Development and Implementation of a Chopper Machine to Improve the Quality of Chopped Grass for Sheep Feed in the Muhammadiyah Agribusiness Centre

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Abstract. The Muhammadiyah Agribusiness Centre has a target of adding 100 sheep each year. The sheep cultivated here are owned by the congregation or residents entrusted with the principle of profit sharing. This centralized land has exceptional land for providing animal feed. This land is planted with various types of grass as the primary food for sheep. And so far, workers still chop manually without the help of machines. It can be done with the help of a grass-cutting machine to increase the capacity of chopping grass for animal feed. This research method involves design, manufacturing process, functional test, capacity of chopping, percentage of grass cutting length, performance test, fuel consumption test, noise test, and profit calculation of sheep farming. The result is that the fuel consumption of the chopping machine is 1.33 hours per liter with a constant engine speed of 3000 rpm. The best grass-chopping results are at 3000 rpm engine speed, and the best grass-chopping is odot grass with the best percentage of the grass-cutting length of 46%. However, at 3000 rpm, it produces the highest noise, 102.1 dB. And the net profit of sheep fattening is 513,750 rupiahs per sheep per month.

1 Introduction

Animal feed is the most important thing in the fattening or breeding process, where grass is the main feed for sheep, which has the nutrients needed for their growth and development. Animal husbandry in the community is still a prima donna for improving the economy of communities and families. There are many programs from the government and other institutions, such as universities, that increase community empowerment in terms of livestock, especially sheep. There is a service that focuses on chopping animal feed to increase the average yield and quantity [1–6]. Some provide training in making grass chopper tools and making them together with partners [2,4,5,7–15].

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Grass is the main form of animal feed used in the fattening or breeding process for sheep. Grass is a fundamental component of livestock production since it supplies vital nutrients required for the ideal growth and development of sheep [1]. Consistently providing high-quality feed is crucial for optimizing productivity in sheep farming, especially in smallholder and rural communities where sheep husbandry is a significant economic endeavor. Cattle farming is a dependable means of sustenance in certain areas, making significant contributions to the economic stability of both communities and families [2]. Initiatives undertaken by the government, colleges, and other organizations have prioritized the improvement of community empowerment in the livestock sector, namely in sheep farming, due to its significant importance. These initiatives strive to enhance livestock productivity by implementing contemporary agricultural techniques, fostering innovation, and facilitating knowledge exchange, enabling farmers to embrace more sustainable and lucrative farming ways.

An area of particular emphasis has been enhancing the effectiveness of animal feed production. The labor-intensive manual procedure of chopping grass is frequently inefficient and leads to feeds of disparate sizes, diminishing its efficacy [3]. In response to this problem, many projects have implemented automated feed-chopping systems to enhance the quality and quantity of milled grass. The adoption of grass chopper machines has resulted in enhanced production by allowing farmers to efficiently handle more quantities of feed within a reduced timeframe while ensuring a uniform level of grass size. This technological advancement is especially beneficial in sheep agriculture, as consistent grass size enhances feed consumption, digestion, and general animal well-being [4].

Furthermore, alongside the provision of equipment, several initiatives have also prioritized the training of farmers in the use and upkeep of grass cutter tools. These training programs frequently entail a cooperative methodology in which farmers, researchers, and technical specialists design and produce grass chopper devices customized to meet the unique requirements of the local farming community [5]. Through the active involvement of local farmers in designing and manufacturing these devices, the programs guarantee that the technology is easily obtainable, easy to use, and suitable for the operational scale commonly observed in smallholder farms. Implementing such programs has played a crucial role in enhancing the effectiveness of livestock management techniques. Their contributions extend beyond enhanced feed processing to encompass community involvement and skills enhancement, both of which are crucial for the enduring viability of rural economies. Collaborative training programs and alliances among farmers, institutions, and technical specialists have effectively disseminated information on contemporary livestock management technologies. Consequently, these endeavors have an enduring influence on livestock productivity and agricultural communities' general welfare [6-11].

Animal feed grass choppers are useful for preparing feed for livestock, especially sheep, which need finely chopped grass [12]. The coarse texture and size of big, unprocessed grass might limit livestock feed intake and digestion efficiency. For fermentation, slicing grass even smaller is essential. Fermented feed, or silage, helps livestock farmers keep the nutritional value of grass for longer and improve feed digestibility. The fermentation process is faster and more efficient with smaller, more uniform chopped grass, producing higher-quality fermented feed [13, 14]. Livestock farmers need a grass-chopping machine to process feed for direct consumption and fermentation. The Muhammadiyah Agribusiness Centre, which breeds and fattens sheep, needs more reliable grass-chopping equipment. The center's profit-oriented concept maximizes productivity and returns through resource efficiency. High-quality feed is crucial to sheep's health, growth, and productivity [15].

