INCREASED DRIVING FORCE OF NATURAL PLANT FIBER EXTRACTION RESULTS BASED ON THE RESULTS OF THE DEVELOPMENT OF NATURAL FIBER EXTRACTORS

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Abstract--*This research was motivated by the lack of utilization of wasted plant parts so that there were previous extractors that had been made but were still not optimal. This study itself aims to determine the effect of changes in the driving power of natural plant fiber extractors on the extracted fibers compared to previous extractors so that later the fiber produced can be used as the main material for making natural composites.*

In this study, the extractor is a tool used to extract plant fibers lining banana stems. The method used in this study is by developing the previous extractor, especially in the drive motor that used to use a DC motor and then replaced with a 5.5 HP gasoline motor, drum blade cap, tool transmission, water drain slide. After the development of the extractor was carried out, it continued with the initial data collection process with the loading method with an average banana stem layer length of 165.5 〖mm〗^2 and an average weight of 6.91 kg where the results can be used to determine the power of the drive motor used in this tool.

The process of extracting plant fiber from banana stem layers to determine the influence of the quality and quantity of fiber produced after tool development. As a result, the time needed to extract plant fibers averaged 9.3 seconds compared to previous tools which averaged 37.6 seconds manually and 42.3 seconds with DC motors.

Keywords: *Effect Improvement, Extraction, Development, Natural plant fiber*

1. INTRODUCTION

Indonesia is a country where many people's livelihoods are mostly farmers [1]. So vast is its territory that it can be planted with all kinds of plants such as banana trees. Banana is one of the germplasm that is widespread in Indonesia [2]. According to [3] approximately 54 banana cultivars were found in Indonesia. In 2015 the availability of per capita energy for bananas increased compared to 2014. That is from 34 kcal/day or 25.84 kg/year to 36 kcal/day or 27.15 kg/year [4] Banana tree is one of the trees with fruit that contains complex carbohydrates. In addition to fruit, the trunk and roots of banana trees also have useful content in everyday human life [5]. The trunk of the banana tree is divided into two, namely the pseudo-trunk which is a pile of leaf midribs, while the original trunk is commonly known as the banana weevil. Banana weevil is one part of the banana tree that is underused and considered as plantation waste and is often thrown away [6]. Waste is waste material or waste material that is no longer used from the results of human activities on a household, industrial, and mining scale. At certain concentrations, the presence of waste can have a negative impact on the environment and on human health, so it is necessary to carry out proper handling of waste [7]. The problem of lack of utilization of parts of banana plants is a problem that is often encountered, such as banana tree trunks whose steam layers is often not used after being cut down. This utilization is very important to provide more value so that it can produce a work that can be useful for life, for example, the use of banana stem layers that can be used for the manufacture of composites which are new materials.

Behind the development of an increasingly modern era, there have been various material innovations that continue to be developed in order to create a material that is lightweight, strong, quality, affordable in terms of cost, and easily available at this time there is now the development of composite materials [7]. Composite is a new type of engineered material consisting of two or more materials where the properties of each material differ from each other both chemical and physical properties, and remain separate in the final result of the material (composite material) [8]. A composite consists of a combination of two materials, or several materials that are combined macroscopically to act as and give a strength result composite consisting of reinforcement and matrix, which affects the mechanical properties [9]. Composite materials are used in many applications such as aerospace, automotive, aerospace, and many more [10]. According to some previous researchers, what is commonly used as a reinforcing material in composite materials is a type of synthetic fiber that cannot be recycled. In fact, there are still many natural fibers that have not been utilized optimally to benefit humans [11].

