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Design and modification of a combined grass cutting and grinding machine

Abstract. Efficient preparation of livestock feed remains a major challenge for small and medium farmers in Bangladesh, where manual fodder cutting, and separate grinding processes require considerable time, labour, and cost. Rising feed prices and limited access to affordable mechanised equipment make the development of locally manufacturable multipurpose machinery highly relevant for the agricultural sector. This article aimed to design, fabricate, and evaluate a combined grass-cutting and grinding machine suitable for practical use in Bangladesh. The study used field visits, focus group discussions, Computer-aided design-based modelling, prototype fabrication, and performance testing to assess the machine's design, operation, and user suitability. The developed machine integrated grass cutting and grain grinding in a single compact system powered by a 3 HP electric motor. Unlike many conventional machines that depend on belt-pulley arrangements, the proposed design uses a spur gear transmission system to improve durability, stability, and power transfer. The gear arrangement provided a final reduction ratio of 0.846, producing a driven shaft speed of approximately 1,015-1,523 rpm and a blade tip speed of about 15.9-23.9 m/s. Trials with fresh grass, straw, and lentils showed that the machine could process 180-200 kg/hr of grass, 150-170 kg/hr of straw, and 50-60 kg/hr of lentils into fine powder. The chopped output was uniform, feeding was smooth, and the protective casing helped improve operational safety. The design also supported blade sharpening, local fabrication, and lower maintenance requirements. The results can be applied in small-scale livestock farming, feed preparation centres, and rural machinery workshops to reduce labour, improve feed processing efficiency, and support agricultural mechanisation

Keywords: grass cutter; grinder; agriculture; agricultural machinery; feed preparation

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INTRODUCTION

Agriculture remains one of the most important sectors of Bangladesh's economy because it supports food security, rural employment, poverty reduction, agro-based industry, and livestock production. Although the relative share of agriculture in national gross domestic product has gradually declined with industrialisation, the sector still contributes substantially to the economy; existing studies report agriculture's contribution at about 13.61% of national gross domestic product (GDP) while earlier sectoral estimates reported nearly 20% of GDP and around 50% of national employment, according to A. Ghimire *et al*. (2021). The rice subsector is particularly important, contributing more than 70% of agricultural GDP, while Bangladesh produces about 37 million tons of rice annually, representing approximately 6.3% of global rice production (Rayhan *et al*., 2023).

Beyond crops, fisheries and livestock also play major roles in rural livelihoods and nutrition; fish production, as noted by M.M. Shamsuzzaman *et al*. (2020), increased from 17.81 lakh metric tons in 2000-2001 to 41.34 lakh metric tons in 2016-2017, showing the growing economic relevance of fisheries in Bangladesh. Similarly, K. Moller *et al*. (2023) pointed out that livestock and aquaculture are closely linked with farm household income, protein supply, and integrated rural production systems, but they face challenges related to climate change, feed availability, disease management, and market access. At the same time, Bangladesh's agricultural production system is highly vulnerable to climate variability, land pressure, labour shortages, and environmental degradation, making improved farm mechanisation and efficient feed-preparation technologies increasingly important (Rahman *et al*., 2021; Chowdhury *et al*., 2022; Jamal *et al*., 2023). Therefore, the development of locally manufacturable, low-cost, and multipurpose agricultural machines, such as combined grass-cutting and grinding equipment, is highly relevant for improving livestock feed preparation, reducing manual labour, and supporting sustainable agricultural mechanisation in Bangladesh.

Several researchers have worked to enhance the design, implement improvements, and increase the efficiency of grass-cutting machines. J. Sinha & A. Kumar (2021) studied the ergonomic and mechanical efficacy of manual chaff cutters used in animal farming, emphasising reduced power consumption during fodder cutting. The study indicated that a three-blade cutter with a smaller feeding area used less energy and was more comfortable to use. This research enhances the design of fodder cutters, increasing their energy efficiency and user comfort. Nevertheless, greater research is required to investigate alternative materials and evaluate the long-term health effects of these alterations. D. Yallappa *et al*. (2024) introduced the design and development of a versatile chaff-cutting machine intended to address the challenges of cutting both dry and wet chaff for animal feeding. The machine was designed to process various types of fodder, including sugarcane waste and other green resources. This concept simplified traditional machinery and gave farmers a simple, portable option. More enhancements could be made to make the machine more useful for different types of fodder and to look into more environmentally friendly energy sources.

N.S. Navgale *et al*. (2023) showed the design and adaptation of a chaff cutter and coconut dehusking machine that operates with a single engine for both tasks. The proposed method was cheaper and required less space because it combined the two units into a single unit. The machine had a 1 HP electric motor, making these jobs much easier for anyone to do. The study laid out a precise plan for building a multitasking machine from mild steel and shows how useful it is for small-scale farmers in rural areas, especially those who have both cattle and coconut trees. P. Jayendra & G.Y. Suresh (2020) examined the design and development of a chaff-cutter machine intended to enhance efficiency and reduce manual labour for farmers. The machine was made to cut several kinds of fodder, such as dry grass, wheat stalks, and maize straw, into smaller pieces so that animals could consume them more easily. The new design was smaller, cheaper, and used less energy than standard chaff cutters. E. Rajkumar *et al*. (2020) investigated chaff-cutter-related injuries in rural India and proposed safety measures to mitigate them. The investigation led to the creation of three interventions: a serrated roller to serve as a warning sign, a blade guard to keep hands away from cutting blades, and a flywheel lock to stop the machine from being used while it isn't working. It was observed that these measures helped prevent people from getting hurt without affecting the machine's performance. Farmers liked that these safety features were added to old chaff cutters.

Although several researchers have worked on the development of grass-cutting machines, there are still gaps in the literature regarding a multipurpose machine. The current study proposed a gear-based modification of a multipurpose grass cutting cum grinding machine suitable for rural, semi-urban, and urban farmers of Bangladesh. This study aimed to develop a machine that will be cost-effective, easy to use, locally manufacturable, more durable, easy to maintain, low-cost, and readily available for the farmers of Bangladesh.

MATERIALS AND METHODS

Research design and overall methodological approach. This study followed a design-fabrication-testing methodology to develop and evaluate a combined grass-cutting and grinding machine suitable for small- and medium-scale livestock farmers in Bangladesh. The methodology consisted of five sequential stages: field investigation, user requirement identification, engineering design and calculation, prototype fabrication, and performance testing. The machine was designed to integrate three major functional units: a feeding unit, a cutting and grinding unit, and a power transmission unit. A 3-horsepower electric motor was used as the prime mover, and power was transmitted

to the cutting and grinding shaft through a spur gear train. Computer-aided design modelling was performed using AutoCAD and SOLIDWORKS before fabrication to ensure proper dimensional arrangement, component fitting, and safe enclosure of rotating parts. Figure 1 shows the methodology used in the current research.