The Muhammadiyah Agribusiness Centre currently oversees a herd of 100 sheep, which holds considerable economic promise for the center and the local community. The center functions on a profit-sharing model, where the sheep are owned by members of the congregation or residents who rely on the center to breed and fatten their animals. This community-oriented strategy for sheep farming guarantees that the center and the animal owners have a financial stake in the earnings derived from sheep sales, establishing a sustainable and mutually advantageous paradigm. To appropriately capitalize on this potential, the center needs access to technologies that can enhance the efficiency of feed preparation. Using an animal feed grass-chopping machine, the center can guarantee the provision of superior, finely diced feed to the sheep [16]. This will not only enhance feed consumption and digestion but also minimize wastage. Additionally, the capacity to produce fermented feed with greater efficiency will allow the center to store excess grass during times of high production, therefore guaranteeing that the sheep have access to nourishing feed even during times of limited availability. The reliable provision of premium feed will result in improved sheep's health, accelerated growth rates, and eventually increased profitability for both the center and the livestock owners.

The chopper machine is a crucial technology in contemporary cattle production [17]. The primary purpose of this indispensable instrument is to masticate a wide range of grass types, including tiny, delicate grass and larger, more resilient species. The adaptability of the grass chopper renders it a crucial resource for farmers, as it can manage a diverse array of grass species frequently employed in animal feed. After being cut, the grass becomes more easily controlled and appropriate for direct livestock consumption and utilization as a raw material in producing fermented animal feed. This is crucial in guaranteeing a sustainable and continuous feed supply throughout the year. Animal feed that has undergone fermentation, commonly known as silage, is essential for preserving the well-being and efficiency of cattle, particularly in times when fresh grass may not be easily accessible [18]. By fragmenting grass into smaller, consistent segments, the fermentation process is enhanced, guaranteeing the production of superior quality feed that is abundant in nutrients and readily digestible by cattle and sheep. The fermentation process also conserves the grass, so retaining its nutritional composition for a prolonged duration is especially advantageous during arid seasons or circumstances of limited grass availability.

Introducing this technology would enhance the operational efficiency of the Muhammadiyah Agribusiness Centre and serve as a model for other livestock farmers in the region. By demonstrating the benefits of mechanized feed preparation, the center can encourage other farmers to adopt similar practices, thereby improving livestock productivity and economic resilience in rural communities.

2 Methodology

2.1 Design

The design of this grass chopper machine reflects a more straightforward and efficient construction than earlier models, facilitating easier operation and maintenance, all while maintaining high-performance levels. The streamlined design enhances the machine's overall functionality, increasing user-friendliness and accessibility for a wider spectrum of farmers, particularly those engaged in small-scale operations. The following provides a comprehensive overview of the components and their distinct functions, as illustrated in Fig. 1.

At the top of the fodder grass chopper, the inlet funnel (1) receives grass. The wide, funnel-shaped form allows large and small grass to be fed efficiently into the machine. The funnel's design prevents obstructions and permits uninterrupted feeding. The top-mounted chopper housing (2) protects the interior chopping components. It protects the operator from moving parts and guarantees safety. The housing guides cut grass to the outlet after processing. Its sturdy design avoids wear and tear, increasing its longevity. Outlet (3) in chopper housing (2) is where chopped grass departs the machine after processing. The outlet's design efficiently discharges chopped grass without clogging, ensuring a smooth workflow. The outlet is designed to handle enormous amounts of chopped grass while maintaining output. The drive motor (4) powers the machine. An electric motor at the bottom of the frame (6) powers the chopper's parts. The driving shaft pulley (12) powers other essential machine parts from the motor. The motor's power can chop harder grass, making it appropriate for diverse farming settings.

Wheels at the bottom of the chassis make the lawn chopper portable. Using this mobility function, the operator can move the machine to process feed or grass. Even on uneven terrain, the wheels travel smoothly, improving the machine's flexibility and convenience. A plain roller inside the chopper housing (2) pulls grass into the machine for cutting. The roller's design evenly feeds grass into the machine, reducing jams and uneven feeding. This function is essential for efficient chopping. The static knife engages grass first as it enters the chopper housing. Before entering the machine, it chops the grass to break it down. This first cut prepares the grass for accurate rotating blade chopping.