Speaking of composites, there are many composites on the market using synthetic materials that are relatively expensive. Of course, this makes people think about creating composites at a cheaper price than usual because the need for the use of composite materials is now increasing. Natural fiber, as a substitute for engineered fiber, has become one of the most researched topics over the past few years. This is due to its inherent properties, such as biodegradability, renewability, and its abundant availability when compared to synthetic fibers. Synthetic fibers are derived from limited resources (fossil fuels) and hence, are mainly affected by oil price volatility and their accumulation in the environment and/or landfill sites as a major drawback of their mechanical properties and thermal properties exceed those of natural fibers. This fiber/filler combination, as a reinforcement of various polymeric materials, offers new opportunities to produce multifunctional materials and structures for advanced applications [12]. Fibers derived from plants generally are grouped into 2 groups, namely non-wood fibers and wood fibers [13]. Composites made from natural materials are one solution that can answer these problems, for example, the use of banana steam layersas a material for the process of making plant fibers as raw materials for natural composites. Of course, to support it all, it needs a tool for preparing natural fibers. There are already several plant extractors to produce natural fibers, but there are still many shortcomings in these tools.

Based on the information above, it is necessary to develop a natural plant extractor to increase the yield of fiber processed using an extractor driven by a gasoline motor. This tool can later help the process of extracting natural plant fibers properly because development has been carried out on this tool. This tool is very useful to support the use of plant parts so that they are not wasted for nothing, because the process must be managed so that it can get selling value in the market, of course, this is what pioneered the author to develop this natural plant fiber extractor tool as a form of supporting these activities. It is necessary to increase the driving power of the motor to speed up the fiber production process because on the one hand, it can save production time and can also produce a greater amount of fiber due to faster fiber production time.

In the end, this study aims to determine the effect of changes in the driving power of natural plant fiber extractors on the extracted fibers compared to previous extractors so that later the resulting fibers can be used as the main material for making natural composites.

2. METHODOLOGY

Broadly speaking, the flow diagram of this research consists of several stages, namely:

1. Stage Preparation of tools and materials
2. Motor Power Determination Stage
3. Extractor Tool Manufacturing Stage
4. Extractor Tool Trial Phase
5. Fiber Extraction Examination Phase
   Data Presentation Stage

For more details, here is the research flow diagram illustrated in Figure 1.

2.1 Tools

The tools used in this study are:

1. An earlier natural plant fiber extractor
2. Welding Machine
3. Scales
4. Knife

2.2 Material

The materials used in this study are:

1. Plate
2. Gasoline Motor
3. Banana stem midrib
4. Belt
5. Pulley
6. Handle

2.3 Research Flow Chart

The steps to conduct research in the form of a flow chart are as follows:

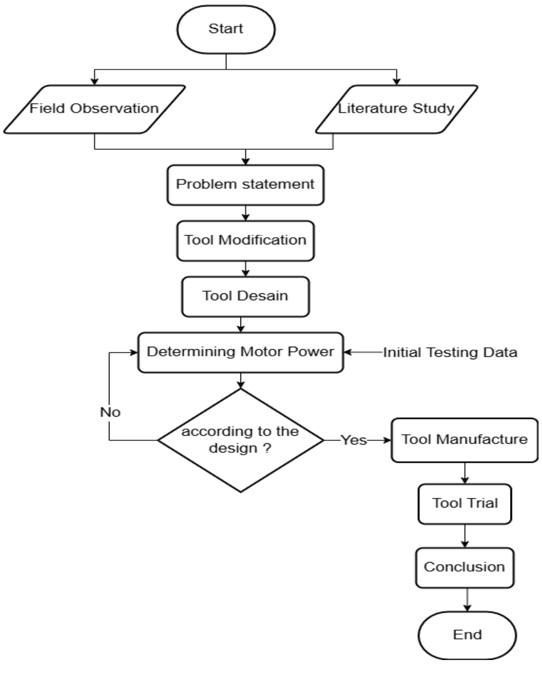

Figure 1. Research Flow Chart

2.4 Development of previous extractors

In the development of previous extractors there were several components added, namely:

