IMPROVEMENT OF THE MILLET MILLING MACHINE

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ABSTRACT

Millet is a cereal crop grown in the northern municipalities of Cebu province as a cash crop and milled for its ready to cook or process grain. It is presently being dehulled by a locally-designed milling machine. However, the machine produced a finished product which requires processors to manually separate the milled millet grain from its hull and bran. With the study the device was redesigned and fabricated to produce a milled grain which is free from millet hull and bran. The machine comprised of a metal roller coated with abrasive material spaced closely against a rubber-lined metal plate serves as the dehuller, an electric blower separates the hull from the milled grain, an electric motor powers the rotating drum roller, and transport rollers attached to the legs of the metal frame for mobility and portability. Testing the machine showed a milling capacity of 25 kg/hr, 62% milling recovery, and 85% completely dehulled grain. Overall cost of fabricating the machine was P20,658.00.

Keywords: Millet, milling machine, dehuller, milling capacity, milling recovery

INTRODUCTION

The use of farm tools and equipment facilitates crop production and processing. Loosening the soil without a plow drawn by a draft animal or machine employs more time and effort on human labor. Harvesting, threshing, and milling crops manually entails low output capacity and more loses. Small intermediate technology implements make many tasks quicker and easier to perform. They also reduce the physical input required, making the task easier (Agriscope, 2010).

Millet is one of the four most important cereals (rice, corn, sorghum) grown in the tropics. It bears small edible seeds that are generally borne on short slim stalks. About 90% of the grain produced is used as human food, animal feed, and as seed or as emergency cash crop. The millets play an important role in the economy of many less developed countries because they are consumed directly for human food and they are the principal sources of energy, protein, vitamins, and minerals (PARC, 2005).

In Cebu province, millet has been considered as a cash crop especially to hinterland farmers (Borbon *et al.,* 2009). On this line, one of the concerns is geared towards the use of mechanical tools and equipment for its production and processing activities. Since millet production is identified as a source of income for the rural population of the province, there is a need to provide alternative means for using agricultural tools and equipment. This is to enhance agricultural production, facilitate processing for production of high-value processed products, and thus improve farmers' and product processors' income.The study aimed to improve the existing design of a milling machine for

millet grain, to fabricate the improved millet milling machine design, and to test and evaluate the performance of the improved millet milling machine.A millet milling machine already existed in the northern part of Cebu province where there is high production of the millet grain. This machine was designed and fabricated by the local farmers because of the necessity to mill the product at the farm level. This fabricated milling machine satisfies the basic requirement which is only dehulling the millet grain. However, upon using the machine, it was found out that it needs improvement in terms of technical design and performance. The design of the existing millet milling machine does not provide a blower to separate the millet hull from its milled grain. Also, the design incurred at least 5% losses due to spreading and flying of the small grains. Portability of the design is another problem. The development of the existing machine addressed these problems while focusing on design capacity, better finish product quality, higher efficiency, ease of operation, and affordability.

MATERIALS AND METHODS

Machine Description

The millet milling machine was designed and fabricated [based on the Philippine Agricultural Engineering Standards (PAES)] with the following major parts: 1) Feeding hopper and cover: It is the part where the millet grains are being fed into the milling drum where it is directly attached to the cover. They are made of galvanized material, height of the hopper is 12 cm from the point where it is attached to the cover with dimensions of 38 cm x 42 cm x 25 cm is hinged to the machine metal frame. 2) Milling drum assembly: It is the part where the millet grains are milled through abrasion as its rotating cylindrical drum measuring 32.5 cm in diameter x 40 cm length is fixed with back-cloth sand paper and spaced closely against a rubber-lined and curved metal plate. 3) Discharge chute: This part is directly at the bottom of the milling assembly and fixed with an electric blower on its side to separate and collect the milled millet product from its hull. 4) Machine frame: The part which supports all the components of the machine including the 0.75 Hp electric motor, transmission pillow blocks, shafts, pulleys, and v-belts assembly. This metal frame with dimensions of 45 cm and 60 cm (top and bottom) x 55 cm x 70 cm is made of 1-1/2 inch x 1-1/2 inch angle bar and its four legs bolted with steel-rubber rollers.

Working Mode of the Machine

A 0.75 Hp electric motor attached with 2-inch diameter pulley provides power by a v-belt to an idler shaft attached with 6-inch and 3-inch diameter pulleys to reduce the rotational speed at this shaft. From the 3-inch diameter pulley another connected v-belt transmits the power to the milling shaft through attached 10-inch diameter pulley. The idler shaft and milling drum shaft which smoothly rotates with the help of pillow block bearings through pulleys and v-belts transmits the drive from the electric motor to mill the millet grain at the milling assembly.

