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Performance Test of Animal Feed Chopping Machine with Electric Motor Drive

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Shredder, Animal Feed, Grass, Banana Stems

ABSTRACT
Animal feed is a crucial factor influencing animal productivity and health. Ensuring the availability of high-quality feed, both in terms of nutritional content and physical appearance, is essential. One way to improve the physical quality of feed is through the shredding process using a shredding machine. This study aimed to test the performance of the shredding machine in processing two types of animal feed: sedge grass and banana stems. The research method used an experimental approach with three repetitions, including measuring effective capacity, cutting uniformity, and percentage of material loss. The test results showed that the machine's effective capacity was more optimal for sedge grass, at 38 kg/hour, compared to 34 kg/hour for banana stems. The cutting uniformity values were relatively similar, at 80.2% for sedge grass and 80.0% for banana stems. The percentage of material loss for sedge grass was 2.6%, significantly lower than for banana stems, which reached 9.2%. This indicates that the machine is more efficient when used on soft, fine-fibered materials. Compared to previous studies, the machine's capacity in this study was still significantly lower due to limited motor power (500 watts) and a simple blade design. However, the machine is capable of producing uniform cuts and quite good efficiency, especially on the grass material.

INTRODUCTION

Animal feed is a major factor influencing livestock productivity and health. The availability of quality feed, both in terms of nutritional content and physical form, is key to supporting livestock growth and performance (Chen, Wang, & Zhang, 2020). In many regions of Indonesia, small-scale farmers still rely on manual chopping methods using simple tools like machetes, which are time-consuming, labor-intensive, and produce inconsistent feed sizes (Balogun & Ibrahim, 2019). This often leads to high feed waste, reduced digestibility, and increased operational costs. For example, field observations in several local farms in Central Java showed that nearly 20–30% of forage is wasted due to inefficient preparation methods (Adebayo, Oladokun, & Oluwole, 2021).

Green forages such as grass, banana stems, and water hyacinth are widely used by livestock farmers because they are readily available, contain sufficient fiber, and provide a source of energy for ruminants (Das, Paul, & Rahman, 2018). However, these feed ingredients are often large in size and have long fibers, making them difficult for livestock to consume directly. This can reduce digestive efficiency and increase food waste (Muhammad, 2023).

To address this problem, animal feed shredding machine technology is an effective solution. Several studies have been conducted in this area, such as research by Sandra (2023) which designed a banana stem chopper with a capacity of 1,384 kg/hour, and Akhiruddin et al.

(2022) which developed a forage chopper with a capacity of 720 kg/hour. Other studies focused on optimizing blade design and motor power for better efficiency. However, most of these studies used motors with power above 1 HP and focused on only one type of material. There is still limited research that comprehensively tests machine performance on multiple types of forage with different physical characteristics, especially using low-power motors suitable for small-scale farmers (Fashina, Olatunji, & Ademola, 2017).

Shredding machines reduce the size of feed ingredients, making them easier for livestock to consume and digest (Hassan, Alam, & Khan, 2019). The shredding process also simplifies mixing feed with other additives such as bran, concentrates, or supplements, resulting in a more balanced feed composition (Jin, Liu, & Li, 2021). Uniform cut sizes can help improve palatability, minimize food waste, and speed up the livestock's consumption process (Guzzomi, Rondelli, & Casaroli, 2022).

The urgency of this research lies in the high rate of feed loss due to suboptimal shredding, which directly impacts feed costs and livestock productivity. Tests on the performance of animal feed shredding machines are necessary to determine their effectiveness in processing various types of feed ingredients with different characteristics. *Belulang* grass has fine but strong fibers, while banana stems have a high water content and a soft texture. These differences in physical properties and water content can affect the shredding speed, the level of uniformity of the cut size, and the percentage of material loss during the process.

The novelty of this research is the testing of a feed shredder using three types of materials with different physical characteristics (*belulang* grass, banana stems, water hyacinth), thus providing comprehensive information on the influence of material properties on capacity, uniformity of cutting, and material loss. Such studies are still limited in Indonesia.