A. Close the Drum Blade

Figure 2. Close the Drum Blade

B. Water Drain Slides

Figure 3. Water Drain Slides

C. Transmission Tool

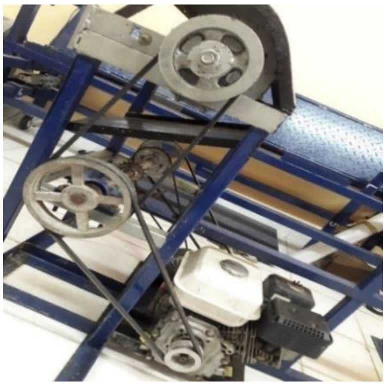

Figure 4. Transmission Tool

2.5 Initial planning and data collection steps

In the development of the extractor device, planning and collecting initial data are carried out to determine the motor power used, with the following steps :

A. Banana stems consist of fused midrib layers, in this stem layer banana fibers are stored. To find the load, it must first dahulknown A (cross-sectional area) of the banana midrib. Take a look at the image below

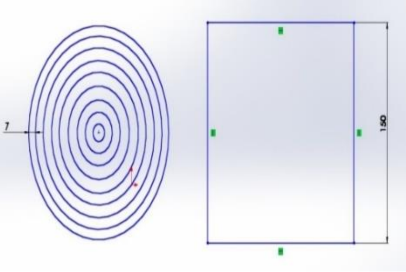

Figure 5. Pieces of banana stems

B. Data collection of test materials is carried out to determine the tensile stress of the test material, namely the banana stem layer. Here are the data and pictures of banana stem layer testing test materials

Figure 6. Five Samples of Banana Stem Pieces

C. In this test, the author weighed the whole weight of each layer of banana stems, seen in Figure 7. is a layer of banana stems that have been weighed

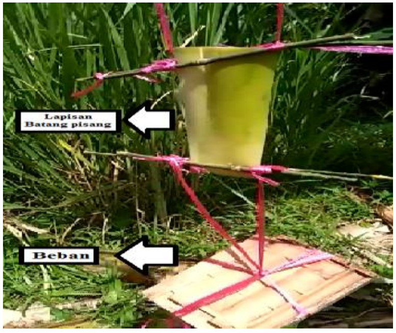

Figure 7. Initial Testing of Tensile Loads

D. Weighing data from each layer of banana stems can be seen in Table 1. as follows.

Table 1. Sample Whole Weight

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NO	Name	Weight (kg)
1	m_1	15.5
2	m_2	19
3	m_3	21.5
4	m_4	23.5
5	m_5	25
	Average	**20.9 kg**

E. Next, carry out the loading process on one / one layer of five banana stems that have been weighed intact. Test result data with loading method starting from the first layer to the seventh layer as follows

As we can see in Table 2. This is the result of the test of the first layer of banana stem fibers from five samples of banana stems taken, informed the location of the breakage of the banana stem fibers in the first layer

Table 2. The First Layer Banana Stem Test Results Data

NO	p x l x t (mm)	L (mm^2)	m (kg)	Results
1	30 x 15 x 8 mm	120	4.5	Break End
2	30 x 15 x 7 mm	105	3.5	Break Middle
3	30 x 15 x 10 mm	150	6.2	Break Bottom
4	30 x 15 x 11 mm	155	6.7	Break Bottom
5	30 x 15 x 9 mm	135	5.7	Break Middle
	Average	**133** mm^2	**5.32 kg**	

As we can see in Table 3. This is the result of the test of the second layer of banana stem fibers from five samples of banana stems taken, informed the location of the breakage of the banana stem fibers in the first layer

Table 3. The Second Layer Banana Stem Test Results Data

NO	p x l x t (mm)	L (mm^2)	m (kg)	Results
1	30 x 15 x 12 mm	180	8	Break End
2	30 x 15 x 11 mm	155	6.7	Break Bottom h
3	30 x 15 x 8 mm	120	4.5	Break End
4	30 x 15 x 7 mm	105	3.5	Break Middle
5	30 x 15 x 7.5 mm	112.5	4	Break Middle h
	Average	**134.5** mm^2	**5.34 kg**	

As we can see in Table 4. This is the result of the test of the third layer of banana stem fibers from five samples of banana stems taken, informed the location of the breakage of the banana stem fibers in the first layer

