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**Kamlesh Lal**
Department of Farm Machinery and Power Engineering, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh, India

**Amol Prakash**
Department of Renewable Energy Engineering, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh, India

**Corresponding Author:**
**Kamlesh Lal**
Dept. of Farm Machinery and Power Engineering, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh, India

# Design, development and testing of hybrid peanut decorticator

## Kamlesh Lal and Amol Prakash

**Abstract**
The study was conducted at FMPE dept. workshop, SHUATS in May, 2022 to September, 2022, Most manually driven peanut decorticators are designed to shell peanuts for domestic consumption rather than for sale, whereas the majority of groundnut decorticators are electric powered and too expensive for small and marginal farmers to afford. The feeding unit, metering unit, and power transmission system underwent the most significant alteration. By taking into account the impact of mechanical parameters of the machine-like concave clearance, number of oscillations $m^{-1}$, and feed rate, the efficiency of shelling, the percentage of unshelled pods, and the percentage of broken kernels were analysed. In the experiment, it was found that a feed rate of 50 $kghr^{-1}$, 12 mm of concave clearance, and 40 cycles $m^{-1}$ were ideal for hand-operated peanut decorticators since they resulted in reduced percentages of broken kernels and unshelled pods as well as higher shelling efficiency. The machine's efficiency was discovered to be between 85 and 90%. After adjustments were made to the power transmission system, feeding unit, and metering unit (while maintaining the study's parameters), it was discovered that a feed rate of 60 $kghr^{-1}$ at 12 mm of concave clearance and 45 cycles $m^{-1}$ was suitable for peanut decortications in order to reduce the proportion of broken kernels and unshelled pods and increase efficiency. The effectiveness of shelling improves with feed rate, and the ideal feed rate was discovered to be 60 $kghr^{-1}$. Since the machine's efficiency grew to 95% throughout the entire test, it was determined that it functioned satisfactorily.

**Keywords:** Peanut, peanut kernel, decorticator, shelling, shelling efficiency, Unshelled pods

## 1. Introduction
A peanut decorticator is a machine used to remove the outer shell of peanuts (Muktar S.K. *et al*., 2017) [10]. It is an essential tool in the peanut processing industry, where the removal of the outer shell is necessary for the production of various peanut products. The use of peanut decorticators is important for several reasons. One primary reason is that it simplifies the processing of peanuts, making it more efficient and cost-effective. Additionally, the use of decorticators improves the quality of the end products, as it reduces the level of impurities in the kernels. This is especially important for industries that rely on high-quality peanut kernels, such as those in the food and pharmaceutical industries (Sridhar and Murugan, 2013) [14]. A legume, the peanut is a member of the pea and bean families. The only nut that grows underground is the peanut. The peanut plant is a variable annual herb that can reach a height of 50 cm (Shalini *et al*., 2015) [12]. The plant's blossoms grow into a stalk that penetrates the ground and produces a pod that typically contains two seeds (Maria, 2019) [7]. When the plant's leaves turn yellow after around two months, the seeds become ripe. The plant is then taken out of the ground and let to dry. They are removed from the plant after three to six weeks. The "monarch" of oilseeds is referred to as the peanut (Kumar and Popat, 2010) [5]. It is among the most significant food and income crops in our nation. Peanuts are a rich source of calcium, iron, and vitamin B complex, including thiamine, riboflavin, niacin, and vitamin A. On average, they also contain 40.1% and 25.3% of protein. It is a cheap product while still being a valuable source of all the nutrients (Long *et al*., 2017) [6]. Other names for peanuts include "miracle nut" and "poor man's cashew nut." (Khon khen, 2012) [4]. China produces the most peanuts, accounting for around 41.5% of global production. China is followed in production by India (18.2%), Nigeria (7.57%), the United States (5.27%), Indonesia (3.86%), and Sudan (3.37%). Asia is where most peanuts are grown (Talawar, 2019) [13]. Together, China and India produced 58.74% of the world's peanuts. In terms of area, China came in second with 19.37% of the global share, followed by Nigeria (10.58%), Sudan (7.88%), and India (30.33%). The process of cracking peanut pods is known as "decorticating." Shelling peanuts also involves

physically breaking the shell with the thumb (Kabir & Fedele 2018). However, this procedure is not appropriate for high quality because it requires a lot of time and shelling money. Because of the extremely low yield worker-1h-1, shelling is expensive and causes worker weariness. If a peanut decorticator is created and modified, this can be decreased. The adjustment is both well-justified and extremely desirable (Putnam *et al*., 2023). The effectiveness of a hand-operated peanut decorticator is likewise lower, and a higher percentage of the kernels are shattered (Mishra, A. *et al*., 2009) [9]. Therefore, it imperative to modify the hand-operated peanut decorticator to increase its effectiveness and reduce worker fatigue (M. Ugargol *et al*., 2022) [8]. India is a major producer and consumer of peanuts, and the use of decorticators is crucial in the peanut processing industry. The demand for peanut decorticators in India has been increasing over the years, as the peanut industry grows and becomes more competitive (Nautiyal *et al*., 2016) [11].