Testing these three types of materials can provide a more comprehensive picture of the machine's capabilities and efficiency. This testing is also useful in determining the best settings and maintenance procedures when using the machine in the field. The resulting data, such as effective shredding capacity, percentage of uniformity of the cut size, and material loss, can serve as a reference for farmers and machine developers to improve the design, blade selection, and rotational speed settings. Thus, testing the performance of animal feed shredding machines not only provides information on machine performance but also contributes to increasing feed efficiency, reducing waste, and optimizing operational costs in the livestock sector. Therefore, this research aims to evaluate the performance of a low-power electric motor-driven shredder on multiple forage types, with the benefit of providing practical insights for the development of efficient, affordable, and environmentally friendly chopping machines suitable for small-scale livestock farmers.

METHOD

This research used an experimental method by testing two different types of animal feed, namely belulang grass and banana stems.

Test Method

a. Tools and Materials
   1. Grass chopper
   2. Types of grass:
      1) Belulang grass

2) Banana stems
3. Digital scale.
4. Stopwatch.
5. Ruler or caliper to measure the volume of the chopped material.
6. Container for the chopped material.

Test Procedure
1. Prepare 5 kg of material to be chopped (belulang grass and banana stems).
2. Cut the belulang grass and banana stems into 50 cm lengths.
3. Weigh the material before chopping.
4. Turn on the machine and adjust the speed according to specifications.
5. Feed the material evenly into the input funnel.
6. Record the time from start to finish.
7. Weigh the chopped material.
8. Number of pieces corresponding to (1 – 4 cm)
9. Number of pieces in the sample
10. Repeat for each type of grass three times

Parameters observed in this study
1. Effective capacity (kg/hour)
2. Percentage of size uniformity (%)
3. Percentage of material loss (%)

RESULT AND DISCUSSION

Test Results

Table 1 presents the average test results from three repetitions for each material type.

Table 1. Test Results of the Animal Feed Shredder Machine

No	Type of Material	Effective Capacity (kg/hr)	Cut Uniformity (%)	Material Loss (%)
1	Scale grass	38	80,2	2,6
2	Banana stem	34	80	9,2

Source: Data from primary research, 2024

The selection of an electric motor as the driving force for the forage shredder in this study was based on several reasons:

1. The shredder's driving force

   In this study, the shredder was designed with a 500-watt electric motor as the driving force. Choosing an electric motor as the main drive offers several advantages over gasoline- or diesel-powered machines, including lower vibration, reduced noise levels, and easier maintenance. A 500-watt power supply is considered sufficient for small- to medium-scale shredders, especially for green fodder such as grass and banana stems.

2. Performance of the 500-watt electric motor

   A 500-watt electric motor produces stable torque and rotational speed. This rotational stability directly impacts the quality of the shredded material. Consistent rotational speed allows for more uniform shredding compared to machines powered by fossil fuels, which tend to experience fluctuations in rotational speed. Test results showed that using a 500-watt electric motor resulted in an effective shredding capacity of 38 kg/hour for bamboo and 34 kg/hour for banana stems. These figures indicate that the motor's power is sufficient to support the shredding machine's performance when handling materials with varying characteristics.

For materials with coarse fibers and high water content, such as banana stems, the motor load tends to increase, resulting in a longer shredding time. This is evident in the lower effective capacity for banana stems. Using a higher-power electric motor or a transmission system capable of increasing torque can be an alternative to improve performance on hard-fiber materials, as shown in Figure 3.1.

Figure 1. Animal Feed Shredder

Source: Documentation from primary research, 2024

The innovative elements in this research, compared to previous studies that generally used motors ≥ 1 HP, demonstrate that a small motor (500 Watts) can still be used for small- to medium-scale shredding with satisfactory results. This indicates an opportunity for the development of an energy-efficient, more environmentally friendly shredder.

Shredder Blade Selection

The blade is a vital component of a shredder because it determines the quality of the cut, the level of uniformity, and the efficiency of the process. In this study, the blade used was a straight blade mounted on the main shaft with a radial orientation.

The straight blade shape was chosen because:

1. It is easy to fabricate and maintain, thus reducing the cost of the machine.
2. It is effective for soft-textured materials, such as grass, which is easy to cut and produces pieces of a more uniform size.
3. It has a low cutting angle, allowing the cutting force to be transmitted directly to the material.