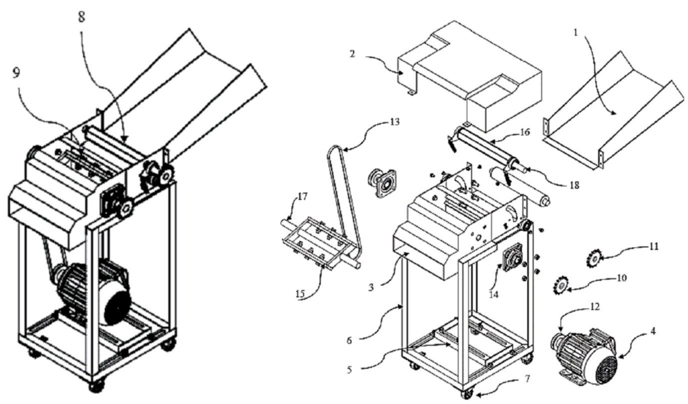


Fig. 1. The design of chopper machine

Both blades of the rotating knife mechanism rotate in opposite directions. Dual blades ensure uniform lawn cutting by cutting more precisely and efficiently. Blades rotate oppositely to uniformly distribute cutting force, eliminating obstructions and assuring smooth chopping. Straight-line driving rollers grasp grass and move it easily into the chopping mechanism. Its design optimizes grass feeding from soft to coarse, ensuring consistent machine feed. This shaft connects to Gear 1 (10) inside the chopper housing. It moves the rotating knives (15) to ensure proper speed and direction for cutting. The simple roller shaft pulls grass into the chopper from the plain roller (8). The shaft's construction keeps the roller moving smoothly and consistently, guiding grass into the chopping system without interruption.

A detailed illustration of the dimensions of this animal feed grass chopper machine is shown in Fig. 2, providing important information on its size, structure, and ergonomic design. The dimensions are precisely designed to achieve a harmonious combination of efficiency, portability, and ease of use, ensuring that the machine is compact and suitable for many agricultural settings. The design prioritizes accessibility, guaranteeing its use in many settings, including small farms, major agribusiness centers, and areas with restricted space. With dimensions of 400x350x630 mm, the machine's frame offers a robust and steady basis, guaranteeing its safe position during operation, even while handling substantial quantities of grass. The small dimensions accommodate it in confined working areas without sacrificing effectiveness or functionality. In addition, the machine's compact size facilitates convenient transportation and storage while not in use, improving its usefulness for farmers who may need to move it often.

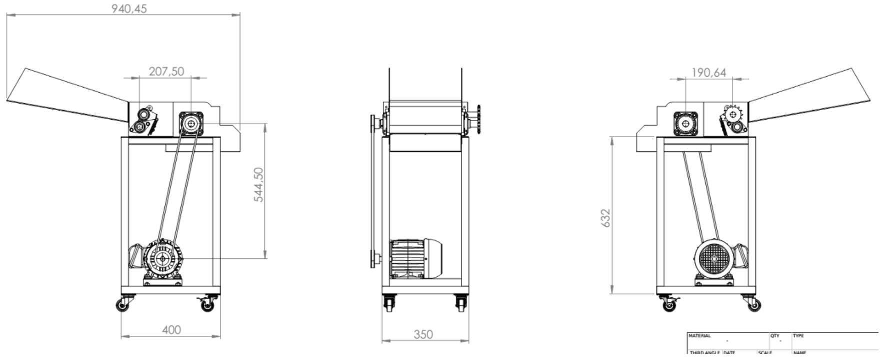


Fig. 2. The dimensions of the chopper machine

Despite its small size, the machine's general design is remarkably efficient and optimizes the available space to accommodate all essential components, such as the motor, rollers, knives, and pulleys. Every component is strategically placed to maximize the efficiency of the chopping operation, guaranteeing smooth movement of the grass from the entrance funnel to the outermost point without obstruction or delays. By incorporating wheels at the bottom of the frame, the machine has more mobility, enabling farmers to effortlessly transport it between various fields or barns as required. The dimensional data presented in Fig. 2 further emphasizes the machine's ergonomic height, specifically engineered to reduce operator fatigue. The height of the entrance funnel is conveniently adjusted to an ergonomic level, facilitating grass loading into the machine without the need for significant bending or lifting by farmers. Implementing this design factor is especially crucial for extended usage, as it effectively minimizes operator exhaustion and enhances overall productivity on the farm.

2.2 Manufacturing Process

After the design drawing was finalized, the subsequent phase in developing the animal feed grass chopper machine requires a thorough assessment of the frame's structural integrity and careful selection of suitable materials to guarantee durability, stability, and efficiency. Once these essential factors are established, the manufacturing process commences, encompassing several pivotal stages: machining, assembly, and finishing. These stages are critical in converting the design into a fully operational and dependable machine.