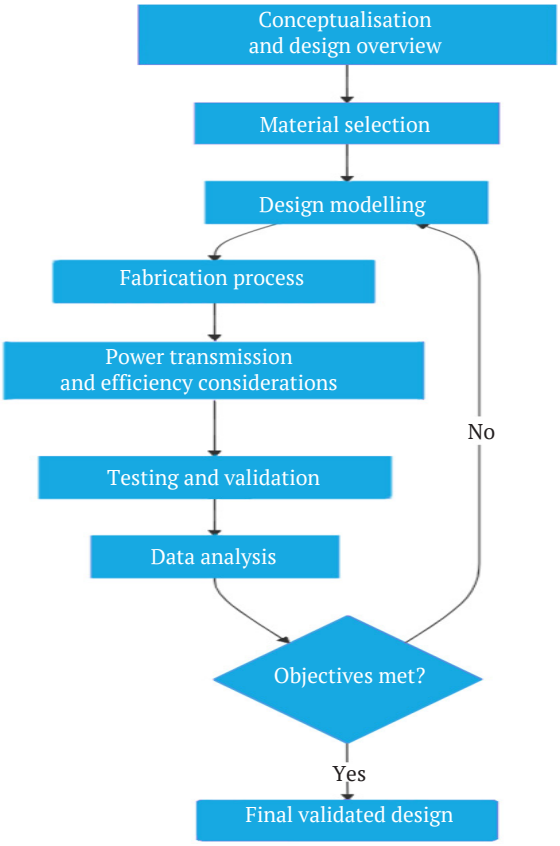

Figure 1. Methodology of research

Source: compiled by authors

Field visit. Field visits were made to Nawabpur and Dholaikhal, Dhaka, Bangladesh's largest engineering marketplaces and fabrication areas, to gather real-world information on current grass-cutting machines, available mechanical parts, fabrication techniques, and maintenance practices. Using a structured observation checklist, the observations were written down in a systematic way. The checklist had information about the type of machine, the size of the motor, the arrangement of the blades, the feeding system, the way power is transmitted, the arrangement of the shaft and bearing, the design of the casing, the safety features, the availability of parts, the ease of repair, and the most typical difficulties that mechanics and users have with the machine. The study team also talked to people at local machine shops and fabrication workshops to find out what kinds of motors, gears, shafts, bearings, blades, sheet metal, and structural elements were available. Measurements of relevant machine parts were taken where possible, and component specifications were compared with locally available alternatives. The collected information was organised into a design requirement sheet and used to determine the major mechanical features of the proposed machine, including motor power, transmission system, blade material, casing arrangement, and fabrication feasibility. This process helped ensure that the proposed design could be manufactured using locally available materials and workshop facilities.

Focus group discussion (FGD). FGDs were conducted in Savar, Sadarpur in Faridpur, and Mithapukur in Rangpur, Bangladesh, with 120 purposively selected participants. The study involving human participants was carried out in accordance with the ethical standards outlined in the Declaration of Helsinki (1964), ensuring voluntary participation, informed consent, and the protection of participants' confidentiality and well-being. The participants included small and medium farmers, livestock feed users, machine operators, and local mechanics. The discussions focused on current fodder preparation practices, labour demand, manual cutting problems, grinding needs, safety, maintenance, repairability, and expected machine performance. The responses were coded into major user requirement categories. Since participants could mention more than one issue, the percentages represent multiple-response frequencies. The frequencies were obtained through manual coding of repeated responses across the three FGD locations. The most frequently reported requirement was

reducing manual labour and processing time, mentioned by 98 participants or 81.7%. This was followed by the need for a combined grass-cutting and grinding machine, reported by 91 participants or 75.8%. Safety during operation was mentioned by 84 participants or 70.0%, while durability and low maintenance were mentioned by 78 participants or 65.0%. Local repairability was reported by 72 participants or 60.0%, easy operation by 69 participants or 57.5%, preferred fodder size by 62 participants or 51.7%, and adequate processing capacity by 56 participants or 46.7% (Table 1).

Table 1. Translation of FGD findings into engineering design decisions

User requirement	Frequency, n = 120	Percentage, %	Design decision
Reduce labour and time	98	81.7	Motor-driven cutting and grinding system
Combine cutting and grinding	91	75.8	Integrated grass-cutting and grain-grinding unit
Improve operator safety	84	70.0	Protective casing and enclosed rotating parts
Ensure durability and low maintenance	78	65.0	Spur gear transmission instead of belt-pulley system
Allow local repair	72	60.0	Use of standard gears, shafts, bearings, and sheet metal
Make operation simple	69	57.5	Separate feed inlets and clear discharge outlets
Produce suitable chopped fodder size	62	51.7	Blade arrangement targeting 2-5 cm chopped output
Ensure practical capacity	56	46.7	Selection of 3 HP motor and gear-driven shaft

Source: compiled by authors

These findings were directly translated into the engineering design of the machine. The strong demand for reduced labour and time led to the selection of a motor-driven system. The need for both fodder cutting and feed grinding resulted in an integrated cutting-grinding chamber. Safety concerns were addressed through a protective casing, enclosed rotating parts, and separate feeding and discharge paths. Similarly, the demand for durability and easier maintenance led to the use of spur gear transmission instead of a belt-pulley system. Local repairability was considered by using standard components that can be sourced and serviced in local workshops. Thus, the FGD findings provided a clear user-centred basis for the final machine design.

Engineering calculation methodology. Engineering calculations were performed to determine gear geometry, gear ratio, driven shaft speed, blade tip speed, angular velocity, torque transmission, and theoretical power transmission. These calculations were used to verify whether the selected motor, gear train, shaft arrangement, and blade system were suitable for the required cutting and grinding operations. The major input parameters used in the calculation were motor power, motor speed, gear teeth number, gear module, blade diameter, driven shaft speed, and processing time. All calculations were performed using standard mechanical design equations. The following assumptions were considered during the calculation: all spur gears had the same module; gear slip was neglected; the intermediate gear acted as an idler gear; the intermediate gear changed the direction of rotation but did not affect the final speed ratio; the motor operated under steady-state conditions; the cutting blade was considered as a rigid rotating circular body; and theoretical power loss due to friction, bearing resistance, and gear tooth wear was neglected.

Gear ratio and shaft speed calculation. For a pair of external spur gears, the speed ratio was calculated using:

$$\frac{N_a}{N_b} = \frac{Z_b}{Z_a}, \quad (1)$$

or,

$$N_b = N_a \times \frac{Z_a}{Z_b}, \quad (2)$$

where N_a is the speed of the driving gear, N_b is the speed of the driven gear, Z_a is the number of teeth on the driving gear, and Z_b is the number of teeth on the driven gear. For the first gear stage, the intermediate gear speed was calculated as:

$$N_2 = N_1 \times \frac{Z_1}{Z_2}, \quad (3)$$

where N_1 is the motor shaft speed, N_2 is the intermediate gear speed, Z_1 is the number of teeth on the drive gear, and Z_2 is the number of teeth on the intermediate gear. For the second gear stage, the driven shaft speed was calculated as:

$$N_3 = N_2 \times \frac{Z_2}{Z_3}, \quad (4)$$

where N_2 is the intermediate gear speed, N_3 is the driven shaft speed, Z_2 is the number of teeth on the intermediate gear, and Z_3 is the number of teeth on the driven gear. Since the intermediate gear acts as an idler gear, the final drive shaft speed can be expressed as:

$$N_3 = N_1 \times \frac{Z_1}{Z_3}, \quad (5)$$

where N_1 is the motor shaft speed, N_3 is the driven shaft speed, Z_3 is the number of teeth on the drive gear, and is the number of teeth on the driven gear. The final transmission ratio was calculated using:

$$i = \frac{Z_1}{Z_3}, \quad (6)$$

where i is the final transmission ratio, Z_1 is the number of teeth on the drive gear, and Z_3 is the number of teeth on

the driven gear. Therefore, the driven shaft speed can also be written as:

$$N_3 = iN_1, \tag{7}$$

where N_3 is the driven shaft speed, i is the final transmission ratio, and N_1 is the motor shaft speed.