The straight blade also has its drawbacks. For materials with a coarse, fibrous structure and high water content, such as banana stems, the straight blade is less capable of producing truly uniform cuts. This is due to the slippery nature of banana stems, which easily slip when they hit the blade. This results in some of the material not being chopped properly, increasing the percentage of material loss (up to 9.2% in testing), as shown in Figure 2.

Figure 2. Shredder blade
Source: Documentation from primary research, 2024

The new elements from this research provide empirical evidence that straight blades remain efficient on soft materials, but are less suitable for high-fiber materials. This opens up opportunities for design modifications, for example:

1. Serrated or curved blades to withstand the friction of slippery banana stems.
2. Combining multiple cutting angles for better distribution of cutting force.
3. Multi-blade systems to increase capacity and reduce losses.

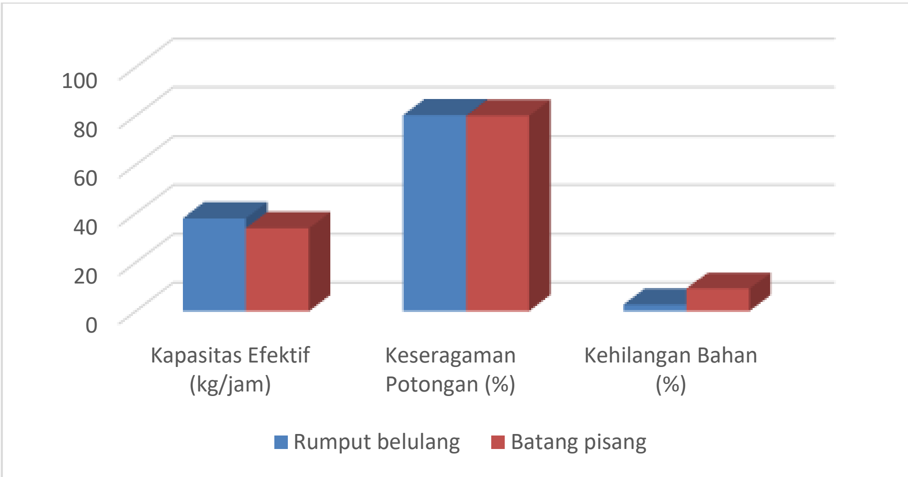

Figure 3. Graph of Test Results for Two Types of Animal Feed
Source: Processed from primary research data, 2024

From the test data presented in Figure 1, effective capacity is the machine's ability to produce pieces of material per unit time. The test results showed that the effective capacity for belulang grass was 38 kg/hour, while for banana stems it was 34 kg/hour. These values indicate that the machine is more optimal at chopping belulang grass than banana stems. This may be influenced by the characteristics of the materials, where belulang grass has a softer texture and finer fibers, making it easier to chop. Conversely, banana stems have a high water content and a coarser fiber structure, requiring more energy and a longer chopping time.

The uniformity of the cut determines the quality of the chopped material. The uniformity value for belulang grass was 80.2%, while for banana stems it was 80.0%. In general, these values are relatively similar and within the good range, approaching the uniformity standard. High uniformity indicates that the machine is capable of producing pieces of the desired size. The slight difference between the two materials is likely due to the physical properties of the materials, where banana stems tend to produce uneven pieces due to their coarse fibers and high water content.

The percentage of material loss indicates the amount of material that is not chopped or lost during processing. Test results showed that material loss for the bamboo grass was relatively low, at 2.6%, while for the banana stems it reached 9.2%. This demonstrates that the machine is more efficient at processing bamboo grass than banana stems. The high material loss in the banana stems is likely due to the high water content and the large fibrous structure of the stems, resulting in some material being wasted or incompletely chopped.

Test results indicated that the chopping machine used in this study had an effective capacity of 38 kg/hour for bamboo grass and 34 kg/hour for banana stems. Compared to previous studies, these capacities are relatively lower.