The machining stage represents the foundational phase in the manufacturing process, during which raw materials are precisely shaped and fabricated into the requisite components for the machine. At this stage, accuracy is crucial to guarantee that every component is manufactured according to the precise specifications detailed in the design drawing. In the machining process, various manufacturing techniques are utilized, including cutting, drilling, milling, and grinding, to produce components like frames, housings, blades, pulleys, and rollers. The use of high-quality metals and alloys is standard practice to guarantee that the machine's components possess the necessary strength to endure the stresses and wear from continuous operation. The frame, serving as the backbone of the machine, requires machining to exact dimensions to guarantee stability and adequate support for the other components (see Fig. 3). The rotating knives, essential to the chopping process, are manufactured from hardened steel to maintain their sharpness and effectiveness over extended periods of use. Every component undergoes a thorough inspection post-machining to verify compliance with design specifications and intended functionality.

Fig. 3. Machine frame assembly

Assembly follows component machining. Starting with the frame, the machine's parts are assembled in this step (see Fig. 4). According to design, the frame holds the engine, drive system, rollers, pulleys, and cutting blades. Smooth and effective functioning requires precise alignment of moving parts like the spinning knife system and roller mechanism. Assembly includes installing electrical components like the drive motor, which drives the device. The motor and drive shaft pulley must be properly installed to minimize mechanical resistance and maximize machine efficiency. The v-belt and other driving mechanisms are meticulously mounted and tensioned to ensure smooth power transmission and uninterrupted grass feeding. The assembly examines Each part for alignment, balance, and functionality. Testing and modifications are repeated to ensure all elements are aligned and working together. Before final assembly, assembly errors are fixed.

Fig. 4. Cutting plates for machine body

The finishing stage represents the concluding phase of the manufacturing process, during which the assembled machine receives final adjustments and enhancements to its appearance. At this stage, all rough edges, surface imperfections, and minor defects are systematically addressed to guarantee that the machine is both functional and visually presentable, as well as safe for operation (see Fig. 5). This process may include the meticulous sanding or polishing of surfaces, the application of protective coatings to inhibit rust or corrosion, and the verification that all joints and connections are firmly secured. The machine is generally treated with a durable finish or paint to safeguard it against environmental influences like moisture, dust, and sunlight, which can impact its longevity. Implementing a weather-resistant coating guarantees the machine's functionality across diverse agricultural settings, particularly in outdoor conditions where exposure to environmental factors is likely. At this stage, protective covers over moving parts are installed as safety features to mitigate the risk of accidents during operation.

Fig. 5. The finished chopper machine

The machine is put through its last functioning test after applying the finishing touches. This involves testing the chopping performance, ensuring all moving parts are aligned perfectly, and running the machine under load to mimic real-world conditions. This extensive testing ensures that the machine is ready for usage after it passes. After the finished product has been created, we must conduct functional testing to know the chopper machine's function.

2.3 Capacity of Chopping

To calculate the chopping capacity of the chopper machine with the following formulation:

$$C = \frac{W}{t_1} \times 3600 \qquad (1)$$

Information:

C : capacity of chopper machine (kg/hours)
W : weight of chopped material (grass) collected from the outlet hole during a certain time (kg)
t_1 : The time specified to accommodate the output of chopped materials through the outlet hole (minutes)

2.4 Percentage of Grass Cutting Length

Calculation of the percentage of grass-cutting length can be calculated using the following equation:

$$Ppk = \frac{W_1}{W_1 + W_2} \times 100\% \qquad (2)$$

Where:
Ppk : percentage of grass length output from chopped result
W_1 : output weight of chopped grass measuring less than 50 mm (g)
W_2 : output weight of chopped grass measuring more than 50 mm (g)

2.5 Performance Test

The grass chopper machine is put through its paces to find its sweet spot regarding operational efficiency. At this pivotal juncture in development, the machine is rigorously tested in real-world settings to determine its efficacy, dependability, and capacity to fulfill the design requirements. The main objective of the performance test is to find ways to improve the machine so that it runs as fast, accurate, and energy efficient as possible.

2.6 Fuel Consumption Test

Determining fuel consumption involves calculating the machine's fuel requirements per hour during its operation. This quantification is essential for comprehending the general effectiveness of the grass chopper machine, especially concerning its energy consumption and operational expenses. Through the analysis of the fuel consumption rate, operators can get significant knowledge about the machine's operating efficiency and ascertain its economic feasibility for extended usage in different agricultural settings. The fuel consumption is determined by operating the machine under standard settings for a predetermined duration, usually one hour, to analyze the fuel needed to sustain peak performance.