Table 4. The Third Layer Banana Stem Test Results Data

NO	p x l x t (mm)	L (mm^2)	m (kg)	Results
1	30 x 15 x 10 mm	150	6.2	Break Bottom
2	30 x 15 x 7 mm	105	3.5	Break Middle
3	30 x 15 x 10 mm	150	6.2	Break Bottom
4	30 x 15 x 13 mm	195	9	Break End
5	30 x 15 x 19 mm	285	12	Break End
	Average	**177** mm^2	**7.38 kg**	

As we can see in Table 5. This is the result of the test of the fourth layer of banana stem fibers from five samples of banana stems taken, informed the location of the breakage of the banana stem fibers in the first layer

Table 5. The Fourth Layer Banana Stem Test Results Data

NO	p x l x t (mm)	L (mm^2)	m (kg)	Results
1	30 x 15 x 19 mm	285	12	Break End
2	30 x 15 x 9 mm	135	5.7	Break Middle
3	30 x 15 x 7 mm	105	3.5	Break Middle
4	30 x 15 x 9.5 mm	142.5	6	Break Bottom
5	30 x 15 x 9 mm	135	5.7	Break Middle
	Average	**160.5** mm^2	**6.58 kg**	

As we can see in Table 6. This is the result of the test of the fifth layer of banana stem fibers from five samples of banana stems taken, informed the location of the breakage of the banana stem fibers in the first layer

Table 6. The Fifth Layer Banana Stem Test Results Data

NO	p x l x t (mm)	L (mm^2)	m (kg)	Results
1	30 x 15 x 8 mm	120	4.5	Break Middle
2	30 x 15 x 13.5 mm	202.5	9.2	Break End
3	30 x 15 x 13 mm	195	9	Break End
4	30 x 15 x 16 mm	240	11	Break End
5	30 x 15 x 10 mm	150	6.2	Break Bottom
	Average	**181.5 mm^2**	**7.98 kg**	

As we can see in Table 7. This is the result of the test of the sixth layer of banana stem fibers from five samples of banana stems taken, informed the location of the breakage of the banana stem fibers in the first layer

Table 7. The Sixth Layer Banana Stem Test Results Data

NO	p x l x t (mm)	L (mm^2)	m (kg)	Results
1	30 x 15 x 18 mm	270	11.5	Break End
2	30 x 15 x 11 mm	165	7	Break Bottom
3	30 x 15 x 11.5 mm	172.5	7.3	Break Bottom
4	30 x 15 x 14 mm	210	10.5	Break End
5	30 x 15 x 9 mm	135	5.7	Break Middle
	Average	**190.5 mm^2**	**8.4 kg**	

As we can see in Table 8. This is the result of the test of the seventh layer of banana stem fibers from five samples of banana stems taken, informed the location of the breakage of the banana stem fibers in the first layer

Table 8. The Seventh Layer Banana Stem Test Results Data

NO	p x l x t (mm)	L (mm^2)	m (kg)	Results
1	30 x 15 x 13 mm	195	9	Break Middle
2	30 x 15 x 12 mm	180	8	Break Middle
3	30 x 15 x 8 mm	120	4.5	Break Middle
4	30 x 15 x 16 mm	240	11	Break End
5	30 x 15 x 8 mm	120	4.5	Break Middle
	Average	**181.5 mm^2**	**7.4 kg**	

F. The following is the breaking point of the banana stem layer after the withdrawal process with the loading method

Figure 8. Banana stem break point

G. After obtaining test data from the seven layers of banana stems, then calculate the average overall from the data that has been obtained. The overall average can be seen in Table 9.

