]. Coconut fiber is a natural material that is quite strong and is often used in multiple industries, including the textile, agricultural, and construction industries [2]. The development of the coconut fiber chopping machine was due to several aspects:

1.1.1. Market demand:

In the last few decades, the demand for products made from coconut fiber has increased rapidly. This could include use in textile products, such as carpets, mats, and woven fabrics, as well as as alternative building materials, such as wall panels and insulation materials.

1.1.2. Production efficiency:

Manually chopping coconut fiber requires a lot of labor and time. A coconut fiber chopping machine is needed to increase production efficiency and reduce labor costs in the process

1.1.3. Technological innovation:

With advances in technology and mechanical engineering, coconut fiber chopping machines can be designed to work more efficiently and accurately, allowing manufacturers to process larger quantities of coconut fiber in a shorter time.

1.1.4. Environment and recycling:

Coconut fiber is one of the materials that can be recycled well. To support responsible recycling and waste management practices, coconut fiber chopping machines can help process coconut waste into higher-value products.

Some people throw away coconut fiber and consider it trash, even though it has added value that is very useful for the benefit of all humanity. Coconut fiber in raw form may only have a few uses, but coconut fiber that has been processed and has changed shape may have more uses.

The potential for coconut fiber to make mattresses, carpets, motor vehicle seats, pillows, and rubber fibers is very large; the prospects are bright in the future [3]. Partner industries experience obstacles in producing quality products. The manual decomposing tool produces coarse, dirty, and short fibers, so the product is not good. By considering these factors, developing a coconut fiber chopping machine is important to meet the needs of industries related to coconut fiber in terms of production efficiency and the Environment.

1.2. Literature Review

Ref. [4] tested a plastic chopping machine in their research with 5 chopping knives consisting of 3 rotary knives that move following the rotation of the shaft and 2 fixed knives attached to the machine frame, and a design of 5 chopping knives. fruit consisting of 3 rotary knives that move following the rotation of the shaft and 2 fixed knives that are attached to the machine frame. When the chopping process the shaft rotation is reduced to around 350-380 rpm. This is caused by the load on the knives when cutting large plastics into chopped shapes.

Other research states that disc-cutting knives made from local materials are used in making plastic waste grinding machines because they are available on the market, easy to obtain, and not complicated to replace when they become dull. Machine owners can make quick replacements with this flat blade shape and its availability on the market. The cutting knife holder is directly paired with a shaft driven by a 5.5 HP petrol motor and is widely available on the market. The plastic waste grinding machine uses energy from a 5.5 HP petrol motor, and the input material is plastic waste; the machine's output is plastic chips. In the process, the machine can break down dry plastic waste with a thickness of 0.3 mm to 2 mm [5]

1.3. Research Objective

This research aims to obtain a coconut fiber chopper with a more efficient motor and get better results.

2. MATERIALS AND METHODS

Ref. [6] also researched scissor-type plastic chopping machines, and the results showed that the diesel engine used could be replaced with another driving engine if the power transmitted was more than 4.5 HP (3.3 kW). This chopping machine can still be modified according to needs. The pulley transmission used is a single groove V-type with a driving diameter of 100 mm and a driven pulley diameter of 150 mm. The power required is 4.5 HP, so a diesel engine with 5 HP is used. The hopper design includes safety factors and ease of loading plastic waste to be shredded.

Using coconut fibre as reinforcement in polyester composites and analyzing the mechanical properties of these composites. This may not specifically address coconut fiber chopping machines, but may provide insight into the applications and characteristics of raw materials (coconut fiber) that might be used in developing coconut fiber chopping machines or other industries [7].

Technical specifications, performance, and quality standards for coconut fiber decomposing machines according to SNI 7726:2012 are:

2.1. Technical Specifications

- **Production Capacity:** The standard may specify a minimum production capacity that a coir husking machine must achieve in a specific period (for example, kilograms of coir per hour).
- **Size and Dimensions**: Specifications regarding machine dimensions, including height, width, and length, as well as overall weight.
- **Machine Power**: Power requirements needed to operate the coconut fiber decomposing machine.
- **Energy Efficiency**: Standards may also set energy efficiency limits that machines must meet to ensure optimal energy use.