## 2. Materials and Methods

Major headings are to be column centered in a bold font without underline. They need be numbered. "2. Headings and Footnotes" at the top of this paragraph is a major heading.

### 2.1 Materials

The major modifications were done in the feeding unit, power transmission system.

In transmission systems following materials were used as per the need. These materials are:

1. **Angle iron:** Angle iron made of mild steel was used. It's thickness was 0.5 mm. it was cut to desired length as per the need.
2. **Rod:** Rod of diameter 1.25 was taken for the frame. This frame was made in the shape of triangle. Rod was also used for the handle. It is made of mild steel
3. **Sprocket and chain:** The power from the pedal drive was transferred to the rocker arm for the shelling process using a chain and sprocket drive. High grade steel or malleable iron were used to make the chain and sprocket. Chain length was 1700 mm, driver sprocket diameter was 120 mm, and driving sprocket diameter was 170 mm. Driving sprocket and driver sprocket had 33 and 47 teeth, respectively.
4. **Bushing:** Two gudgeon pins were used as bushing. It was made up of alloy steel. The external diameter was 30 mm and the internal diameter was 20 mm. one bushing was welded to the frame while the other was fixed using nuts and bolts for easy dismantling of rocker arm and rasp-bars assembly.
5. **Paddle:** A cycle pedal with shaft was fixed on bicycle frame (made of mild steel) as the height of 250 mm from the ground to transmit the generated power to the rocket arm for shelling operation.
6. **Shaft:** The machine had three shafts: the main shaft, the crankshaft, and the feeder shaft. The primary shaft's length was 420 mm, and its diameter was 25 mm. The shafts were supported by bushings. The feeder shaft had a diameter of 12 mm and a length of 420 mm. Two shaft-blocks on an inclined iron frame held the feeder shaft. Mild steel was used to make each of the three shafts.
7. **Ball bearing:** A ball bearing is a specific kind of rolling-element bearing that uses balls to keep the bearing races apart. A ball bearing's main functions are to support radial and axial loads and lessen rotational friction. Stainless steel is usually used in its construction. The machine used four ball bearings, one of which was soldered to the crank that connected to the connecting rod (dia. 45 mm). One was fixed to the circular plate with a 20 mm diameter that was fixed to one end of the feeder shaft, and two were fixed to the crankshaft that was protected by a shaft block.
8. **Crank:** A crank was used in the machine at one end of the crank shaft attached to the driving gear. It was made up of a MS flat iron of size 30 mm x 7 mm and length150 mm. A ball-bearing was welded on another end of crank that attached with connecting rod.
9. **Connecting rod:** Length of connecting rod was 350 mm and it was made up of MS flat iron of size 25 x 4 mm. It was used to transport generated energy from crank to rocket arm.
10. **Pulley:** A pulley was used in the machine of diameter 700 mm. It was made of cast iron. A flywheel stores energy when the supply is in excess and releases energy when energy is in deficit thus it controls the speed variations of crankshaft.
11. **Shaft support blocks:** Shaft support blocks are utilised for end or intermittent support in situations with light loads and minimal shaft deformation. Shaft support blocks make it possible to clamp shafts and do away with the requirement for fasteners to keep the shaft in place. They are constructed from malleable iron. The machine uses two blocks to support the crankshaft.
12. **Seat:** Seat was adjusted on the frame at a height of 85 cm. the seat was made of plastic. For the comfort of operator, a leather covering could be kept over it.

In the feeding unit some minor modifications were done using following materials:

**1. Flat iron sheet**

A Flat iron sheet of 0.2 mm was taken and mounted at a certain arc to cover the feeding cup. This was done to avoid the falling of peanut kernel from the feed hopper.

**2. Flat iron**

Flat iron was taken of 0.5 mm thickness as per the need.

**3. Nut and bolts**

Nuts and bolts of different diameters were used for the proper adjustment of the different components of the manually operated peanut decorticator.