The angular velocity of the driven shaft was calculated using:

$$\omega = \frac{2\pi N}{60}, \tag{8}$$

where ω is the angular velocity, N is the rotational speed in revolutions per minute, and π is the mathematical constant pi.

The blade tip speed was calculated using:

$$V = \frac{\pi DN}{60}, \tag{9}$$

where V is the blade tip speed, D is the blade diameter, N is the driven shaft speed, and π is the mathematical constant pi. The motor torque was calculated from motor power and rotational speed using:

$$T = \frac{P \times 60}{2\pi N}, \tag{10}$$

where T is the torque, P is the power in watts, N is the rotational speed in revolutions per minute, and π is the mathematical constant pi. When power is expressed in kilowatts, torque can also be calculated using:

$$T = \frac{9{,}550P}{N}, \tag{11}$$

where T is the torque in $N \cdot m$, P is the power in kW, and N is the rotational speed in rpm. For a gear pair, torque changes in proportion to the gear teeth ratio:

$$T_b = T_a \times \frac{Z_b}{Z_a}, \tag{12}$$

where T_a is the torque on the driving gear, T_b is the torque on the driven gear, Z_a is the number of teeth on the driving gear, and Z_b is the number of teeth on the driven gear. For the first gear stage, torque on the intermediate gear was calculated as:

$$T_2 = T_1 \times \frac{Z_2}{Z_1}, \tag{13}$$

where T_1 is the torque on the drive gear, T_2 is the torque on the intermediate gear, Z_1 is the number of teeth on the drive gear, and Z_2 is the number of teeth on the intermediate gear. For the second gear stage, torque on the driven gear was calculated as:

$$T_3 = T_2 \times \frac{Z_3}{Z_2}, \tag{14}$$

where T_2 is the torque on the intermediate gear, T_3 is the torque on the driven gear, is the number of teeth on the intermediate gear, and is the number of teeth on the driven gear. Considering transmission efficiency, the driven shaft torque may be expressed as:

$$T_3 = T_1 \times \frac{Z_3}{Z_1} \times \eta, \tag{15}$$

where T_3 is the driven shaft torque, T_1 is the motor shaft torque, Z_3 is the number of teeth on the driven gear, Z_1 is the number of teeth on the drive gear, and η is the transmission efficiency.

RESULTS AND DISCUSSION

Modelling of the grass cutting machine. The 3D model is developed in SOLIDWORKS. Different parts of the machine are numbered as shown in Figure 2, and their names are listed in Table 2. Figure 2. (a, b) schematic diagram, (c) right side view, and (d) front side view of the model

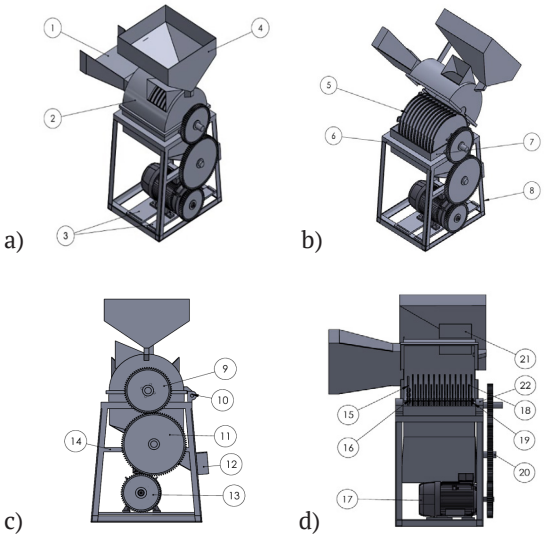

Figure 2. (a, b) schematic diagram, (c) right side view, and (d) front side view of the model
Source: compiled by authors

Table 2. Chaff cutter components

1. Grass feed inlet	12. Outlet 1 (grain powder)
2. Upper casing	13. Drive gear
3. Electric motor base	14. Intermediate gear shaft base
4. Grain inlet hopper	15. Grass cutter blade
5. Circular Blade	16. Cutter blade nut and bolt
6. Base	17. Electric motor
7. Lower casing	18. Grinder hammer
8. Frame	19. Grinder hammer holder
9. Cutter Roller Gear (Driven Gear)	20. Intermediate gear shaft
10. Casing Hinge	21. Outlet 2 (dry fodder)
11. Intermediate gear	22. Bearing house and bearing

Source: compiled by authors

Each component was modelled in 2D using AutoCAD for better understanding (Fig. 3). Details of each part are described as follows. *Grass cutter blade and grinder hammer holder*. This part is a combination of a grass cutting blade, a grass cutting blade holder, nuts and bolts, and a grinder hammer holder shaft. First, on top of the blade holder, grass-cutting blades are placed with nuts and bolts. In the centre, the main shaft is located, and the grinder hammer shaft is arrayed around the main shaft at an equal distance. At the end of the hammer shaft, bolts are used to secure the whole set.