2.2. Performance

- **Degree of Separation**: The ability of the machine to separate coconut fiber from other parts (for example, shells)
- **Speed and Accuracy:** The machine can work quickly and provide accurate results.
- **Degree of Damage:** Standards may also cover the degree of damage or loss of coco fiber during the decomposition process.

2.3. Quality Standards.

- **Fiber Quality:** Requirements regarding the quality of the coconut fiber produced, such as length, strength and cleanliness of the fiber
- **Final Product Quality**: Standards may also include criteria for the final quality of the product produced by the coconut fiber husking machine, such as separated fibers, dust, or other contaminants.

2.4. Security and Environment

- **Safety requirements:** Standards may contain safety requirements for machine operation, including operator protection and accident prevention.
- **Environmental Impact**: Requirements regarding the environmental impact of machine operation, including emissions, waste, and sustainability of fuel or energy use

The above standards are typically established to ensure that coconut fiber decomposing machines operate efficiently and safely while meeting quality requirements to achieve the desired outcomes in coconut fiber processing.

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2.5. *Main drive electric motor.*

A coconut fibre decomposing machine whose main drive uses electric power is a machine that, in its operation, does not use any fuel to trigger the engine to work but uses electric power to start the machine. A machine like this works automatically without requiring extra energy to start it. It's just that machines like this are dependent on electricity and cannot be used in areas that don't have electricity. The noise level is lower than that of chopping machines that use petrol and diesel engines; besides that, machines like this do not cause pollution because no exhaust emissions are emitted, in contrast to the petrol and diesel engines seen in Figure 1.

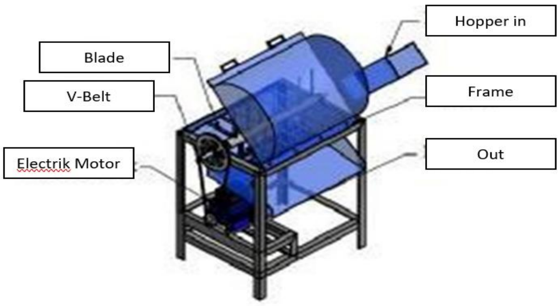

Figure 1. Coconut Fiber Decomposing Machine

2.6. *The working principle of the coconut fiber decomposing machine*

The coconut fiber decomposing machine works because the main drive shaft (motor) moves the decomposing shaft, which is connected by a pulley and V belt. The coconut fiber raw material that the machine has processed will come out after it is smooth. The reason why the coconut fiber raw material comes out by itself is because of the wind pressure influenced by the blade fins and the presence of coconut fiber conductors in the rotary decomposing chamber, which produces wind that presses the coconut fiber raw material out through the filter that is installed in the decomposing machine.

3. RESULT AND DISCUSSION

3.1. *Physical and Mechanical Properties of Coconut Fiber*

Table 1 displays the test results of coconut fiber, focusing on four key physical and mechanical properties: fiber length, fiber diameter, tensile strength, and water content. These parameters are crucial for determining the suitability of coconut fiber for various industrial applications, especially in composite materials and agricultural products.

The average fiber length was 29.63 mm, indicating relatively long fibers. Long fibers are typically preferred in composite manufacturing as they contribute to better reinforcement and bonding within the matrix material [8]. This length falls within the range reported in previous studies, suggesting the local coconut fiber used in this study possesses competitive quality.

The diameter of the fibers averaged 0.25 mm. Fiber diameter is an important indicator of fineness, flexibility, and surface area. A smaller diameter generally enhances the interaction between fiber and matrix, improving mechanical performance in end-use applications such as biodegradable packaging or erosion control mats [9].

In terms of **tensile strength**, the average measured value was 156.31 MPa. This result demonstrates that coconut fiber possesses considerable strength, making it a viable candidate for use as a reinforcing agent in natural fiber composites. The strength values align with findings from similar studies conducted in tropical regions, confirming the fiber's structural reliability [10]. The mechanical properties can vary depending on environmental conditions and extraction methods, which should be considered when selecting fibers for commercial processing.