The feeding of the millet grain at the hopper to the closely spaced rotating rough surface and rubber provides the friction to dehull or remove the hull from the tiny millet grains. As millet is channeled and passed through this milling drum, feeding and dehulling is continuous. The mixture of the milled

grain is separated by a small electric motor that sucks and blows the hull away from the dehulled grain. The millet finished product is channeled through a discharge chute to a collecting vat or pan.

Design Analysis

The design analysis was carried out to evaluate the considered design parameters: a) machine output capacity, b) finished millet grain product free from hull, c) mobility or portability, and d) cost of fabrication. Generally, the design was based on the engineering principles and standards (PAES) on utility and functionality, strength of the materials, ease of use, efficiency, and economy on the manufacture and use of the equipment.

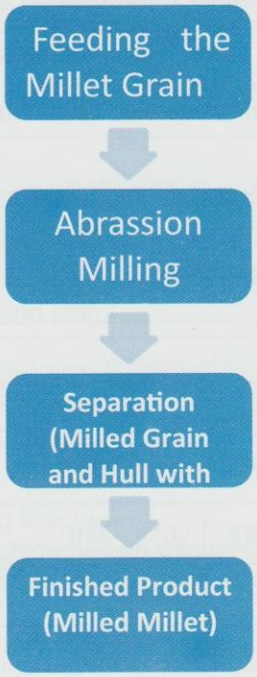

Figure 1. Process flow of milling millet grain using the designed and fabricated machine.

Testing and Evaluation of the Millet Milling Machine

Testing and evaluation were done for the fabricated machine. The milling machine was tested and evaluated by milling dried millet grain (at 14% moisture content) in a processing shed. The above design criteria were used as bases for these activities. Series of testing and evaluations were made according to engineering procedures [Philippine Agricultural Engineering Standards (PAES 207:2000)] to measure machine milling output capacity, milling recovery, and other machine performance and physical characteristics. Millet grains were procured from a farmer group in a millet growing municipality for milling tests. The machine was first run with no load condition driven by a 0.75 Hp electric motor with speed rating of 1740 rpm. This was done to ascertain the smoothness of operation for the machine rotating parts.

A digital laser tachometer was used in testing the speed of the rotating shafts of the machine as it was ran idle. The testing of the machine with load was aimed to evaluate its milling efficiency, milling recovery, milling degree, and rotating speed of the milling drum during operation. Five (5) trials using 8 kg millet grain per trial were done to evaluate the milling performance. Milling elapse times were monitored using a stopwatch and recorded, shaft rotation speeds were measured, and weights of the milled millet products were obtained and recorded.

Cost in Fabrication of the Millet Milling Machine

Table 1 reflects the cost in fabricating the machine. Its bill of materials cost amounted to P13,772.00 while P6,886.00 for the labor cost. There were actually incurred costs in parts which were replaced during the fabrication and evaluation of the machine, as there were adjustments made in its previous design. This material cost including its labor cost was neglected. The newly designed millet milling machine can be fabricated with an overall cost of P20,658.00.

Table 1. Cost in fabricating the millet milling machine.

Qty.	Unit	Particular	Unit Cost (PhP)	Amount (PhP)
A. Cost of Bill of Materials				13,772.00
1	piece	G.I. sheet, gauge 16	1,067.00	1,067.00
2	pieces	Angle bar, 3/16" x 1-1/2" x 1-1/2"	341.00	682.00
1	piece	Steel bar, square, 1 cm x 1 cm	200.00	200.00
4	pieces	Pillow block, 1-inch diameter	500.00	2,000.00
1	piece	Pulley, 10" diameter	250.00	250.00
1	piece	Pulley, 6" diameter	150.00	150.00
1	piece	Pulley, 2" diameter	80.00	80.00
2	pieces	V-belt, 30 cm	60.00	120.00
2	pieces	Steel shaft, 1-inch diameter	230.00	460.00
1	piece	B.I. pipe, 7 mm thick x 32.5 cm dia. x 40 cm	1,500.00	1,500.00
1	meter	Cloth-back sand paper	500.00	500.00