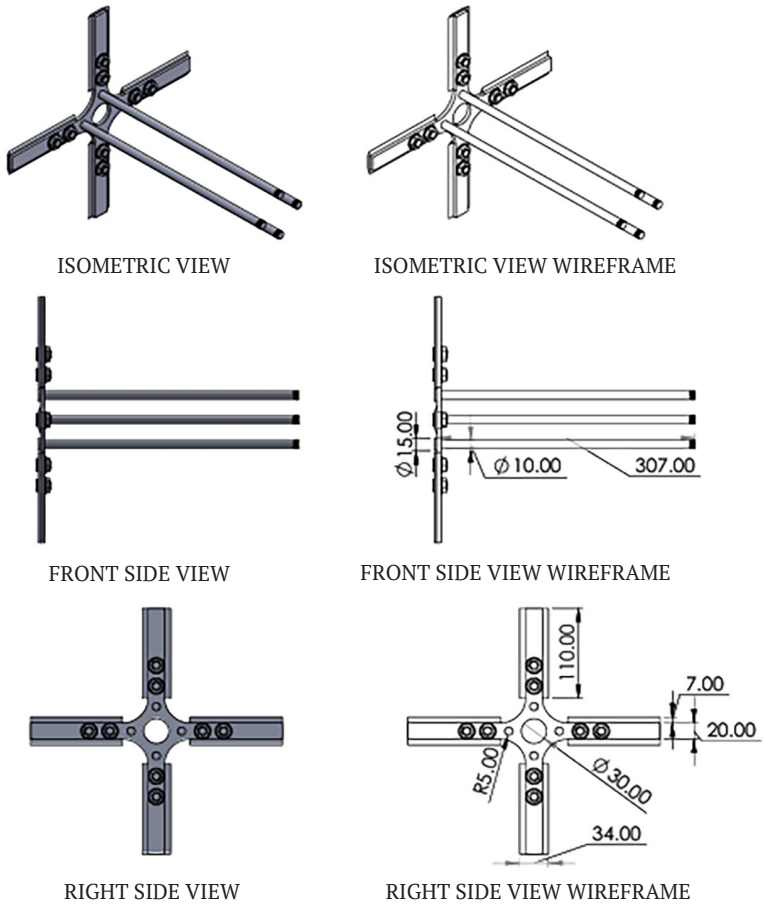

Figure 3. Grass cutting blades and grinder hammer set

Source: compiled by authors

Grass cutting blade holder. To secure cutting blades, this part is used, along with nuts and bolts to hold the blades in place (Fig. 4). These blades can be removed from the holder for sharpening using the nuts and bolts. Including that the main shaft and grinder hammer shaft are attached to this part.

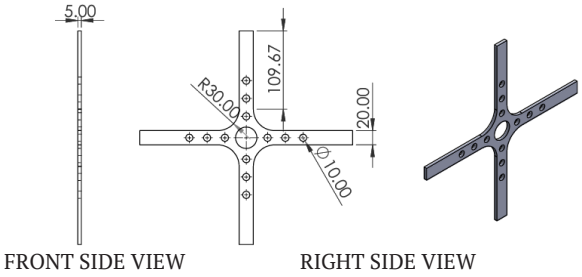

Figure 4. Grass cutting blade holder

Source: compiled by authors

Grass cutting blade. The grass-cutting blade (Fig. 5) performs the primary chopping of fresh grass and straw. Its functional role is to convert long fodder into smaller pieces suitable for livestock feeding and mixing. The blade also affects feeding resistance, cut length, power requirement, and output uniformity. The blade diameter used in the machine is 300 mm. The driven shaft speed is approximately 1015-1523 rpm, producing a blade tip speed of about 15.9-23.9 m/s. The blade material is high-carbon steel.

High-carbon steel was selected because the blade is exposed to repeated impact, abrasive contact with grass/straw, and edge wear. This material provides better hardness and edge retention than ordinary mild steel. The removable bolted arrangement was selected so that the blades can be sharpened or replaced without replacing the complete blade holder. The blade interacts with the grass feed inlet, blade holder, main shaft, bearing housing, and outlet for chopped grass. Its alignment and balance are critical because imbalance can increase vibration and bearing load.

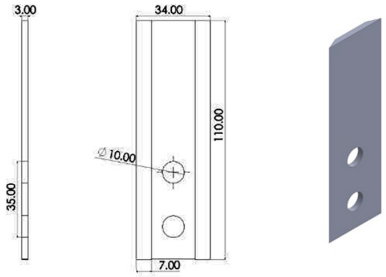

Figure 5. Grass cutting blades

Source: compiled by authors

Blades holding nuts & bolts. These nuts & bolts (Fig. 6) are used to hold the cutting blade with the holder in place.

Circular blade. The circular blade (Fig. 7) assists in cutting and grinding, especially for grain or harder feed materials. Its role is to create additional shearing and size-reduction action inside the processing chamber. It improves the machine's multifunctionality by allowing the same shaft assembly to support both fodder cutting and grain grinding. Key design parameters include diameter, thickness, tooth or edge geometry, material, mounting diameter, and clearance from the casing. High-carbon steel is justified because grinding and cutting create abrasive wear. A circular blade is preferred because it provides continuous rotational cutting action and distributes cutting load around the blade circumference. It interacts with the main shaft, grinder hammer, grain hopper, casing, and powder outlet.

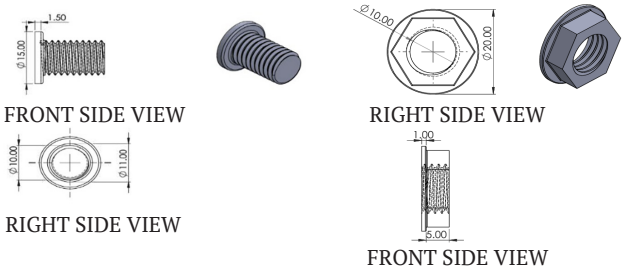

Figure 6. Nuts and bolts of the machine

Source: compiled by authors

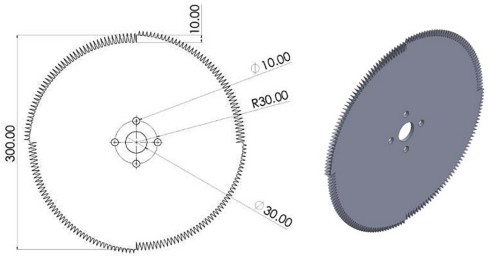

Figure 7. Circular blades used in the machine

Source: compiled by authors

Bearing house and bearing. This part (Fig. 8) holds the main shaft, grass-cutting blades, circular blades, and grinder hammers. It also helps to rotate all the cutting parts together with the driven gear. It is the most important component that transfers the power from the gear to the cutting parts and holds all the parts in place.

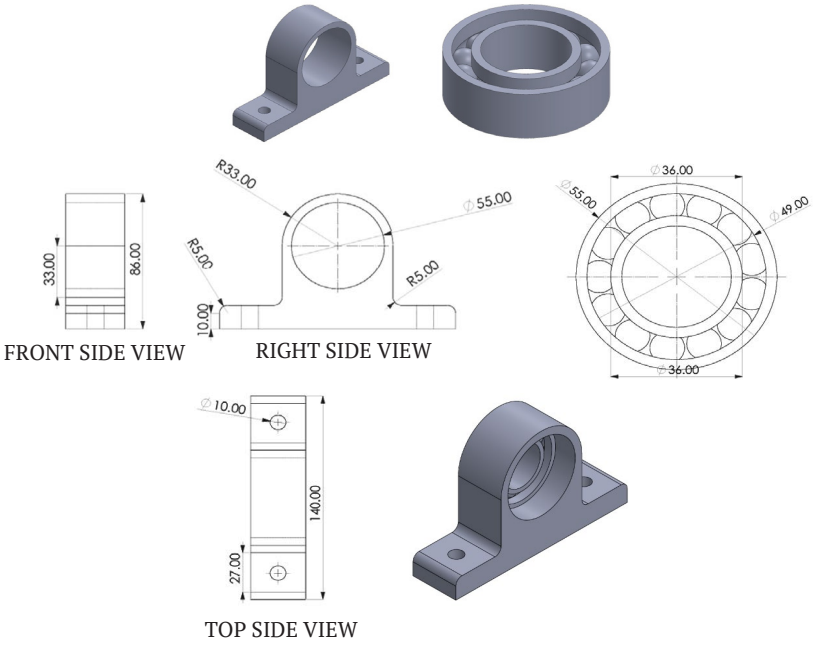

Figure 8. Bearing housing and bearing

Source: compiled by authors

Grain inlet hopper. This part (Fig. 9) is made of a thin metal sheet that holds and circulates grain at a specific speed into the grinding or cutting chamber. Generally, gravity is used to send the grain into the grinding chamber.