2.7 Noise Test

The noise test is conducted with a sound level meter, a highly accurate device specifically engineered to quantify the magnitude of noise generated by the grass chopper machine while in operation. A critical aspect of this test is ascertaining if the machine functions within permissible noise thresholds, guaranteeing a safer and more pleasant working environment for operators and individuals nearby. The assessment of the machine's noise levels is a crucial aspect of the performance testing procedure since excessive noise might result in enduring hearing impairment and heightened fatigue among operators.

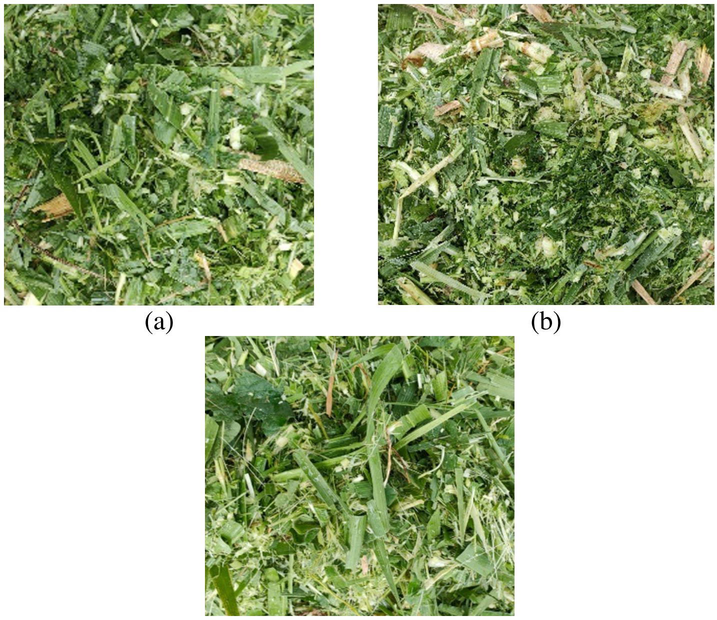
2.8 Profit Calculation

Analyzing and calculating the possible economic revenue gained from better feed quality is vital for properly understanding the impact of the chopper machine on chopped grass quality and its subsequent implications on sheep farming. Improving growth rates, feed efficiency, and overall profitability for sheep producers is closely correlated to using high-quality chopped grass, which directly impacts sheep productivity and health. We can evaluate the chopper machine's contribution to optimizing economic returns in sheep farming by thoroughly analyzing these parameters.

3 Results and Discussion

3.1 Percentage of Grass Cutting Length

An essential consideration in maximizing feed preparation for cattle is the chopping efficiency, and the experiments' results show substantial differences across grass species. Different types of grass produced different results when tested for chopping consistency and feed compatibility for sheep; these differences were measured by the percentage of grass cut to the specified length. The chopping efficiency for Gama Umami Grass was 32% (Fig. 6a), which means that around a third of the grass was cut to the desired length. While the results show modest efficacy, they also show that the chopper machine may have a harder time dealing with Gama Umami Grass because of its unique structure and texture. The lower chopping % of this grass could be due, in part, to its coarser or more fibrous structure. Still, you can use Gama Umami Grass as feed for your cattle; you might have to tweak the machine's settings a bit or process it longer to get consistent results.



(a) (b) (c)

Fig. 6. The result of chopping a) Gama Umami, b) Odot and c) Pachong Grass

The chopping tests showed that Odot Grass was the most efficient grass to process with the machine, with a chopping efficiency of 46% (Fig. 6b). Odot Grass's more uniform structure and softer texture make it easier to chop consistently; nearly half of the grass was cut to the optimal length. Because of its exceptional efficiency, Odot Grass is better suited for feed applications and uses less energy and processing time overall. Because it produces more consistently chopped feed, Odot Grass is an excellent option for sheep producers trying to maximize feed preparation. This is because greater feed intake and digestibility lead to healthier and faster-growing livestock. Figure 6c shows that just 23% of Pachong Grass reaches the target chopped length, making it the grass with the worst chopping efficiency. Because of its thicker stems or more fibrous nature, Pachong Grass appears to be the most challenging for the chopper machine, according to this finding. Because of its poor efficiency, the machine's blade setup or operating parameters could need some tweaking to produce better cutting results when used on Pachong Grass. Pachong Grass could be pre-processed or mixed with other, softer grass varieties to produce a more consistent feed quality.