Previous research Sandra (2023) designed a banana stem chopping machine with a capacity of 1,384 kg/hour, while research Akhiruddin et al. (2022) designed a forage grass chopping machine with a capacity of up to 720 kg/hour. This difference in capacity is quite significant and can be explained by several technical factors, namely:

1. Motor Power

   This study used an electric motor with a power of 500 Watts (±0.67 HP), while the two previous studies used motors with power above 1 HP. The higher the motor power, the more energy available for the chopping process, resulting in a greater capacity. This aligns with the basic principle of mechanics that higher power will increase the machine's ability to chop materials with hard textures and coarse fibers.

2. Test Material Characteristics

   In this study, the materials tested were bamboo grass and banana stems. Bamboo grass has a soft texture and fine fibers, making it relatively easy to chop, while banana stems have a high water content and coarse fibers, requiring more energy. In previous research Sandra (2023), the primary focus was chopping banana stems using a machine design optimized for this material. Research Akhiruddin et al. (2022) used bamboo grass, which is generally easier to process, resulting in a greater capacity.

3. Blade Design and Chopping Mechanism

   Differences in blade design also have a significant impact. Previous studies generally used larger blades, a greater number of blades, and higher rotational speeds, enabling significantly higher capacity. The machine in this study employed a simpler blade design, so while it was able to produce cuts with fairly good uniformity (80.2% for sedge grass and 80.0% for banana stems), the resulting capacity was lower.

4. Machine Efficiency

The percentage of material loss in this study indicates that the machine was more efficient at processing sedge grass (2.6%) than banana stems (9.2%). This demonstrates that efficiency is also an important aspect in assessing machine performance, in addition to capacity. Previous studies, despite their high capacity, did not provide detailed information on material loss. Therefore, efficiency should be considered as a key strength of this study.

a) Effective Machine Capacity

The effective capacity of the shredder was tested on two types of materials: bamboo and banana stems. The measurement results showed a difference in machine performance on the two materials, as shown in Graph 3.2 below:

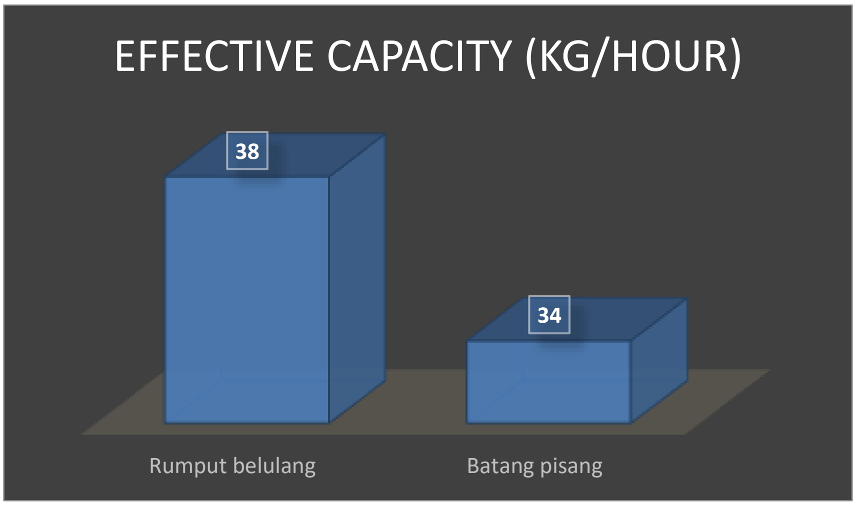

Figure 4. Effective Capacity Graph
Source: Processed from primary research data, 2024

Test results showed an effective capacity of 38 kg/hour for the sedge grass, while the effective capacity for the banana stems was 34 kg/hour.

The higher effective capacity for the sedge grass indicates that the machine is more efficient at processing materials with a soft texture and finer fibers. Sedge grass is relatively easy to cut, resulting in a faster shredding rate. Conversely, banana stems have a coarser fiber structure and a higher water content, slowing the shredding process and reducing the machine's effective capacity.

Comparatively, the effective shredding capacity for sedge grass is approximately 11.7% higher than that for banana stems. This indicates that material characteristics significantly influence machine performance. For coarse-fiber materials like banana stems, greater cutting force is required, resulting in a reduced effective capacity.