Table 9. Overall Average Data

NO	Layer	Average L (mm^2)	Average m (kg)
1	1st Layer	133	5.32
2	2nd Layer	134.5	5.34
3	3rd Layer	177	7.38
4	4th Layer	160.5	6.58
5	5th Layer	181.5	7.98
6	6th Layer	190.5	8.4
7	7th Layer	181.5	7.4
	Overall average	**165.5 mm^2**	**6.91 kg**

H. Then find F_{es} where it is known from table 9. that the tensile stress of the banana midrib τp = F/A (1)
6.91 / 165.5 = 0.04 kg/mm² and the area of banana frond is A = 1158.5 mm²

$$F_{es} = \tau_p \cdot A \quad (2)$$
$$= 0{,}04 \text{ kg/mm}^2 \times 1158.5 \text{ mm}^2$$
$$= 46.34 \text{ kg} \times 9.81 \text{ m/s}^2$$
$$= 454.5 \text{ N}$$

If the results of the F_{es} have been obtained, the required torque can be searched

$$\begin{aligned} T_{rs} &= F_{es} \text{ x } D/2 \\ &= 454.5 \text{ N x } 10 \text{ cm} \\ &= 4545 \text{ N.cm} \end{aligned} \quad (3)$$

- **Finding gasoline motor power**

Where it is known that the torque has been determined by the calculation above, then the motor power can be found by the following calculation [1]

T_{Roll} = 4545 N.cm

$F_{kc} = \frac{2.5 \text{ x } T}{D}$

(4)

$= \frac{2.5 \text{ x } 4545}{20}$

= 568.1 N

$$\begin{aligned} F_{kn} &= \frac{T}{2D} \\ &= \frac{4545}{2 \text{ x } 20} \\ &= 113.6 \text{ N.} \end{aligned} \quad (5)$$

- **Torque on Pulley II**

In this calculation, the torque can be found, namely:

$$\begin{aligned} T_1 &= \frac{F_{kn} \text{ x } D}{2.5} \\ &= \frac{113.6 \, x \, 16}{2.5} \\ &= 727 \text{ N.cm} \end{aligned} \quad (6)$$

$$\begin{aligned} T_2 &= F_{kn} \text{ x } 2 \text{ x } D \\ &= 113.6 \text{ x } 2 \text{ x } 16 \\ &= 3635.2 \text{ N.cm} \end{aligned} \quad (7)$$

- **Pulley I = Pulley II** (8)

$\frac{N_1}{N_2} = \frac{10.4}{16}$

$\frac{120}{N_2} = 0.65$

N_2 = 250 rpm

N_3 = 250 / 0.3 = 833 rpm

- **Required power**

P = T (N.m) x π x 833 / 60 (9)

= 45.4 x 2 x π x 833 / 60

= 3966 watt

Then converted to HP = 5.3 HP Then get the required motor power of 5.3 HP because in the market there is no 5.3 HP then 5.5 HP motor power is used.

3. RESULTS AND DISCUSSION

After all the processes of determining the gasoline motor power required for this extractor, of course, we proceed to the stage of testing this tool using a banana stem layer, but we need to weigh the banana stem layer first as shown in Fgure 9.

Figure 9. Banana stem layer weighing

After weighing, the following results are obtained from each layer of banana stems as in table 10.

Table 10. Layer weight of banana stems

No	Banana stem layer	Weight (kg)
1	The first stem layer	0.27
2	The second stem layer	0.11
3	The third stem layer	0.30

After that, the process of extracting the banana stem layer is carried out as shown in figure 10. By using a time reference so that later you will see the difference between using the manual method, DC motor and gasoline motor along with the resulting fiber results

Figure 10. Extraction Process

A. TEST DATA

The following test data was obtained from manual extraction as shown in Table 11.

Table 11. **Manual Testing**

NO	Slit Distance	P (cm)	L (cm)	T (sec)
1	1-3 cm	94	12	45
	Neat fiber but still remaining frond meat (No.1 Results)			
2	1-3 cm	84	16.5	37
	Neat fiber but still remaining frond meat (No.2 Results)			
3	1-3 cm	94	12	31
	Neat fiber but still remaining frond meat (No.3 Results)			

NO	**Slit Distance**	**P (cm)**	**L (cm)**	**T (sec)**
	Average			**37.6 second**

Figure 11. Manual Extraction Results

The following test data was obtained from DC motors as shown in Table 12.

