SALAGA Journal
Vol. 02, No. 1, June 2024, pp. 32~38
ISSN: 3032-2677
DOI: 10.70124/salaga.v2i1.1743

Performance Test of the No-fuss Corn Sheller Production Benteng Tellue Workshop

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Article Info

Keywords:

Corn
Shelling
No-Husk Corn Sheller
Post-Harvest Processing

ABSTRACT

The post-harvest handling of corn involves threshing, the process of separating kernels from the cob. A corn shelling machine without husking offers advantages for both sellers and buyers by allowing manual sorting of good and damaged kernels before threshing. This study evaluates the performance of a no-husk corn sheller used in the Amali District, Bone Regency. Key parameters analyzed include fuel consumption, shelling capacity, percentage of damaged kernels, and cleanliness level at three different rotational speeds (500, 600, and 700 rpm). The results indicate that increasing the rotational speed leads to higher fuel consumption and improved shelling capacity. However, the percentage of damaged kernels decreases with higher speeds, achieving an average damage rate of 0.049%. Additionally, the cleanliness level of the shelled corn reaches an average of 98%, confirming the machine's efficiency. These findings suggest that optimizing the rotational speed enhances both productivity and output quality, making the no-husk corn sheller a viable tool for post-harvest processing.

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1. INTRODUCTION

The agricultural sector, particularly the cultivation of corn, plays a pivotal role in the economic growth of the Republic of Indonesia. This is evident in the processing of corn as a raw material for food companies and its importance as a staple food in various regions of Indonesia. Corn can also be processed into margarine, cooking oil, whole-grain corn rice, corn flour, and snacks. Corn can be cultivated using the rice and corn intercropping system in rainfed areas as well as in dry and arid lands, either with the rice and corn or corn and corn cropping models. Particularly, the Amali District is the largest corn cultivation area in Bone Regency, with a potential dry land area of 11,835 hectares primarily used for hybrid and combination corn cultivation. For hybrid corn, the harvested area covers 5,069 hectares with an average productivity of 7.80 tons per hectare [1].

Efforts to handle corn after harvest typically include the process of threshing, which involves separating the corn kernels from their cobs. This critical step can be performed using specialized machinery, such as corn threshers that operate without requiring prior husking. These types of machines are considered particularly advantageous for both sellers and buyers, as they allow for the manual sorting of good and damaged corn before the threshing process begins. In the case of hybrid corn, it is often sold in its whole form due to the expensive costs associated with husk-free threshing. As a result, corn threshing machines that do not require husking have become the most commonly utilized equipment for separating kernels from cobs in the Amali District, where this efficient method has gained widespread adoption [2].

Based on observations and interviews conducted with 20 corn buyers out of the total 30 corn collectors in the Amali District, it was found that the threshing machines used are branded "Power Tech" made in Thailand, with a production capacity of 15 tons per day and a fuel consumption of 2 liters per ton. These machines have not undergone scientific testing. To conduct this research, it is necessary to comply with Minister of Agriculture Regulation No. 5, Chapter II, Article 5, issued by the Ministry of Agriculture since 2007 regarding research on agricultural tools or machinery, including requirements, procedures, and the publication of agricultural tool certificates. Machines produced domestically or imported must be tested before distribution to farmers and industries. Based on these considerations, this research was conducted in the Amali District, Bone Regency, South Sulawesi, to determine the capacity of corn threshing machines that do not use husking.

2. MATERIALS AND METHODS

2.1 Materials

The tools needed for this research include the use of bags, corn sheller machine without a tachometer, corn moisture meter, tarpaulin, digital scale (with a precision of 0.01 grams), plastic bags, label paper, stopwatch, manual scale, camera, measuring cup, aluminum foil, paper, notebooks, spotlight, and pens.

As for the materials utilized in this study, gasoline fuel and corn without husks from the NK PERKASA variety in the Bone Regency area of South Sulawesi. The process conducted on corn samples involves manually removing the corn kernels by human labor, while black or damaged corn is separated first. The corn is then stored in sacks for 3 days, after which the moisture content of the corn is measured before further processing. Meanwhile, the fuel used in this research is Pertalite gasoline.

2.2 Research Procedure

As for the research procedure, it involves the preparation of tools and materials, followed by a performance test of the machine with calculations and measurements of parameters at 3 speeds: 500, 600, and 700 rpm.

2.2.1 Measurement of the Drive Motor

The measurement process of the drive motor component is carried out at motor speeds of 500, 600, and 700 rpm before the material is placed in the hopper. Next, the tachometer sensor is directed towards the attached condensation paper. The tachometer functions to measure the speed of the drive motor. When the machine is started, 15 kg of corn, which has been husked, is processed into the hopper (feed port), and the rotation speed of the drive motor is recorded.