These results demonstrate that the shredder is more suitable for softer materials like sedge grass. The machine is capable of producing high capacity without significant energy loss (Ndukwu, Bennamoun, & Abada, 2021). However, for materials like banana stems, the machine can still be used, but its performance is less than optimal (Manyong, Houedjissin, & Coulibaly, 2018). To improve performance on coarse-fiber materials, modifications such as increasing blade sharpness, adjusting the cutting angle, or adjusting the engine speed are necessary. In terms of capacity, although lower than previous research (720–1384 kg/hour), this study provides insight into the relationship between material characteristics and engine performance. The sedge grass proved more suitable for small-power engines. This confirms that household-scale engines can focus on soft materials, while banana stems require additional innovations (e.g., a torque-increasing transmission).

b) Percentage of Cut Uniformity

Cut uniformity testing was conducted to determine the machine's ability to produce uniformly sized pieces. The test results for two types of materials, sedge grass and banana stems, are presented in graph 3.3 below:

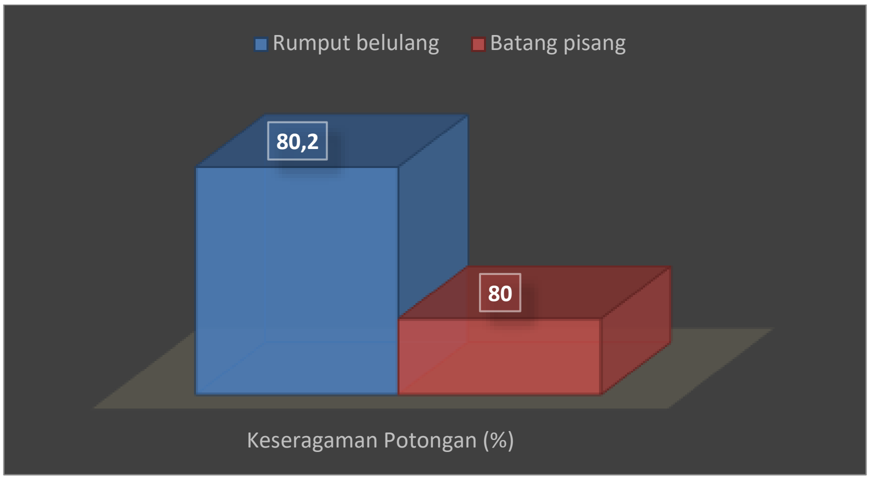

Figure 5. Percentage of Cut Uniformity

Source: Processed from primary research data, 2024

Test results show that the cut uniformity level for the sedge grass was 80.2%, while for the banana stems it was 80%. Both values are considered high and within the same range, indicating that the machine is capable of producing fairly uniformly sized pieces for both sedge grass and banana stems.

Although the difference in values between the two materials is very small (0.2%), this difference still indicates the influence of material characteristics on the cut results. Sedge grass, with its softer texture and finer fibers, tends to be easier to cut, resulting in slightly more uniform cut sizes. Meanwhile, banana stems, with their coarser fibers and higher water content, tend to produce less consistent cuts, although they are still considered uniform.

A uniformity value above 80% indicates that the cut results are good enough for animal feed. This level of uniformity is important because consistent-sized pieces facilitate further processing, speed up drying times, and increase livestock consumption efficiency.

These results demonstrate that the shredder can work effectively on both types of materials. For materials with coarse fibers like banana stems, adjustments to the blade or the machine's rotation speed may be necessary to optimize the uniformity of the cuts.

These results demonstrate that the rotational stability of the 500-watt electric motor plays a crucial role in maintaining uniform results, despite varying capacities. Therefore, this study emphasizes that uniformity is more influenced by motor stability and blade design, rather than simply motor power.