Table 12. **Testing Using DC Motors**

NO	**Slit Distance**	**P (cm)**	**L (cm)**	**T (sec)**
1	1-3 cm	94	12	39
	The fiber is slightly crumpled but the frond meat is peeled off (No.1 Results)			
2	1-3 cm	94	12	44
	The fiber is slightly crumpled but the frond meat is peeled off (No.2 Results)			
3	1-3 cm	84	16.5	44
	The fiber is slightly crumpled but the frond meat is peeled off (No.3 Results)			
	Average			**42.3 second**

Figure 12. Extraction Results Using DC Motors

Furthermore, fiber extraction is carried out using a gasoline motor, and the results are in Table 13. It can also be seen in Figure 13.

Table 13. Testing Using a Gasoline Motor

NO	**Slit Distance**	**P (cm)**	**L (cm)**	**T (sec)**
1	1-3 cm	94	12	39
	The fiber is slightly crumpled but the frond meat is peeled off (No.1 Results)			
2	1-3 cm	94	12	44
	The fiber is slightly crumpled but the frond meat is peeled off (No.2 Results)			
3	1-3 cm	84	16.5	44
	The fiber is slightly crumpled but the frond meat is peeled off (No.3 Results)			
	Average			**9.3 second**

Figure 13. Extraction Results Using a Gasoline Motor

When viewed in terms of speed, compared to extracting using manual methods and DC motors, using a gasoline motor is much faster in the production process as shown in the graph below

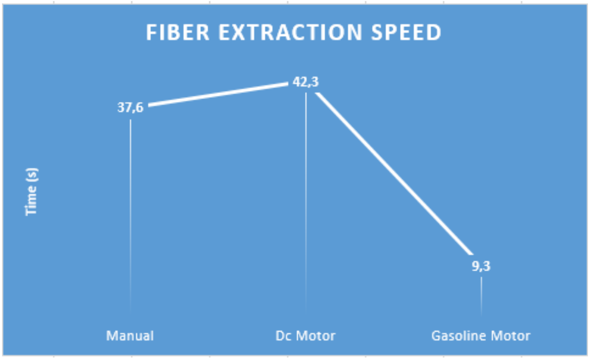

Figure 14. Production speed side comparison chart

From the test, it can be seen that the fastest fiber extraction speed is using a gasoline motor with an average speed of 9.3 seconds, while the longest fiber extraction speed is using a DC motor with an average speed of 42.3 seconds.

4. CONCLUSION

Overall, there are several problems that occur in previous extractor tools, in general, can be minimized by adding new parts that are very useful for this tool so that it has an impact on changes in the quality and quantity of the fiber produced. The development of this extractor is to fix problems with previous tools before modifications. Speed up the fiber production process by converting the driving power from DC motors to gasoline motors. The quantity of fiber produced increases after a change in the power of the drive motor. The fiber quality is relatively the same as the manual way but slightly better compared to DC motors.

From the results of this test, the following results were obtained in terms of extraction speed:

1. The average time of extraction of banana frond fiber using the manual method was 37.6 seconds.
2. The average extraction time of banana frond fiber using the DC motor method was 42.3 seconds.
3. The average time of extraction of banana frond fiber using the Gasoline motor method was 9.3 seconds.

The fastest banana fiber extraction speed based on testing is using a gasoline motor with an average speed of 9.3 seconds. This proves that the increase in motor drive power has an affects the fiber extraction time speed. When viewed from the average quality of fiber produced, the following results are obtained:

1. Manual Method, Neat fiber is obtained but still remains frond meat.
2. DC Motor Method, Obtained slightly crumpled fibers but the frond meat peeled off.
3. Gasoline Motor Method, obtained fiber tends to be neat and the frond meat remains a little.

Suggestions for further development can be redeveloped as follows:

1. This study only uses natural fibers in the form of banana fronds, it can still be tested with other fibers and observes its behavior.
2. The extractor tool is still very large, maybe in the future a more minimalist extractor can be made and the level of mobility is better.
3. Maybe you can make a tool with automation by looking at the development of future trends.

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