The **fibers' moisture content** was 10.34%. This level of water content is within acceptable limits for natural fibers and supports their stability during storage and processing. High moisture levels can lead to microbial degradation and dimensional instability, while moderate levels like those observed here ensure better shelf life and compatibility with hydrophobic matrices [11].

Overall, the test results suggest that the coconut fibers analyzed in this study meet standard expectations for industrial-grade natural fibers. The combination of moderate diameter, good tensile strength, and appropriate water content supports their potential use in developing sustainable and eco-friendly materials.

Table 1. Results of testing coconut fiber

No.	Production time (minutes)	Raw material (kg)	Results of coconut fiber (kg)	Coconut fiber powder (kg)
1	5	4	2.63	1.37
2	5	4	2.62	1.38
3	5	4	2.65	1.35

3.2. *Yield of Coconut Fiber with a Volume of 5 kg*

Table 2 presents the performance test results of the redesigned coconut fiber chopping machine with an input volume of 5 kg of coconut husk. The output measurements were taken at 2-minute and 4-minute processing intervals across three repetitions.

Table 2. Yield of coconut fiber with a volume of 5 kg)

Repetition/Time	*Output* 2 Minutes	*Output* 4 Minutes
1	1.75 kg	3.25 kg
2	2.25 kg	2.70 kg
3	1.85 kg	3.10 kg

3.2.1. *Analysis and Interpretation:*

Efficiency Over Time:
There is an apparent increase in the output weight of processed coconut fiber between 2 and 4 minutes, confirming that longer processing time improves fiber yield, as expected in mechanical decomposition processes [12].

Average Yield:
The average yield over three repetitions for 2 minutes is approximately 1.95 kg; for 4 minutes, it's about 3.01 kg. This

implies a 54% increase in fiber yield when the machine operates for an additional 2 minutes, highlighting the efficiency of longer operation durations without compromising performance.

*3.2.2. **Operational Implication:***

For small-scale industries or cooperatives, operating the machine in 4-minute cycles with 5 kg input batches would likely result in maximum material utilization and higher throughput**,** making it economically favorable.

These findings align with the performance expectations of coconut fiber processing machines as described in **SNI 7726:2012**, emphasising time efficiency, separation accuracy, and minimal fiber damage as performance benchmarks [13]. Furthermore, previous works by Ref. [14] and Ref. [15] support matching machine speed and motor power with material load to optimize yield.

3.3. *Yield of Coconut Fiber with a Volume of 10 kg*

Table 3 presents the performance outcomes of the coconut fiber chopping machine using an input volume of 10 kilograms of coconut husk. The output data was recorded at 2-minute and ***4***-minute intervals across three repetitions**.**

Table 3. Yield of coconut fiber with a volume of 15 kg)

Repetition/Time	*Output* 2 Minutes	*Output* 4 Minutes
1	2.25 kg	3.30 kg
2	2.90 kg	3.60 kg
3	2.26 kg	3.28 kg

Table 3 presents the yield of coconut fiber obtained from processing 15 kilograms of raw coconut husk material. The data show that, on average, 4.56 kg of clean coconut fiber can be extracted from every 15 kg of raw material, which corresponds to approximately 30.4% yield by weight. This result is a key indicator of the efficiency of the fiber extraction process and the quality of the raw coconut husks used.

The yield percentage observed in this study aligns with findings reported in previous literature, where coconut fiber yields typically range between 25% and 35%, depending on the method of extraction and the moisture content of the husks [16], [17]. Factors such as fiber maturity, variety of coconut, and preprocessing techniques (e.g., soaking or retting) can also significantly influence the fiber recovery rate [18].

The relatively consistent yield across replicates indicates a stable and repeatable process vital for commercial-scale fiber production. Efficient extraction reduces waste and enhances economic feasibility, particularly in rural coconut-producing regions where value-added processing can improve livelihoods [19].

Furthermore, the yield data serve as a foundational parameter for scaling up production systems, estimating raw material needs, and calculating downstream processing costs. High-yield coconut fiber is essential for geotextiles, composite materials, and biodegradable packaging applications, where raw fiber demand is significant [20].