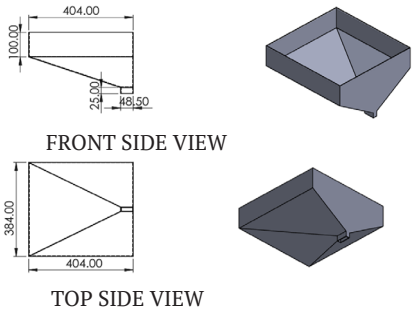

Figure 9. Grain inlet hopper

Source: compiled by authors

The top casing and the feed inlet. It prevents the spread of feeding materials outside and protects people from injury from the rotating parts. The feed inlet, as well as the grain inlet hopper, is attached to it (Fig. 10).

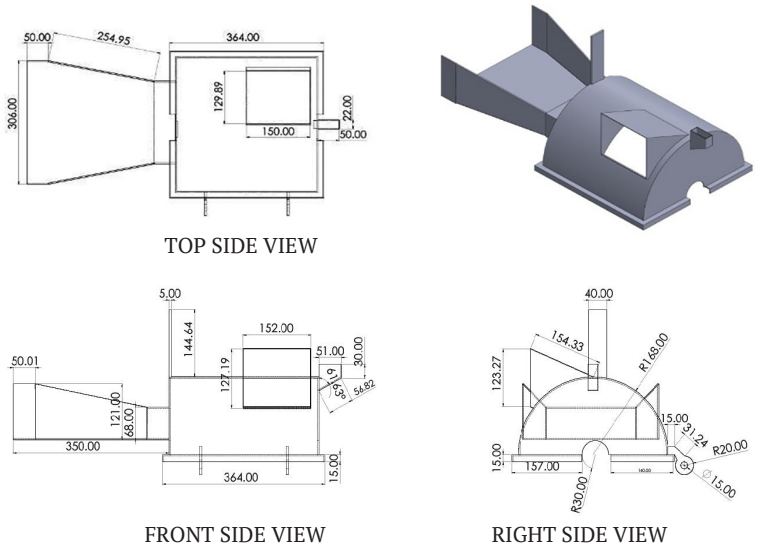

Figure 10. Top casing & feed inlet

Source: compiled by authors

Base, frame and motor base. Basically, this part holds all other parts in place in an order and also provides the necessary support for the cutting and grinding process (Fig. 11).

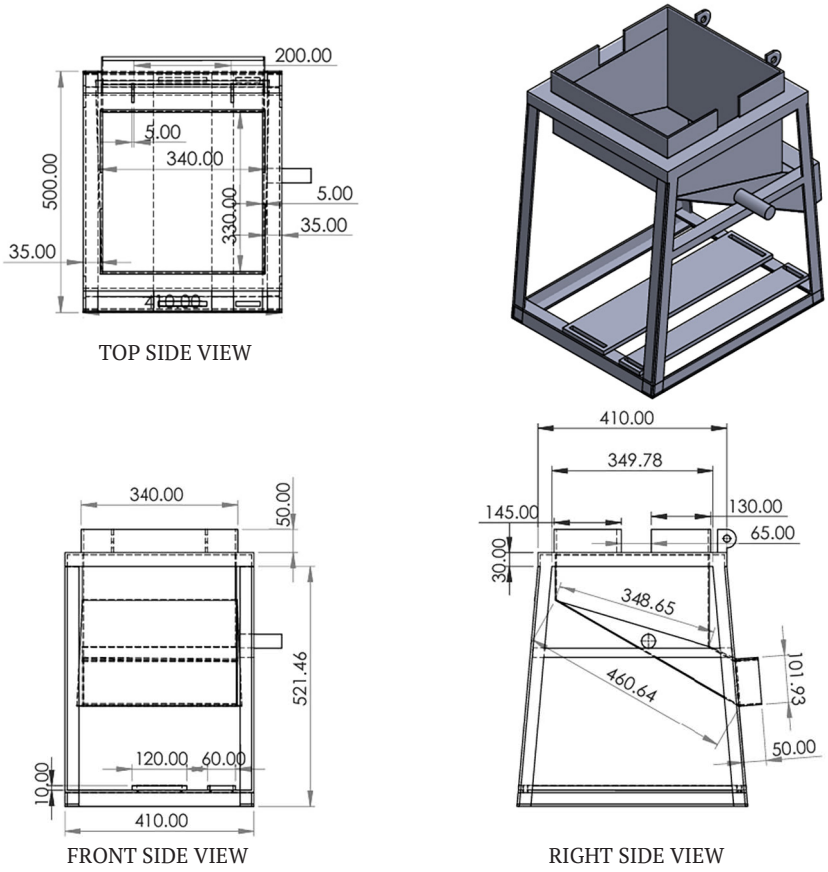

Figure 11. Frame and base

Source: compiled by authors

Power transmission. In this chaff cutter, there are 3 spur gears that transmit the power needed for cutting and grinding grass & grain (Table 3). There is a drive gear attached directly to the motor, then the intermediate gear, which is attached to a shaft that runs to the frame. After that, there is a driven gear directly connected to the main shaft. These gears mesh with each other to form a gear train.

Table 3. Specification of the gear

Gear	Teeth Z	Pitch dia d = mZ (mm)	Outside dia / Addendum dia d + 2 m (mm)	Clearance = 0.157 m (mm)	Dedendum = m + clearance (mm)	Dedendum circle / Root dia d – 2b (mm)
Driven gear (3)	65	208	214.4	0.502	3.702	200.6
Intermediate gear (2)	90	288	294.4	0.502	3.702	280.6
Drive gear (1)	55	176	182.4	0.502	3.702	168.6

Source: compiled by authors

Gear ratio:
Stage 1:

$$N_2 = N_1 \times \frac{55}{90};$$

stage 2:

$$N_{driven} = N_2 \times \frac{90}{65}.$$

Combine:

$$N_{driven} = N_{motor} \times \frac{55}{65} = N_{motor} \times 0.846.$$

Final reduction ratio: 0.846.

Required RPM from the motor. In this chaff cutter machine, a 3 hp electric motor is used. The motor's rpm can be regulated from 1,200 to 1,800 rpm using an inverter.

Shaft rpm at 1,200 rpm motor:
$N_{driven} = 0.846 \times 1{,}200 = 1{,}015$ rpm.
At 1,800 rpm motor:

$$N_{driven} = 0.846 \times 1{,}800 = 1{,}523\ RPM.$$

Shaft speed ranges from 1015 to 1523 rpm.

Blade tip speed:
Blade diameter is 300 mm, thus the tip speed will be $V = \pi DN/60$.
At 1,015 RPM:
$V = 15.9$ m/s. At 1,523 RPM:

$$V = 23.9 \text{ m/s}.$$

Blade tip speed range:

$$15.9 - 23.9 \text{ m/s}.$$

This is ideal for efficient cutting.
Torque at driven gear:

Motor power = 3 HP = 2,238 W
Gear train:
Motor → 55T → 90T (intermediate) → 65T (driven).