**4. Washer**

Washers of different diameters were used for proper adjustments and to avoid the wear of the parts due to friction.

These materials were used for the modification of the manually operated peanut decorticator. These materials were employed to construct the paddle operated peanut decorticator and modify the feeding unit. The major modifications done in the hand operated peanut decorticator was:

1. Feed cup cover.
2. Metering of feed cup.
3. Power transmission system.
4. Shovel for husk removing.
5. A seat with a view to impact less fatigue to the operator.

### 2.2. Isometric design of Peanut Decorticator

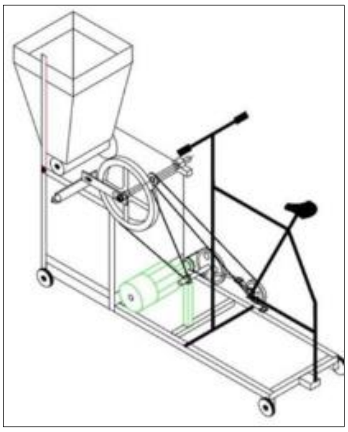

**Fig 1:** Isometric view of a hybrid peanut decorticator

### 2.3. Methods

To ensure the smooth functioning of the machine, the operator was made to sit on the seat for testing of the machine. The machine was operated at a uniform speed without feeding peanuts to shelling units. To checks whether the functioning of the machine was smooth and all the parts are properly functioning for the test to be conducted, the machine was run for 30 m.

Then a certain amount of peanut was fed to the shelling unit by opening the shutter. The machine was run and that time of feeding and rotation speed was noted using a stop-watch. Then the weight of broken kernels, unbroken kernels, peanut shells and unshelled pods was taken for various oscillations were noted using stop-watch.

Four replications were taken for each test conducted to calculate the effects of concave clearance and feed-rate for calculating the shelling efficiency, percentage of unshelled pods and percentage of broken kernels

### 2.4 Performance evaluation of peanut decorticator deals with the following terms

### 2.4.1 Decorticating efficiency

The decorticating efficiency is the ratio of actual weight of shelled material to the total weight of Peanut fed into the machine expressed in percentage.

Decorticating efficiency (%) =

$$\frac{\text{Weight of Shelled material (Kg)}}{\text{Total Weight of Peanut feed (Kg)}} \times 100 \qquad (1)$$

**2.4.2 Broken kernels percentage:** Broken kernels percentage is the ratio of the weight of broken kernels to the total weight of kernels

$$\text{Broken kernels (\%)} = \frac{Weight\ of\ Broken\ Kernel\ (Kg)}{Total\ Weight\ of\ Kernel\ (Kg)} \times 100 \qquad (2)$$

**2.4.3 Unshelled pods percentage:** Unshelled pods percentage is the ratio of unshelled pods to the weight of the Peanut input (kg)

$$\frac{Weight\ of\ unshelled\ pods\ (kg)}{Total\ Weight\ of\ Peanut\ fed\ (Kg)} \times 100 \qquad (3)$$

### 3. Results and discussion

The analysis and interpretation of the experimental data obtained during the testing of the modified peanut decorticator is taken into account in this chapter.

### 3.1. Effect of the concave clearance on the decorticating efficiency, unshelled pods and broken kernels

The relationship between the concave clearance and decorticating efficiency are presented in table 1 and 2, at constant rate of oscillation and feed-rate. The test was performed taking into account four values of concave clearance i.e., 8 mm, 10 mm, 12 mm and 14 mm. The figure 2 shows that with increase in concave clearance, shelling efficiency increased at initial stage to attain a curve with peak value and then the curve decreased in the end. This behavior was perhaps due to the fact that at 12 mm concave clearance, the compaction between the concave and rasp-bar was perfect. Hence, at 12 mm concave clearance the shelling efficiency was found to be quiet high attaining a value of around 95.33%. Also, it was found from the graph that the percentage of unshelled pods gradually fell from (4.00%) beyond the unshelled pods percentage increased (16.00%) it was due to reduction in compaction between the concave clearance and the rasp-bar, beyond that the clearance was too much therefore the compaction was decreased insufficiently, as the concave clearance was too much therefore the compaction was decreased insufficiently as the concave clearance increased. It was noticed from the graph that the broken kernels percentage slightly decreased as the concave clearance increased. It may be due to the reduction in compaction between rasp-bar and concave clearance.