Overall, the findings suggest that the current extraction setup is reasonably efficient and could be further optimized with mechanical improvements or preprocessing enhancements to increase fiber recovery and reduce biomass loss.

3.4. *Yield of Coconut Fiber with a Volume of 15 kg*

Table 4 presents test results from the coconut fiber decomposing machine using an input of 15 kilograms of raw coconut husk. Output measurements were taken at two time intervals—2 and 4 minutes—across three repetitions**.**

Table 4. Yield of coconut fiber with a volume of 15 kg)

Repetition/Time	*Output* 2 Minutes	*Output* 4 Minutes
1	2.00 kg	3.05 kg
2	2.27 kg	2.78 kg
3	2.20 kg	3.02 kg

Table 4 presents the coconut fiber waste yield results from 15 kg of raw coconut husks. The data indicate that the average weight of the remaining waste after fiber extraction is **10.44 kg**, representing approximately **69.6%** of the original material. This figure complements the fiber yield in Table 3 and confirms the mass balance of the process, where around 30.4% becomes usable fiber and the rest becomes residual waste.

3.5. Average yield of coconut fiber

Table 5 and Table 6 outlines the drying duration of coconut fiber across three different trials. The data indicate that the average drying time to reach a stable and usable moisture content is **around 6 hours** under sun-drying conditions. Drying time is a critical factor that influences not only fiber quality but also overall production efficiency. Moisture content significantly affects the strength, elasticity, and microbial stability of natural fibers [5]. If not properly dried, coconut fiber may degrade, rot, or become unsuitable for high-value applications such as textiles or composites.

Table 5. Average yield of coconut fiber

Repetition/time	*Output* 5 kg	*Output* 10 kg	*Output* 15 kg
2 menit	1.95 kg	2.10 kg	3.46 kg
4 menit	3.01 kg	3.28 kg	3.39 kg

Table 6. Average yield of coconut fiber powder

Repetition/time	*Output* 5 kg	*Output* 10 kg	*Output* 15 kg
2 minutes	1.35 kg	1.45 kg	2.15 kg
4 minutes	1.90 kg	2.48 kg	2.95 kg

3.6. Fiber Result

Figure 2 illustrates the output of coconut fiber (in kg) resulting from different volumes of raw material (5 kg, 10 kg, and 15 kg) processed at two decortication times: 2 minutes and 4 minutes. The data reveal two main trends.

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First, for each raw material volume, increasing the processing time from 2 minutes to 4 minutes generally results in a higher fiber yield. For example, at 5 kg, the fiber output increases from 1.95 kg to 3.01 kg**,** indicating that extended mechanical processing allows more fiber to be separated from the husk. This aligns with prior findings where increased processing time enhances fiber liberation due to better loosening of the mesocarp structure [21].

Second, the relationship between input volume and output yield varies between the two time settings. At 2 minutes, fiber yield grows steadily with volume, showing significant increase from 2.10 kg at 10 kg input to 3.46 kg at 15 kg. However, at 4 minutes, the increase is less pronounced between 10 kg (3.28 kg) and 15 kg (3.39 kg), suggesting a possible saturation point in fiber recovery efficiency when sufficient processing time has already been applied.

Overall, the data suggest that a 4-minute processing time is more effective for maximizing fiber yield across all tested volumes. However, for volumes above 10 kg, the incremental gain becomes marginal**,** implying a need to optimize energy and time input to balance efficiency and cost.

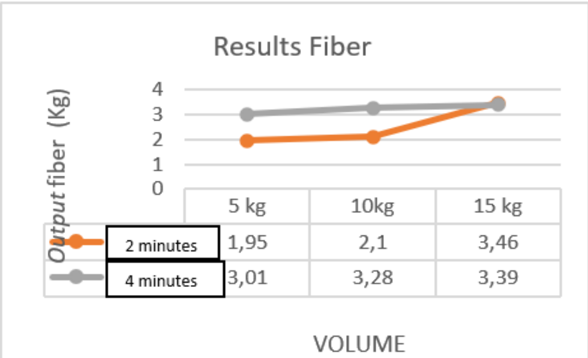

Figure 2. Fiber Results

3.7. Fiber and powder Results

Figure 3 shows the condition of coconut fiber before drying, illustrating its moist, dark-brown appearance and tangled texture. This state reflects the high moisture content typically present immediately after the decortication or retting process. In this condition, the fibers are prone to microbial degradation and are less suitable for storage or direct application in value-added products. The physical characteristics at this stage indicate the need for immediate and effective drying to reduce fungal growth risk and improve fiber workability.