Material Loss Percentage

The material loss test aims to determine the percentage of material that is not chopped or lost during the chopping process. The test results for two types of material, namely, belulang grass and banana stems, are shown in Figure 6 below:

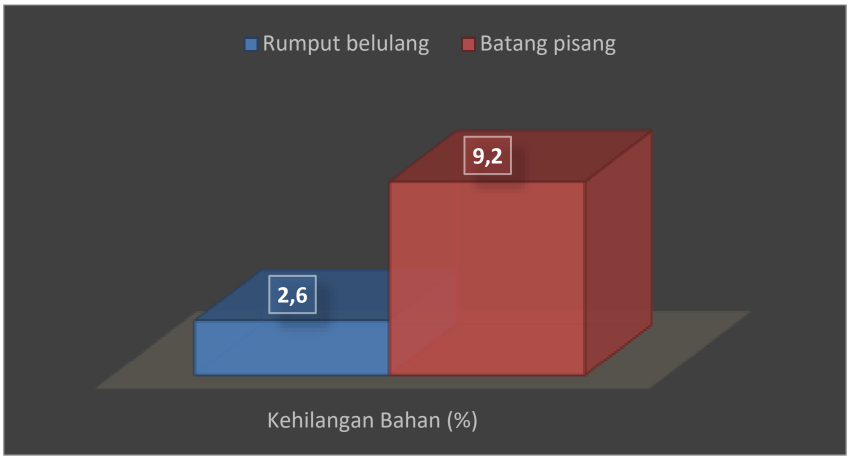

Figure 6. Material Loss Graph

Source: Processed from primary research data, 2024

Test results show that material loss for the sedge grass was relatively low, at only 2.6%. This value indicates that the machine is quite efficient at chopping sedge grass. The soft, fine-fibered characteristics of sedge grass make it easier to chop, resulting in a significant portion of the material being chopped well, with minimal waste (Rahman, Islam, & Hossain, 2022).

Material loss for banana stems was higher, at 9.2%. This figure indicates inefficiency in the banana stem chopping process (Hilal et al., 2025). This may be due to the rough, watery, and slippery nature of banana stems, which can lead to incomplete chopping or even loss of some material from the chopping chamber (Kumar, Singh, & Sharma, 2020).

Comparatively, material loss for banana stems was approximately 3.5 times higher than for sedge grass. This difference indicates that the chopping machine is more suitable for softer materials. For materials with coarse fibers and high water content, such as banana stems, chopping efficiency decreases, increasing the percentage of material loss. Low material loss is crucial in the shredding process because it directly impacts machine efficiency, productivity, and the availability of processed food. A 2.6% loss in the sedge grass is considered satisfactory, while a 9.2% loss in the banana stem indicates that the machine requires improvements in blade design, rotation speed, or material delivery mechanism to increase efficiency (Ogunlowo, Adesuyi, & Aigbodion, 2016).

Unlike previous research that rarely addresses these aspects, this study confirms that the percentage of material loss is a key indicator of machine efficiency. Low losses in the sedge grass indicate high efficiency, while high losses in the banana stem indicate the need for improvements in the input-output channel design or blade system (Li, Chen, & Wang, 2023).

CONCLUSION

The performance test of the chopping machine on two types of animal feed materials (*rumput belulang* grass and banana stems) showed that the machine was more optimal in chopping *rumput belulang*, with an effective capacity of 38 kg/hour compared to 34 kg/hour for banana stems. This difference was influenced by the material characteristics, where *rumput belulang* has a softer texture and finer fibers, while banana stems contain higher moisture and coarser fibers that are more difficult to chop. The 500-watt electric motor proved adequate for softer materials. The uniformity of chopped results was relatively similar, namely 80.2% for *rumput belulang* and 80.0% for banana stems, although banana stems were slightly less uniform due to their coarse fibers. Material loss for *rumput belulang* was only 2.6%, much lower than the 9.2% loss for banana stems, indicating higher efficiency on softer materials. Compared to previous studies that achieved capacities of 1,384 kg/hour and 720 kg/hour, the machine capacity in this study (34–38 kg/hour) was significantly lower. This difference was attributed to the motor power, material characteristics, blade design, and machine efficiency. This study employed a 500-watt (±0.67 HP) electric motor with a simple blade design that limited chopping capacity but was still able to produce fairly uniform results with good efficiency, particularly for *rumput belulang*. The findings highlight the potential for developing energy-efficient, environmentally friendly, and cost-effective chopping machines suitable for household and small-scale farming use.

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