Overall ratio:
$N_{driven} = N_{motor} \times \frac{55}{65} = 0.846 N_{motor}$.

Case 1: At 1,200 RPM Motor

Torque at Motor Shaft (55T Gear)
Formula:
$T = \frac{9{,}550P}{N} T_{motor} = \frac{9{,}550 \times 2.238}{1200} T_{motor} = 17.8\ Nm$ Torque on 55T gear = 17.8 Nm

Torque on 90T Intermediate Gear
Torque increases proportional to gear ratio:
$T_{90} = T_{55} \times \frac{90}{55} = 17.8 \times 1.636 = 29.1 Nm$ Torque on 90T gear = 29.1 Nm.

Torque on 65T Driven Gear
Second stage:
$T_{65} = T_{90} \times \frac{65}{90} = 29.1 \times 0.722 = 21.0 Nm$ Torque on 65T gear (Drum shaft) = 21 Nm.

Case 2: At 1,800 RPM Motor
Motor Torque (55T):
$T = \frac{9{,}550 \times 2.238}{1{,}800} T = 11.9\ Nm$ Torque on 55T = 11.9 Nm

Torque on 90T Gear
$T_{90} = 11.9 \times 1.636 = 19.5\ Nm$ Torque on 65T Gear (Driven):

$$T_{65} = 19.5 \times 0.722 = 14.1\ Nm.$$

The final torque summary is shown in Table 4.
Key attributes of the designed model are summarised in Table 5.

Table 4. Final torque summary

Gear	Teeth	Torque at 1,200 rpm	Torque at 1,800 rpm
Motor gear	55	17.8 Nm	11.9 Nm
Intermediate gear	90	29.1 Nm	19.5 Nm
Driven gear	65	21.0 Nm	14.1 Nm

Source: compiled by authors

Table 5. Summary of the key attributes

Attribute	Value (from report)	Notes / derived value
Primary functions	Chaff/grass cutting (wet + dry) + grain grinding	Multipurpose intent is explicit.
Motor power	3 hp	The report uses 3 HP ≈ 2.24 kW.
Motor speed control	1,200-1,800 rpm via "inverter"	Variable speed is a key differentiator.
Transmission	Spur gears (drive, idler, driven)	Tooth counts: drive 55T, idler 90T, driven 65T.
Reduction ratio	0.846 (final reduction ratio)	Used to compute driven shaft speed.
Driven shaft speed	~1,015-1,523 rpm	Derived: 0.846 × 1,200 = 1,015 rpm; 0.846 × 1,800 ≈ 1,523 rpm.
Blade diameter	300 mm (0.30 m)	Used for tip-speed estimate.
Tip speed (derived)	~15.9-23.9 m/s	Derived: $V = \pi DN/60$, D = 0.30 m, N = 1,015 – 1,523 rpm.
Reported torque (driven gear)	~21.0 Nm @ 1,200 rpm motor; ~14.1 Nm @ 1,800 rpm motor	Values appear in the report's computed table.
Blade material	High carbon steel (for grass blade and circular blade)	Durability-positive.

Source: compiled by authors

Manufacturing. The production stage confirmed that it was possible to turn the CAD-based design into a working prototype. The main result of the fabrication was that the proposed integrated layout, which included the feeding unit, cutting and grinding chamber, spur gear transmission, motor base, frame, bearing support, and protective casing, could be put together without changing how the designed model worked. But the final prototype was afflicted by a number of production limitations. Standard sizing for shafts, bearings, sheet metal, and gears meant that during fabrication, only small changes needed to be made to the mounting positions and casing clearances. These changes didn't change how the machine worked; they merely made sure that the motor gear, intermediate gear, and driving gear were all in the right place.

Keeping the gear meshing and shaft alignment correct was the most important manufacturing problem. Because the machine has a spur gear transmission system instead of a belt-pulley system, slight mistakes in positioning could make vibrations, noise, and tooth wear worse. To lower this danger, the motor base and intermediate gear shaft support were changed during assembly to keep the 55-tooth drive gear, 90-tooth intermediate gear, and 65-tooth driven gear in stable contact with each other. The made-up gear configuration kept the planned transmission function and supported the calculated driven shaft speed range of about 1,015-1,523 rpm.

There was also an important result that had to do with the cutting and grinding chamber. The shell had to be close enough to the 300 mm rotating blade to keep materials from moving around inside the chamber, but it also had to be far enough away to let the blade move freely. To avoid blade contact, vibration, and material leakage, the space between the blade path and the casing was verified during fabrication. Using high-carbon steel for the cutting and circular blades made the prototype more resistant to wear, which is significant because these parts will be hit and scraped by grass, straw, and grains again and over again. The bolted blade configuration also made it easier to keep up with because the blades can be taken off for sharpening or replacement.

The built frame and base were strong enough to hold the motor, gear train, casing, and rotating assembly. Any little differences between the model and the built structure were mostly due to cutting, welding, and bending sheet metal by hand. Before the final assembly, local grinding, slot correction, and re-alignment were used to fix these differences. The protective case also made the created prototype safer by covering the revolving cutting and grinding parts. In general, the manufacturing stage showed that the design can be made with workshop tools that are available in the area. However, it also showed that gear alignment, shaft concentricity, blade clearance, and casing rigidity are the most important factors for keeping performance, durability, and safe operation. The manufacturing process is demostrated on Figure 12.

Figure 12. Illustration of the manufacturing process

Source: taken by authors

Manufactured model. The manufactured prototype confirmed that the designed system could integrate grass cutting and grain grinding within one machine structure. The completed model included the grass feed inlet, grain inlet hopper, cutting blade, circular blade, grinder hammer, frame, motor base, bearing housing, protective casing, and spur gear transmission system. The 3 HP motor and gear train produced an estimated driven shaft speed of approximately 1,015-1,523 rpm, with a blade tip speed of about 15.9-23.9 m/s and driven gear torque of about 21.0 N · m at 1,200 rpm and 14.1 N · m at 1,800 rpm. These calculated values indicate that the fabricated power transmission system was suitable for rotating the combined cutting and grinding assembly under the selected operating range.

The performance of the manufactured model was verified through trial operation using fresh grass, straw, and lentils. As shown in Table 5, the machine processed fresh grass at 180-200 kg/hr and produced chopped material of 2-5 cm. For straw, the measured throughput was 150-170 kg/hr with a similar cut size of 2-5 cm, although the feeding rate was slightly lower because of the drier material condition. In the grinding test, lentils were processed at 50-60 kg/hr and produced fine particles below 2 mm. The trial observations also showed smooth feeding and uniform chopping for fresh grass, consistent cutting for straw, and uniform grinding without clogging for lentils. These results provide direct evidence that the manufactured prototype can process both fodder and grain-type material under the tested conditions.