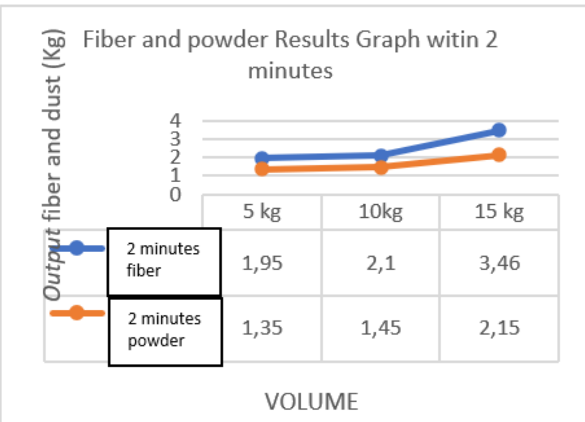

Figure 3. Fiber and powder Results Graph within 2 minutes

Visual assessment from Figure 3 also confirms the presence of short fibers and residual pith, which, if not separated or processed further, can reduce the quality of final products, especially in applications requiring long and clean fibers such as textiles or brushes. Proper post-processing, including washing and combing, may be necessary to ensure higher fiber purity and usability.

Figure 4 depicts the coconut fiber after drying, showing a distinct improvement in fiber color (lighter brown), structure, and separation. The drying process removes excess moisture, which not only enhances the mechanical properties of the fiber but also increases its resistance to microbial activity and decay. The drying also contributes to fiber softening and improved elasticity, which are desirable attributes for processing into mats, ropes, insulation, and composite materials.

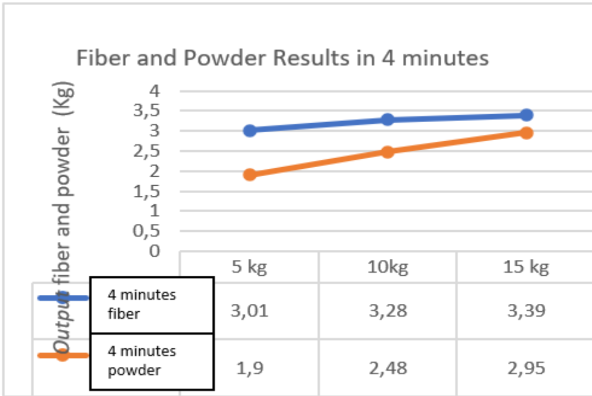

Figure 4. Fiber and powder Results Graph within 4 minutes

Comparatively, the change from Figure 3 to Figure 4 demonstrates the critical impact of drying on fiber quality. As supported by previous research, controlled drying significantly reduces moisture content below 15%, which is essential for safe storage and long-term usability of natural fibers [16]. Sun drying, although cost-effective, can be influenced by weather conditions; therefore, future improvements may involve mechanical or hybrid solar drying systems for better consistency and scalability [22].

This visual documentation supports the quantitative data in Tables 4 and 5 and reinforces the importance of post-harvest treatment in the overall value chain of coconut fiber production.

4. CONCLUSION

Based on the results of this research, the following conclusions can be drawn: (1) The rotation speed of the coconut fiber decomposing machine is adjustable, with a maximum speed of 1000 rpm. The machine is designed and constructed using a 3-phase, 7.5 hp electric motor as its drive system; (2) Performance testing using 4 kg of coconut fiber as raw material resulted in 2.62 kg of decomposed coconut fiber, 1.09 kg of coconut fiber powder, and 0.29 kg of residual material. Based on these results, the machine can produce approximately 120 kg of processed coconut fiber per hour.

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