2.2.2 Seed Shelling Capacity

Corn without cobs, continuously fed into the hopper, collects the corn kernels obtained from the discharge hole. Then, the weight is measured over a period of approximately 3 minutes, and the treatment process is repeated 3 times.

2.2.3 Percentage of Damaged Corn Kernels

A random sample of 250 grams of corn is taken from the main discharge hole and repeated 3 times during the shelling process. The sample is then analyzed, and damaged corn kernels (cracked or broken kernels and blackened ones) or contaminants (corn cobs, husks, soil) are sorted out.

2.2.4 Cleanliness Level

A random sample of 250 grams of corn is taken from the main discharge hole and repeated 3 times during the shelling process, for both damaged and intact corn kernels. They are then separated from contaminants or foreign objects and weighed.

2.2.5 Fuel Consumption

The shelling process is timed and the volume of oil fuel used is calculated, including for each sample in the shelling parameter that is repeated.

2.3 Observation Parameters

The research parameters to be tested are as follows:

2.3.1 Fuel Consumption

Fuel consumption is determined using the formula below:

$$Fc = \frac{Vc}{t} \quad (1)$$

Fc = oil fuel consumption (l/hour)
t = operating time (hours)
Vc = fuel requirement (l)

2.3.2 Pilling Capacity

Based on [3], the pilling capacity for corn pilling machines without huskers is calculated using the following formula:

$$Kpo = Wpo \times \frac{cÞ}{o} \quad (2)$$

Kpo = output capacity of corn pilling process (kg/hour)
Wpo = total weight of corn kernels collected from the main discharge hole in time t (kg)
t = time during the pilling process (minutes)

2.3.3 Percentage of Damaged Kernels

According to [3], damaged corn kernels include whole or cracked kernels caused by physical, biological, and enzymatic effects. The percentage of damaged corn is calculated using the formula (SNI 7428:2008):

$$Wr = \frac{Wr1\text{-}Wr2}{Wc\text{-}Wk} \times 100\% \qquad (3)$$

W r = percentage of damaged corn kernels (%)
Wr1 = weight of damaged corn kernels ejected from the corn pilling machine (grams)
Wk = weight of impurities (grams)
Wr2 = weight of damaged corn kernels before pilling (grams)
Wc = sample weight (grams)

2.3.4 Cleanliness Level

The cleanliness level is calculated using the following formula:

$$Tb = \frac{Wp1}{Wp} \text{ x } 100\% \qquad (4)$$

Tb = cleanliness level of corn kernels (%)
Wp1 = weight of corn kernels (whole and damaged) from the main discharge hole (grams) Wp = weight of the total output from the main discharge hole (grams).

2.4 Equipment Specifications

(a) (b)

Figure 1. (a). Side view of the equipment photo and (b) Front view of the equipment photo.

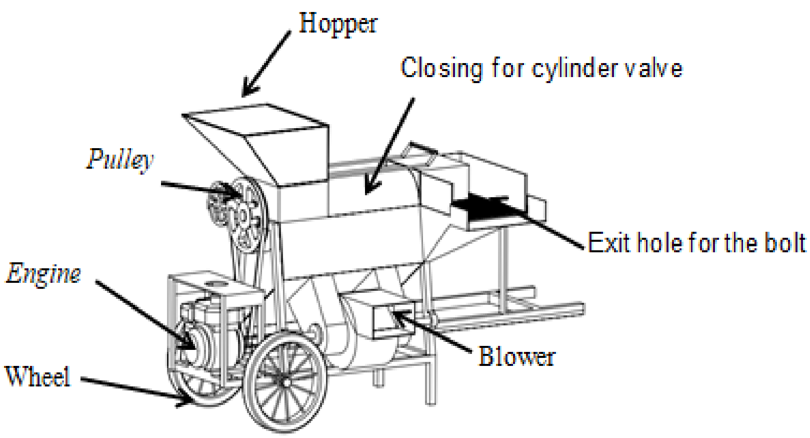

Figure 2. 3D Corn Shucker Tool.