The safety features of the manufactured model were evaluated through design verification and operational observation during the trial. The cutting and grinding elements were enclosed by a protective casing, and separate feeding and discharge paths were provided for grass, grain powder, and chopped material. During the test operation, the casing prevented direct exposure to the rotating blade and hammer assembly, while the outlets allowed processed material to leave the chamber without manual contact with the cutting zone. However, no quantitative safety test, such as failure rate measurement, operator risk scoring, vibration level, noise level, or long-duration reliability testing, was conducted. Therefore, the result should be interpreted as validation of incorporated safety features during prototype operation, not as a full safety certification. Further testing is required to measure energy consumption, vibration, noise, blade wear, and long-term failure rate under continuous operating conditions. The final manufacture of the machine is presented on Figure 13.

Figure 13. Final manufacture of a multipurpose grass cutting machine
Source: taken by authors

Trial of the machine. The test findings showed that the prototype that was made could chop fodder and grind grain in the conditions that were evaluated. Three materials were tested: lentils, fresh grass, and straw. Table 5 shows the results in terms of throughput, output size, and operational observations. The machine had the highest throughput for fresh grass, which was between 180 and 200 kg/hr. The chopped output size was around 2-5 cm, which means that the cutting mechanism made fodder that was about the same size, which is good for making feed for animals. During the fresh grass testing, the feed entrance, blade configuration, and discharge path were all in the right places for soft green fodder, which meant that feeding went smoothly.

The throughput for straw dropped to 150-170 kg/hr, but the cut size stayed the same at about 2-5 cm. The reduced throughput compared to fresh grass is because straw is drier and stiffer, which makes it harder to chop and less smooth to feed. But the output stayed the same, which means that the cutting blade and rotating shaft assembly could handle dry food without too much trouble. The machine-made fine particles smaller than 2 mm and processed 50 to 60 kilogram of lentils per hour. This result proves that the prototype can grind things up and that the hammer and circular blade configuration can turn grain-type materials into powder. During the lentil trial, there were no clogs, which means that the grain inlet, grinding chamber, and powder output all worked well together under the specified environment.

Overall, the trial results, shown on Figure 14, reveal that the machine cut fresh grass better than straw in terms of throughput. The grinding operation had a lower throughput since it needed to reduce the size of the particles more finely. The test also showed that one prototype could use the same motor-driven system to treat both long, fibrous feed and grain-like material. The testing did not, however, contain

any quantitative measurements of energy use, vibration, noise level, blade wear, or failure rate over a long period of time. So, the results should be seen as early prototype validation rather than full performance certification.

Figure 14. Illustration of the input and output of the feed

Source: taken by authors

The results demonstrate that the machine worked differently based on the type of input material and the sort of processing operation that was needed. Fresh grass had the highest throughput of all the materials evaluated, ranging from 180 to 200 kg/hr. This means that the cutting device worked best while it was cutting soft, wet feed. The fresh grass came out in pieces that were 2 to 5 cm long, which showed that the blade arrangement could make chopped fodder that was quite uniform and good for feeding livestock. The throughput for straw dropped to 150-170 kg/hr, but the output size stayed in the same 2-5 cm range. The average throughput for straw was around 16% lower than that of fresh grass. The drier and stiffer structure of straw makes it harder to cut and slows down the feeding of materials. This is why the amount of straw has gone decreased. But the machine nevertheless made cuts of the same size, which means that the cutting blade and shaft assembly could handle both green and dry feed materials in the conditions that were tested.

The grinding test with lentils had a reduced throughput of 50-60 kg/hr and a particle size of less than 2 mm. This decreased capacity is predicted because grinding needs to break things down into smaller pieces than just chopping. You simply need to chop grass and straw into little pieces, but you need to break lentils into small pieces, which means the circular blade and grinder hammer need to touch them more. The fact that there was no clogging during the lentil trial shows that the grain input, grinding chamber, and powder exit were set up correctly for the material that was tested. In general, Table 5 shows that the prototype can do more than one thing. The machine was able to cut more fodder than it could grind grain, but it was still able to do both jobs. The results also show that the same motor-driven system may handle materials with varying textures and processing needs. The table, on the other hand, just shows throughput, output size, and basic operating observations. For a more thorough performance assessment, subsequent testing must encompass energy consumption, cutting efficiency, grinding efficiency, vibration, noise level, blade wear, and long-term operational stability. So, the results in Table 6 should be seen as a first step in proving that the prototype works, not as a full test of its long-term engineering reliability.

Table 6. Summary of the trial results

Material	Throughput (kg/hr)	Cut/Particle Size	Observations
Fresh Grass	180-200	2-5 cm	Smooth feeding, uniform chopping
Straw	150-170	2-5 cm	Slightly slower due to dryness; consistent cut
Lentils	50-60	Fine powder (< 2 mm)	Uniform grinding; no clogging

Source: compiled by authors

The results of the present study demonstrate that the developed combined grass-cutting and grinding machine can perform two feed-preparation operations within a single mechanical system. The prototype successfully processed fresh grass, straw, and lentils, producing a throughput of 180-200 kg/hr for fresh grass, 150-170 kg/hr for straw, and 50-60 kg/hr for lentil grinding. The results also showed that the machine produced relatively uniform

chopped material of 2-5 cm and fine ground particles below 2 mm for lentils. These findings indicate that the proposed machine is suitable for handling both soft green fodder and comparatively dry or hard feed materials. The use of a 3 HP electric motor, spur gear transmission, removable cutting blades, grinder hammers, and protective casing contributed to the stable operation of the system.

The findings of this study are partly consistent with the work of J. Sinha & A. Kumar (2021), who examined the ergonomic and mechanical performance of fodder cutters by changing the number of blades and feeding throat geometry. They showed that blade arrangement and feeding design strongly influence cutting efficiency and user comfort. The present study also confirms the importance of blade arrangement and feeding stability, as smooth feeding was observed during the trial with fresh grass. However, J. Sinha & A. Kumar mainly focused on ergonomic improvement of manual fodder cutters, whereas the present study developed a powered multipurpose machine that integrates both cutting and grinding operations. N. Sankpal *et al*. (2017) worked on the design and modification of chaff cutter machines to improve cutting efficiency and reduce manual effort. Their study emphasized machine modification for better usability, which is also reflected in the current design. The common point between their work and the present study is the intention to reduce labour and improve fodder-cutting performance. However, the present study differs by introducing a gear-based transmission system and an additional grinding function, while N. Sankpal *et al*. mainly focused on chaff-cutting improvement.

A. Kumar *et al*. (2013), M. Yadaw (2015) and M. Hammad (2019) designed and modelled a portable and safe chaff cutter machine, giving importance to compactness and operator safety. The present study supports this safety-oriented approach by including a protective casing around the cutting and grinding parts. Both studies recognise that exposed rotating components create operational risk. However, Hammad's work was mainly centred on portability and safe cutting, while the present research extends the design concept by combining grass cutting and grain grinding in one machine. S.M.S. Kumar *et al*. (2025) developed a chaff cutter using an AISI-1019 blade and focused on blade strength, cutting ability, and fabrication. Their work is related to the present study because blade durability is also an important design consideration here. In this research, high-carbon steel was selected for the grass-cutting and circular blades to improve wear resistance and service life. The difference is that S.M.S. Kumar *et al*. concentrated more on blade material and cutting structure, whereas the present study considered the whole machine system, including power transmission, grinding mechanism, casing, and local manufacturability. M.P. Patil *et al*. (2019) designed a flexible chaff-cutting machine capable of handling different types of fodder materials. Their work is comparable with the present study because both machines aim to process more than one type of agricultural material. The trial results of the present prototype with fresh grass and straw show that it can handle materials of different texture and moisture condition. However, M.P. Patil *et al*. focused mainly on flexibility in cutting, while the present study adds a grinding unit, making the machine more multifunctional for feed preparation.