3.2 Performance Test of Chopper Machine

The chopping weights of three different varieties of grass—Gama Umami Grass, Pachong Grass, and Odot Grass—at three different engine speeds (2300 rpm, 2564 rpm, and 3000 rpm) are compared in Figure 7. Higher engine speeds typically result in larger chopped output, as seen clearly in the picture, which affects the chopping efficiency for each variety of grass. Chopped Gama Umami Grass weighs about 1000 grams at 2300 rpm, which is a somewhat efficient level at the lowest tested engine speed. The efficiency with which the machine processes the grass is enhanced when the engine speed increases to 2564 rpm, resulting in a weight gain of approximately 1500 grams of chopped grass. Chopped weight is still rather low compared to other grass varieties, even at this medium pace. Chopped weight rises, reaching approximately 2000 grams when engine speed is pushed to 3000 rpm. Although the growth is slower for Gama Umami Grass than other varieties, this consistent improvement demonstrates the one-to-one correspondence between engine speed and cutting output.

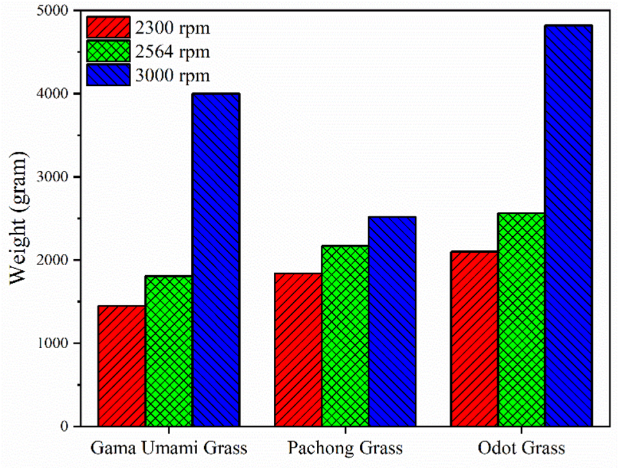


Fig. 7. Performance test of chopper machine

Increasing the engine speed has a more noticeable effect on Pachong Grass's chopping performance. Chopped Pachong Grass weighs about 1500 grams at 2300 rpm, somewhat more than Gama Umami Grass, suggesting that this grass is initially easier to handle. The weight of the chopped Pachong Grass grows significantly, reaching roughly 2500 grams, when the engine speed increases to 2564 rpm. It appears that the extra engine power is significantly impacting Pachong Grass since it can now chop more efficiently at higher speeds. The chopped weight increases significantly to about 4000 grams at the highest tested speed of 3000 rpm, showing that Pachong Grass reacts very well to the higher engine speed. The sharp increase in chopped weight indicates the machine's excellent chopping performance for Pachong Grass at the highest speed, making it perfect for processing bigger volumes of feed.

Among the three engine speeds tested, Odot Grass responded best to increased chopping power, showing a significant increase in chopped weight at each. Approximately 1000 grams of chopped Odot Grass and Gama Umami Grass are produced at 2300 rpm, indicating a baseline cutting efficiency at this lower speed. On the other hand, when the engine speed is raised to 2564 rpm, the chopped weight increases to almost 2000 grams, which is twice the output at maximum speed. Since Odot Grass is softer and more flexible than other grasses, it chops more easily when mechanically processed, which may explain why its use has increased. Optimal overall performance is shown by Odot Grass at 3000 rpm, with a chopped weight approaching 5000 grams. This makes Odot Grass the study's most effectively chopped grass variety, suggesting that processing results are ideal when engine speed and the physical qualities of the grass are combined. Optimal chopping efficiency seems to be achieved with Odot Grass due to its remarkable response to the chopper machine's enhanced mechanical power.

The results show that the chopping weight increases with increasing engine speed for all three grass varieties, with 3000 rpm consistently producing the highest output. The extent to which grass types improve, however, differs. With the maximum chopped weight at every speed, especially at 3000 rpm, Odot Grass performs the best. While Gama Umami Grass has greater starting output at slower speeds, Pachong Grass becomes much better at faster speeds. Unlike the other two kinds of grass, Gama Umami Grass doesn't get as much chopped weight as it should when the engine speed increases. This could be because its structure is more resistant to chopping.

3.3 Fuel Consumption of Chopper Machine

The fuel usage of the grass chopper machine, running at 3000 rpm for 20 minutes, is broken down in Table 1. To plan operational efficiency and calculate the expenses of operating the machine for extended periods, it is important to understand the fuel usage of the machine. The gasoline consumption rate is broken down in this table so we can observe the fuel used at different intervals and how it increases with operation time. Twenty minutes were spent running the machine at a steady 3000 rpm. Starting with 700 ml of fuel, the tank was monitored after 20 minutes of operation to find that 450 ml of fuel remained. The fuel utilized during these 20 minutes can be directly measured by subtracting the initial fuel level from the remaining. This signifies that the machine used 250 cc of gasoline in 20 minutes, which is the fuel needed to keep the machine running at 3000 rpm for that exact amount of time.