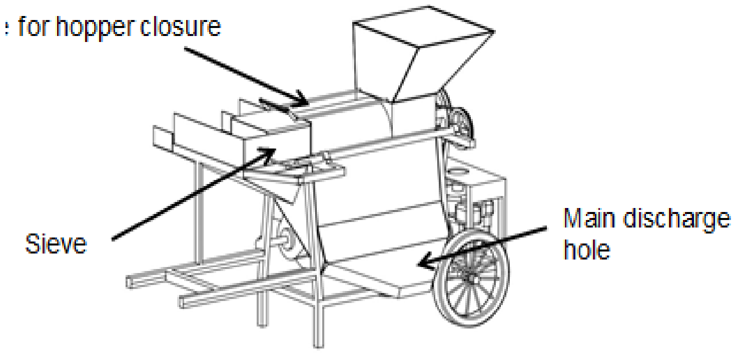

Figure 3. 3D Corn Shucker Tool.

The specifications of the corn sheller without husks, which are the subject of this research, consist of several main structures, such as the corn sheller frame (P=163 cm, L=116 cm, H=119 cm), which serves to support the main components of the machine. The corn shelling cylinder (Diameter=18.9 cm, P=7.2 cm) serves as the driving force for the VX 200 Thailand brand machine with a power of 6.5 Hp. The clean corn outlet hole (P=80 cm, La=70 cm, Lb=25 cm) serves as the exit point for the shelled corn, while the cob outlet hole (P=32 cm, L=24 cm) functions as the exit point for the corn cobs. This is different from the sieve, which is used to separate the shelled corn kernels from impurities or corn cob fragments, with dimensions (P=70 cm, L=39.5 cm). Additionally, the blower serves as a fan for blowing away impurities that may still be carried by the shelled corn kernels after passing through the sieve hole with dimensions (P=46 cm, L=23.5 cm). The motor pulley diameter connected to the corn shelling cylinder is 46 cm, while the blower pulley is 35.5 cm, and the sieve pulley is 49 cm.

3. RESULTS AND DISCUSSION

3.1 Fuel Consumption

Table 2. Average fuel consumption and loading capacity

Motor Speed (rpm)	Fc (Litre/Hour)	Kpo (Kg/Hour)	Average (Kg/Litre)
500	1.56	265.04	169.90
600	1.70	313.97	184.69
700	1.87	354.98	189.83

Table 1 shows that at a speed of 500 rpm, the fuel consumption is 1.56 liters per hour, capable of shelling corn at a rate of 169.90 kg per liter. At a speed of 600 rpm, it requires 1.70 liters of gasoline per hour to shell corn at a rate of 184.69 kg per hour. Meanwhile, at a speed of 700 rpm, there is an increase in fuel consumption by 1.87 liters per hour, with an average of 189.83 kg of corn shelled per liter. Therefore, fuel consumption is the activity of consuming oil fuel itself, intended to meet the energy needs of the combustion engine type, which can be calculated by dividing the total fuel requirements by the time it takes to shell the corn. Fuel consumption during the corn shelling process at motor shelling speeds of 500 rpm, 600 rpm, and 700 rpm can be seen in Figure 1.

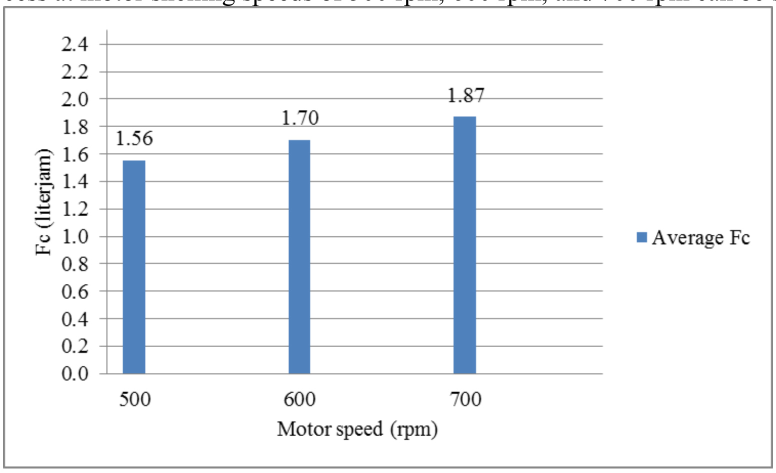

Figure 1. Graph of Fuel Consumption (Fc).

Figure 1 shows that higher shaft rotation speeds lead to greater fuel consumption. This occurs because faster rotations increase the combustion rate inside the engine cylinder, requiring more fuel. This finding aligns with [4], which states that higher engine speeds result in increased fuel consumption due to the greater fuel demand for combustion.

3.2 Storage Capacity

The corn sheller machine with its main structure driven by two pulleys, namely the motor pulley and the sheller pulley. The working principle of the device is that when it is powered by the motor, the sheller pulley rotates simultaneously. In the research results of corn shelling capacity testing at wheel speeds of 500 rpm, 600 rpm, and 700 rpm as shown in Figure 2.