D. Yallappa *et al*. (2024) evaluated a power-operated chaff cutter for selected fodder crops and considered performance parameters such as cutting efficiency and throughput. Their study is closely related to the present research because both works tested machine performance using fodder materials. The present machine showed a throughput of 180-200 kg/hr for fresh grass and 150-170 kg/hr for straw, which indicates practical applicability for small- and medium-scale farms. However, D. Yallappa *et al*. focused on performance evaluation of a chaff cutter, whereas the present study includes design, modelling, fabrication, and performance testing of a combined cutting and grinding machine. N.S. Navgale *et al*. (2023) developed a modified machine that combined chaff cutting and coconut dehusking using a single motor. Their work demonstrated that multiple agricultural operations can be integrated into one compact system. The present research follows a similar multifunctional design philosophy, but the functional combination is different. Instead of combining cutting with dehusking, this study combines grass cutting with grain grinding, which is more directly related to livestock feed preparation. Therefore, the present machine addresses a different user requirement and is more suitable for farmers who need both chopped fodder and ground feed ingredients. D.V. Nimbalkar (2018) and D.V. Nimabalkar *et al*. (2018) designed a low-cost lightweight chaff cutter cum grinder for small-scale farmers. Their work is one of the closest to the present study because both machines combine cutting and grinding functions. The common finding is that a combined machine can reduce the need for separate equipment and simplify feed preparation. However, the present study differs by using a spur gear transmission system instead of depending mainly on conventional belt-pulley arrangements. This gear-based design is expected to provide better durability, more stable power transmission, and reduced maintenance requirements.

Overall, comparison with previous studies shows that many researchers have addressed individual aspects of fodder-processing machinery, such as ergonomics, blade design, portability, safety, flexibility, and cutting performance. The present study contributes by integrating these concerns into a single locally manufacturable machine with both grass-cutting and grinding capacity. Its main technical distinction is the use of a gear-based power transmission system with a 3 HP motor, which produced a driven shaft speed range of approximately 1,015-1,523 rpm and supported effective cutting and grinding operation. The study also demonstrates that practical design decisions based on field visits, user feedback, component availability, and engineering calculation can lead to a machine suitable for local agricultural conditions. However, further testing with a wider range of fodder crops, longer operating

periods, power consumption measurement, noise assessment, and blade wear analysis would be necessary to validate long-term reliability and commercial readiness.

CONCLUSIONS

The purpose of this study was achieved through the design, fabrication, and preliminary testing of a combined grass-cutting and grinding machine for livestock feed preparation. The developed prototype successfully integrated two major feed-processing operations- fodder cutting and grain grinding, within a single motor-driven mechanical system. The use of a 3 HP electric motor, spur gear power transmission, cutting blades, grinder hammers, separate feeding paths, and protective casing demonstrated that the proposed design can operate as a practical multipurpose machine under the tested conditions.

The review of relevant literature showed that previous studies mainly focused on individual aspects of chaff cutter development, such as ergonomic improvement, blade configuration, portability, safety, low-cost fabrication, and performance evaluation. However, limited attention was given to an integrated machine capable of both grass cutting and grain grinding with a durable gear-based transmission system. The concept of a combined feed-preparation machine is important because grass cutting and grinding are related but mechanically different processes: cutting requires controlled shearing of fibrous material, while grinding requires impact and repeated size reduction of harder feed materials. This study addressed both functions through a combined cutting and grinding chamber.

The results of prototype testing confirmed the functional performance of the machine. The machine processed fresh grass at 180-200 kg/hr with an output size of 2-5 cm, straw at 150-170 kg/hr with a similar cut size, and lentils at 50-60 kg/hr with particle size below 2 mm. These results indicate that the machine performed better for soft green fodder than for dry straw, while the grinding operation naturally produced lower throughput because finer size reduction was required. The protective casing, enclosed rotating assembly, and separate outlets also contributed to safer operation during the trial.

The novelty and practical value of this work lie in the development of a locally manufacturable combined machine using spur gear transmission instead of a conventional belt-pulley system. This design can reduce the need for separate cutting and grinding machines and may support small and medium-scale livestock farmers in feed preparation. Further research should include long-duration performance testing, measurement of energy consumption, vibration, noise level, blade wear, gear wear, and failure rate. Future studies should also test the machine with different fodder crops and grain types, optimise blade and hammer geometry, and conduct a detailed safety and reliability assessment before commercial production.

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CONFLICT OF INTEREST

None.

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Конструкція та модифікація комбінованої траворізально-подрібнювальної машини

Анотація. Ефективне приготування корму для худоби залишається серйозною проблемою для малих та середніх фермерів у Бангладеш, де ручне різання корму та окреме виконання процесів подрібнення характеризуються значними витратами часу, трудових ресурсів і фінансових затрат. Зростання цін на корми та обмежений доступ до доступного механізованого обладнання роблять розробку багатоцільової техніки місцевого виробництва надзвичайно актуальною для сільськогосподарського сектору. Метою цієї статті було спроєктувати, виготовити та оцінити комбіновану машину для скошування та подрібнення трави, придатну для практичного використання в Бангладеш. У дослідженні використовувалися польові виїзди, спілкування з фокус-групою, моделювання на основі автоматизованого проєктування, виготовлення прототипу та випробування продуктивності для оцінки конструкції, експлуатації та придатності машини для користувача. Розроблена машина об'єднує скошування трави та подрібнення зерна в єдиній компактній системі, що живиться від електродвигуна потужністю 3 к.с. На відміну від багатьох традиційних машин, які залежать від ремінно-шківної системи, запропонована конструкція використовує систему передачі з циліндричними зубчастими колесами для підвищення довговічності, стабільності та передачі потужності. Зубчаста конструкція забезпечує кінцеве передавальне число 0,846, що забезпечує швидкість веденого вала приблизно 1015-1523 об/хв та швидкість кінчика леза приблизно 15,9-23,9 м/с. Випробування зі свіжою травою, соломою та сочевицею показали, що машина може переробляти 180-200 кг/год трави, 150-170 кг/год соломи та 50-60 кг/год сочевиці на дрібний порошок. Подрібнений матеріал був рівномірним, подача – плавною, а захисний кожух допоміг підвищити безпеку експлуатації. Конструкція також забезпечує заточування лез, місцеве виробництво та нижчі вимоги до технічного обслуговування. Результати можуть бути застосовані в дрібномасштабному тваринництві, центрах приготування кормів та майстернях сільської техніки для зменшення трудозатрат, підвищення ефективності переробки кормів та підтримки механізації сільського господарства

Ключові слова*:* газонокосарка; подрібнювач; сільське господарство; сільськогосподарська техніка; приготування кормів