Table 1. Fuel consumption of chopper machine

Time	rpm	Fuel Before Process	Remain Fuel After the Process
20 minutes	3000	700 ml	450 ml
Fuel Consumption Use for 20 minutes			250 ml
Fuel Consumption Use for 1 hour (60 minutes)			750 ml

The machine's fuel consumption for a complete hour (60 minutes) of operation can be determined by scaling the fuel consumption data from 20 minutes. Fuel consumption for 60 minutes is calculated by multiplying the quantity consumed in 20 minutes by 3, so an hour is divided into three 20-minute intervals. Continuous operation of the machine at 3000 rpm results in a fuel consumption of 750 ml per hour. The fuel consumption rate is a crucial measure for assessing the machine's efficiency and approximating the total operational expenses over prolonged hours of use. Gaining insight into the fuel consumption rate enables operators to strategically plan fuel usage, particularly when the equipment needs to operate for extended periods, such as several hours daily. Since the machine has a fuel consumption rate of 750 ml per hour, operators can estimate the fuel needed for daily or weekly operations. This helps them to adequately provide fuel and prevent any disruptions in the grass-chopping process. Moreover, knowing the fuel consumption rate at 3000 rpm enables one to compare it with other engine speeds to evaluate whether the machine is being operated at optimal driving efficiency. An increase in engine speed, although enhancing chopping performance, can lead to higher fuel consumption. Therefore, this information is important for balancing performance and cost-effectiveness.

3.4 Noise Level

The grass cutter machine made loud noises at 2300, 2500, and 3000 rpm, as shown in Figure 7. Noise levels affect operator comfort, health, and safety; hence, they should be considered when assessing the machine's performance. Knowing and controlling noise production is important since agricultural machines make loud noises for lengthy periods. High-volume environments often require earplugs and other protection. The grass cutter's noise was lowest at 2300 rpm, around 95 dB, of all three settings. Yes, it's the quietest, but 95 dB is still loud by most OSHA standards. The operator should wear earplugs or earmuffs even at this slow rate to protect their hearing from regular exposure to noise levels above 85 dB. Managing noise is crucial even at lower machine speeds since 95 dB of noise can weary operators in high-uptime operations.

When the engine is revved up to 2500 rpm, the noise level increases somewhat, reaching approximately 98 dB. Since increased vibrations, friction, and noise are common results of mechanical activities, it stands to reason that noise levels will climb in tandem with machine rotation speed. Even though there's barely a noticeable change in noise level from 2300 rpm to 2500 rpm, it's worth mentioning that the decibel system is logarithmic, so even little increases in decibels indicate a considerable increase in noise intensity. Therefore, operators should wear hearing protection when operating at 2500 rpm, which is still above the acceptable exposure limit for continuous operation and could cause long-term hearing loss.

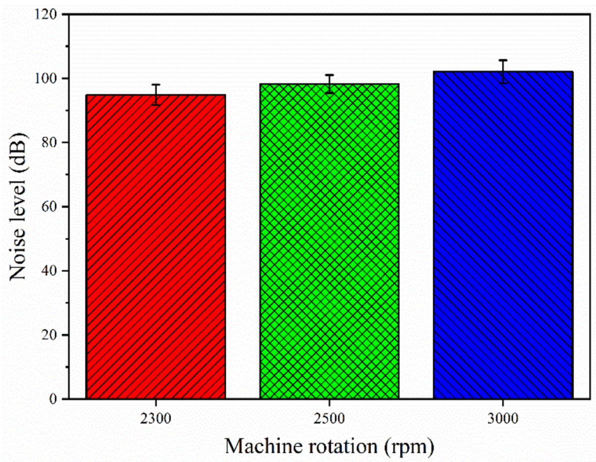


Fig. 7. The noise levels produced by the grass chopper machine

The greatest noticeable noise production, reaching nearly 102 dB, is produced at the maximum engine speed of 3000 rpm. A clear trade-off exists between greater machine power and noise creation, as this noise level is significantly higher than lesser speeds. Here, the machine makes a lot more noise, which could harm your hearing immediately if you don't wear earplugs. Operators are strongly encouraged to wear high-quality noise-canceling earmuffs or other appropriate protective gear while using the machine at maximum speed to avoid permanent hearing loss caused by prolonged exposure to noise levels above 100 dB. On top of that, if the equipment is utilized often or for extended periods, the noise it produces could potentially bother others in the surrounding neighborhood.