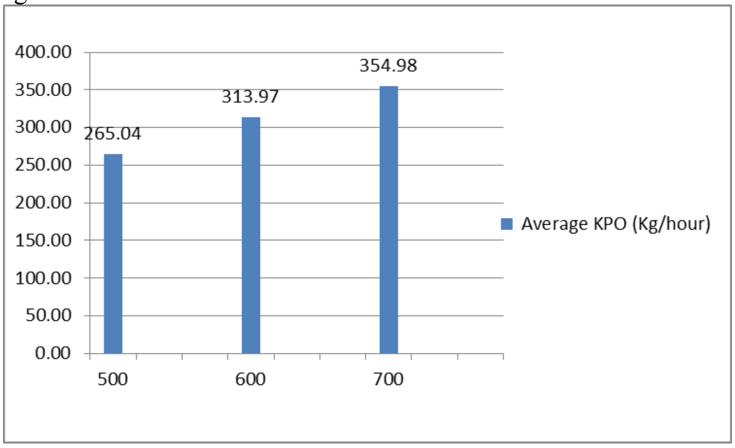

Figure 2. Graph of Storage Capacity.

Figure 2 shows that the first test with a motor speed of 500 RPM resulted in an average output capacity of corn shelling process within 1 hour. This tool can shell as much as 265.04 kg/hour. In the second test, with a motor speed of 600 RPM, the average output capacity within 1 hour was 313.97 kg/hour. For the third test, with a motor speed of 700 RPM, the average output capacity of the corn shelling process within 1 hour was 354.97 kg/hour. The average shelling capacity results indicate that a shaft rotation speed of 700 RPM yields more than the 500 RPM and 600 RPM rotations. Therefore, it can be inferred that higher shaft rotation speed in the corn shelling machine results in greater corn shelling capacity. This aligns with the statement [5], which suggests that the working capacity of the corn shelling machine can be determined by the moisture content of the corn used, thus affecting the machine's rotation speed.

3.3 Percentage of Damaged Seeds

The percentage of damaged seeds is influenced by several factors such as drying time and the speed of cylinder rotation, where the longer the corn is dried, the lower the percentage of damaged seeds will be. Corn before drying has a high moisture content level, which can trigger damage to the corn seeds, ultimately affecting the quality. The moisture content in the material in this study is 18%, which is in line with [6] that one of the important parameters ensuring the quality of corn and the presence of damaged grains is influenced by the moisture level in the corn.

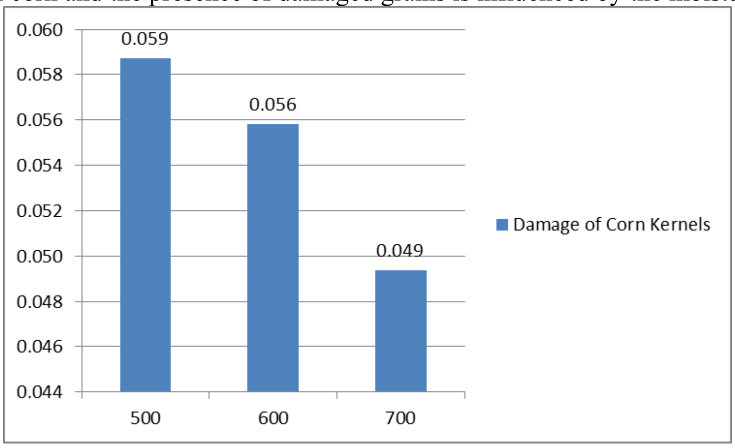

Figure 3. Graph of Percentage of Damage Seeds.

Figure 3 shows that the percentage of damaged corn kernels at three consecutive cylinder rotation speeds, namely 500 rpm, 600 rpm, and 700 rpm, is 0.059%, 0.056%, and 0.049%, respectively. This indicates that the cylinder rotation speed has an influence on the reduction of damaged corn kernels by 0.049% at a cylinder rotation speed of 700 rpm. It suggests that a high level of corn kernel damage occurs at a cylinder rotation speed of 500 rpm, almost causing the sheller cylinder to stall due to the insufficient torque received, resulting in a significant amount of corn experiencing damage and being unable to detach from the cob. According to [6], the breaking of damaged corn kernels is due to corn kernels being trapped on the non-elastic surface of the shelling cylinder, causing a lot of friction that leads to splitting and damage.