1	meter	Rubber, braided flat belt, 1/4 inch x 5 inches	500.00	500.00
16	pieces	Bolt and nut w/ lock washer, 8mm dia. x 3 cm	15.00	240.00
12	pieces	Bolt and nut w/ lock washer, 12mm dia. x 4 cm	40.00	480.00
4	pieces	Steel-rubber roller/wheel	100.00	400.00
1	unit	Electric motor, 0.75 Hp	2,500.00	2,500.00
1	unit	Electric blower, 1.6 Amp.	1,800.00	1,800.00
2	liters	Red lead primer	125.00	250.00
2	liters	Acrylic paint, light green	200.00	400.00
1	bottle	Lacquer thinner	45.00	45.00
1	bottle	Paint thinner	38.00	38.00
1	bottle	Rugby adhesive	60.00	60.00
1	set	Electrical wire and plug	50.00	50.00
B. Labor Cost in Fabrication				**6,886.00**
Total Cost of the Fabricated Machine (PhP)				**20,658.00**

RESULTS AND DISCUSSION

The Fabricated Millet Milling Machine

The millet milling machine has an overall dimension of 60 cm x 55 cm x 95 cm. This was made mainly of angle bars and steel plates. Its cylindrical milling drum with dimension of 32.5 cm diameter x 40 cm length is made of block iron pipe and its outer surface pasted with clothed-back sand paper for the milling action. The milling machine transmits the power from a 0.75 Hp electric motor to drive the milling drum through combined pulleys and v-belts. The improved design of the machine enables continuous milling operation, just like milling of rice and corn, where feeding and extracting of milled product does not require frequent turning on and off the machine. An electric blower attached to the side of the discharge chute assembly separates the hull from the finished or milled millet product. To address the mobility and portability of the machine, each leg of its metal frame was bolted with steel-rubber roller or wheel.

From the series of testing and evaluation on performance, the machine showed an average milling capacity of 25 kg/hr, 62% average milling recovery, and 85% completely dehulled millet grain (Table 3). However, on the degree of milling it was found out that most of the milled grains were further grounded to smaller pieces. This was due the uneven clearance between the milling drum and the rubber mounted on metal for the abrasive action. The very tiny millet seeds posed difficulty in maintaining precise space clearance between the frictional machine parts.

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The machine was able to produce at most 96% hull-free finished or milled millet product.

Table 3. Performance of the millet milling machine.

Parameter	Performance
Milling output capacity (kg/hr)	25
Milling recovery (%)	62
Completely dehulled grain (%)	85
Hull-free milled product (%)	96

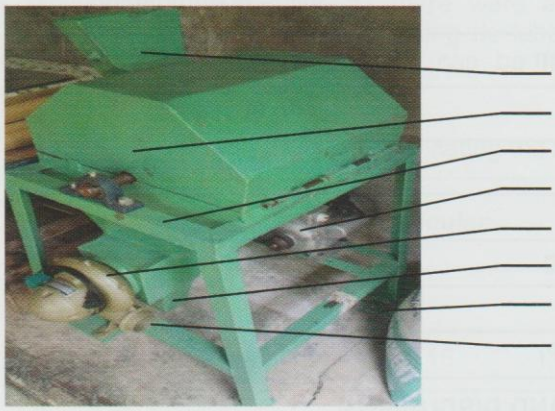

Figure 2. The designed and fabricated millet milling machine.

Table 3. Average rotation speeds (rpm) of the millet milling machine at shaft-pulley locations during idle running and milling operation states.

State	Shaft-Pulley		Average Speed (rpm)	Reduction in Speed (%)	
Idle Running (Without Load)	At electric motor	2-inch	1764	90.0	8.5
	At idler shaft	6-inch	588		
		3-inch			
	At milling drum	10-inch	176		
Milling Operation (With Load)	At electric motor	2-inch	1709	90.6	
	At idler shaft	6-inch	553		
		3-inch			
	At milling drum	10-inch	161		

Performance Testing and Evaluation of the Machine

The millet milling machine was designed to have a milling drum rotational speed of at most 200 rpm. A 90% reduction of the rotation speed of the electric motor driver through combination of pulley sizes was set to minimize vibration of the machine parts for a smooth milling operation. Table 2 shows that when the machine was ran idle, it has average rotation speeds of 1764 rpm and 176 rpm at the electric motor shaft and at milling drum shaft, respectively. Under milling operation, the machine has average rotation speeds of 1709 rpm and 161 rpm at the electric motor shaft and at milling drum shaft, respectively. A reduction in speed of the millet machine at the milling drum by 8.5% was observed due to the milling load.

CONCLUSION

The millet milling machine was improved to enable a continuous milling operation, produce a finished product free from hull and bran, and portable. Its simple design and affordable cost make it possible for processors to fabricate the machine. Through testing and evaluation on the performance of the machine, it can be concluded that milling millet grain can be carried out easier, faster, and economical.

To optimize its milling capacity and milled grain quality, it is recommended that further assessment of the design has to be conducted also to find alternative mechanism to obtain the best milling performance.

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