The grass chopper machine's noise level peaks at 3000 rpm, while it rises gradually along with engine speed. While increasing the machine's speed improves its performance and chopping efficiency, it also increases its noise. It is imperative that operators wear earplugs or earmuffs to protect their hearing, as the noise levels, especially at 3000 rpm, are higher than the levels that are considered acceptable for extended exposure.

3.5 Profit Income of Sheep Fattening

Sheep fattening is a widely used method intentionally implemented to enhance livestock's weight and market worth within a defined timeframe. Usually, the fattening protocol is conducted for five months, during which sheep are provided with a uniform, nutrient-dense diet to facilitate the fast increase in weight. This situation involves the farm overseeing a group of 100 sheep in a regulated setting, enabling meticulous observation of their feed consumption, weight development, and general well-being.

The operation's profitability is further enhanced by the average weight gain of 7 kg per month experienced by each sheep. Profit per sheep per month is 525,000 rupiahs (7 kg x 75,000 rupiahs), based on the market profit of 75,000 rupiahs per kilogram of weight gained. A monthly profit of 52,500,000 rupiahs would be generated from the weight rise of all 100 sheep in the cage, assuming 525,000 rupiahs per sheep.

The fuel cost of the feed chopper machine is 7,500 rupiahs per hour, or 750 ml of fuel, for 10,000 rupiahs per liter of fuel. To ensure the sheep have enough chopped grass for their diet, the machine runs for five hours every day. That brings us to the daily gasoline cost: To calculate the daily fuel cost, multiply 7,500 rupiahs per hour by 5 hours, which is 37,500 rupiahs. The cumulative cost of gasoline use for a month (based on 30 days of operation) is as follows: The monthly fuel cost is 1,125,000 rupiahs, calculated as 37,500 rupiahs every day multiplied by 30 days.

After deducting the cost of gasoline for operating the chopper machine, we may determine the net profit per sheep every month. The gross profit from each sheep's weight growth is calculated by subtracting the fuel expenditures. The following is the formula for the net monthly profit per sheep, given that the gross profit per month is 525,000 rupiahs and the fuel expense is distributed among all 100 sheep: The monthly fuel cost per sheep is 11,250 rupiahs, calculated by dividing 1,125,000 rupiahs by 100 sheep. After deducting 11,250 rupiahs from 525,000 rupiahs, the net monthly profit per sheep is 513,750 rupiahs.

During the five months it takes to fatten a sheep, the animal keeps gaining weight and making money for the farm. By multiplying the net monthly profit by the number of months in the fattening cycle, we can determine the total net profit for each sheep: For five months, the net profit per sheep was 2,568,750 rupiahs, calculated as 513,750 rupiahs each month multiplied by five months. Total Net Profit for 100 Sheep = 2,568,750 rupiahs per sheep x 100 sheep = 256,875,000 rupiahs for 5 months of fattening that complete flock of sheep.

4 Conclusions

The study provides numerous critical findings demonstrating the performance and economic benefits of grass chopper equipment in sheep rearing. The chopper's fuel economy is the first conclusion. The machine uses 1 liter of fuel every 1.33 hours, which is efficient given livestock farming's constant feed processing need. Maintaining a constant engine speed of 3000 rpm ensures fuel efficiency and consistent chopping performance. Running the machine for long periods with low fuel usage reduces operational expenses, allowing farmers to maximize profits while keeping a consistent supply of high-quality chopped grass for their sheep. The second conclusion concerns grass-chopping quality. Its 3000 rpm engine speed is perfect for grass-chopping. The machine chops grass reliably at this pace, especially odot grass, a popular sheep feed. Odot grass, with a cutting length consistency of 46%, was optimal for feeding livestock due to its uniform size and digestibility. 3000 rpm is best for fuel efficiency for grass-chopping, but it makes the most noise at 102.1 dB. This noise level is well beyond the acceptable threshold for continuous exposure, which may affect operator comfort and safety. Continuous exposure to such high noise levels without protection might damage hearing. Thus, personnel should wear earplugs or earmuffs when operating the machine at full speed. The machine's architecture could also be improved to reduce noise and preserve performance. The third conclusion emphasizes the economic benefits of sheep fattening with the chopper machine. The machine enhances feed preparation efficiency, resulting in a 513,750-rupiah monthly fattening profit per sheep. The sheep develop faster due to constant, high-quality feed, and the chopper machine reduces operational costs. Farmers maximize revenues with fuel efficiency, grass-chopping performance, and sheep productivity. The net profit per sheep throughout a five-month fattening cycle is 2,568,750 rupiahs, proving that grass cutter machines are profitable. Larger farms that fatten hundreds of sheep at once make much more money, helping them survive and succeed.

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