In the testing at 700 rpm, with a percentage of damaged kernels of 0.049%, there was a decrease in percentage compared to the speeds of 500 rpm and 600 rpm by 0.06%. If the device's rotation speed is less than 600 rpm, the shelling capacity decreases due to the large number of corn kernels that are not separated from the corn cob. This is consistent with [7]. Several factors can affect the percentage of kernel damage, such as the shelling method, high corn moisture content, and the time required for the material to be processed in the shelling chamber. The longer the processing time, the greater the friction between the corn kernels and the shelling teeth, increasing the likelihood of kernel damage.

3.4 Cleanliness Level

The cleanliness level is a comparison between the weight of corn kernels (whole and damaged) that exit from the primary outlet hole to the total weight of the expelled yield from the same outlet hole, expressed as a percentage. The percentage of cleanliness level at the rotation speeds of the threshing drum shaft at 500 rpm, 600 rpm, and 700 rpm is shown in Figure 4.

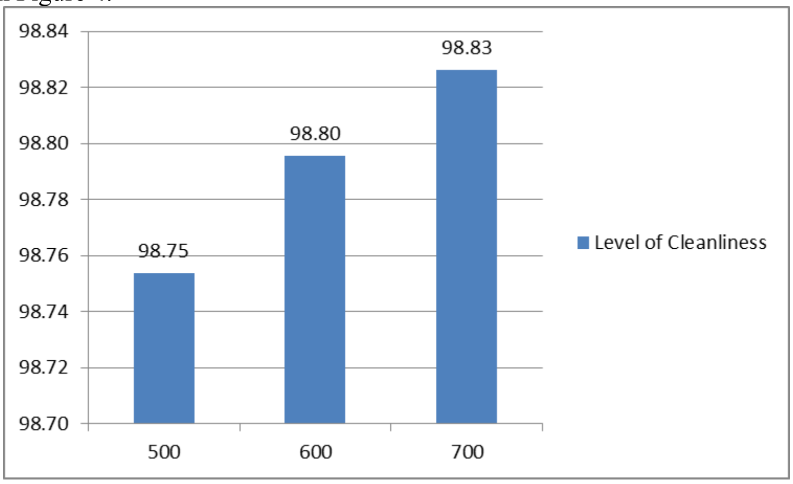

Figure 4. Graph of Cleanliness Level.

Figure 4 shows that the first test with a corn threshing shaft speed of 500 rpm resulted in a cleanliness level percentage of 98.78%. The second test with a corn threshing shaft speed of 600 rpm resulted in a cleanliness level percentage of 98.80%, and a shaft speed of 700 rpm resulted in a cleanliness level percentage of 98.83%. This indicates that the cleanliness level achieved in the corn threshing process is considered high. This is consistent with the research conducted [8], which stated that a cleanliness level of corn kernels above 93% indicates that the threshed corn kernels are already considered clean.

The percentage of cleanliness of the corn kernels obtained from the threshing process increases with higher shaft rotation speed. This is due to the higher shaft rotation speed causing a greater mass of air to be carried by the cleaning blower, making it easier to blow away impurities during the corn threshing process. In the threshing process, the moisture content of the corn kernels also affects the percentage of cleanliness. Lower moisture content in the corn kernels results in lighter impurities in the threshed corn, making it easier for the cleaning blower to remove them. Therefore, it is advisable to determine the moisture content of the corn kernels before threshing. This is supported by the research conducted by [9] ,which found that lower moisture content in corn kernels tends to result in higher cleanliness levels, whether at high or low cylinder rotation speeds. The initial moisture content of corn kernels significantly affects the cleanliness level of the threshed corn kernels.

4. CONCLUSION

Based on the performance test results of the Corn Sheller Machine Without Husk Production at Benteng Tellue Workshop, it can be concluded that:

1. Fuel consumption increases with the increasing rotational speed of the sheller shaft (rpm).
2. The shelling capacity experiences a significant increase due to the influence of the sheller shaft's rotational speed (rpm), which becomes larger.
3. The physical quality of the corn, such as the percentage of damaged kernels, is affected by the cylinder's rotational speed, resulting in a reduction of damaged corn kernels by 0.059% and 0.49%.
4. The cleanliness level of corn kernels with different shaft rotation rates reached an average of 98%, indicating that the cleanliness level produced by the corn shelling process is considered high.

From the conclusion, To minimize fuel consumption, it is recommended to identify and maintain an optimal rotational speed that balances fuel efficiency with shelling capacity. Maintain proper machine calibration and regular maintenance to ensure the consistently high cleanliness level of 98%, as observed during testing.

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