Table 1: Effect of concave clearance on the shelling efficiency, percentage of unshelled pods and broken kernels pedal operated.

| Concave clearance (mm) | Weight of Peanut fed (kg) | Weight of Decorticat or peanut (kg) | Weight of Kernels (kg) | Weight of Broken Kernels (kg) | Percent Broken Kernels (%) | Average Percent of Broken kernels (%) | Weight of Unshelled Peanut (kg) | Percent of Unshelled Peanut (%) | Average Percent of Unshelled Peanut (%) | Shelling Efficiency (η) | Average Percent of Shelling Efficiency (ηA) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.5 | 0.438 | 0.403 | 0.029 | 4.71 | | 0.062 | 12.4 | | 87.6 | |
| 8 | 0.5 | 0.433 | 0.412 | 0.027 | 6.55 | 6.57 | 0.062 | 13.4 | 13.73 | 86.6 | 86.26 |
| | 0.5 | 0.432 | 0.343 | 0.029 | 8.45 | | 0.077 | 15.4 | | 84.6 | |
| | 0.5 | 0.4 | 0.313 | 0.039 | 9.9 | | 0.1 | 20 | | 80 | |
| 10 | 0.5 | 0.438 | 0.333 | 0.033 | 9.91 | 9.48 | 0.062 | 12.4 | 15.6 | 87.6 | 84.4 |
| | 0.5 | 0.428 | 0.37 | 0.032 | 8.65 | | 0.072 | 14.4 | | 85.6 | |
| | 0.5 | 0.44 | 0.375 | 0.017 | 4.55 | | 0.06 | 12 | | 88 | |
| 12 | 0.5 | 0.433 | 0.327 | 0.019 | 5.81 | 5.56 | 0.067 | 13.4 | 13.6 | 86.6 | 86.4 |
| | 0.5 | 0.423 | 0.337 | 0.021 | 6.34 | | 0.077 | 15.4 | | 84.6 | |
| | 0.5 | 0.42 | 0.372 | 0.007 | 1.88 | | 0.08 | 16 | | 84 | |
| 14 | 0.5 | 0.416 | 0.386 | 0.009 | 2.33 | 2.03 | 0.084 | 16.8 | 16.93 | 83.2 | 83.06 |
| | 0.5 | 0.41 | 0.423 | 0.008 | 1.89 | | 0.09 | 18 | | 82 | |

Table 2: Effect of concave clearance on the shelling efficiency, percentage of unshelled pods and broken kernels of power operated

| Concave clearance (mm) | Weight of peanut fed (kg) | weight of Decorticated peanut (kg) | Weight of Kernels (kg) | Weight of broken kernels (kg) | Percent Broken Kernels (%) | Average Percent Broken Kernels (%) | weight of Unshelled Peanut (kg) | Percent of Unshelled Peanut (%) | Average Percent of Unshelled Peanut (%) | Shelling efficiency (η) | Average percent of shelling efficiency (ηA) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.5 | 0.45 | 0.391 | 0.024 | 5.33 | | 0.05 | 10 | | 90 | |
| 8 | 0.5 | 0.432 | 0.393 | 0.029 | 7.38 | 6.83 | 0.048 | 9.6 | 10.13 | 90.4 | 89.87 |
| | 0.5 | 0.466 | 0.399 | 0.031 | 7.77 | | 0.054 | 10.8 | | 89.2 | |
| | 0.5 | 0.448 | 0.391 | 0.029 | 6.92 | | 0.052 | 10.4 | | 89.6 | |
| 10 | 0.5 | 0.46 | 0.433 | 0.034 | 7.85 | 6.91 | 0.04 | 8 | 9.33 | 92 | 90.67 |
| | 0.5 | 0.452 | 0.413 | 0.027 | 5.97 | | 0.048 | 9.6 | | 90.4 | |
| | 0.5 | 0.47 | 0.348 | 0.015 | 4.31 | | 0.03 | 6 | | 94 | |
| 12 | 0.5 | 0.48 | 0.427 | 0.019 | 4.45 | 4.22 | 0.02 | 4 | 4.67 | 96 | 95.33 |
| | 0.5 | 0.48 | 0.461 | 0.018 | 3.1 | | 0.02 | 4 | | 96 | |
| | 0.5 | 0.44 | 0.39 | 0.008 | 2.1 | | 0.06 | 12 | | 88 | |
| 14 | 0.5 | 0.46 | 0.389 | 0.009 | 2.31 | 1.93 | 0.4 | 8 | 12 | 92 | 88 |
| | 0.5 | 0.42 | 0.351 | 0.007 | 1.37 | | 0.08 | 16 | | 84 | |

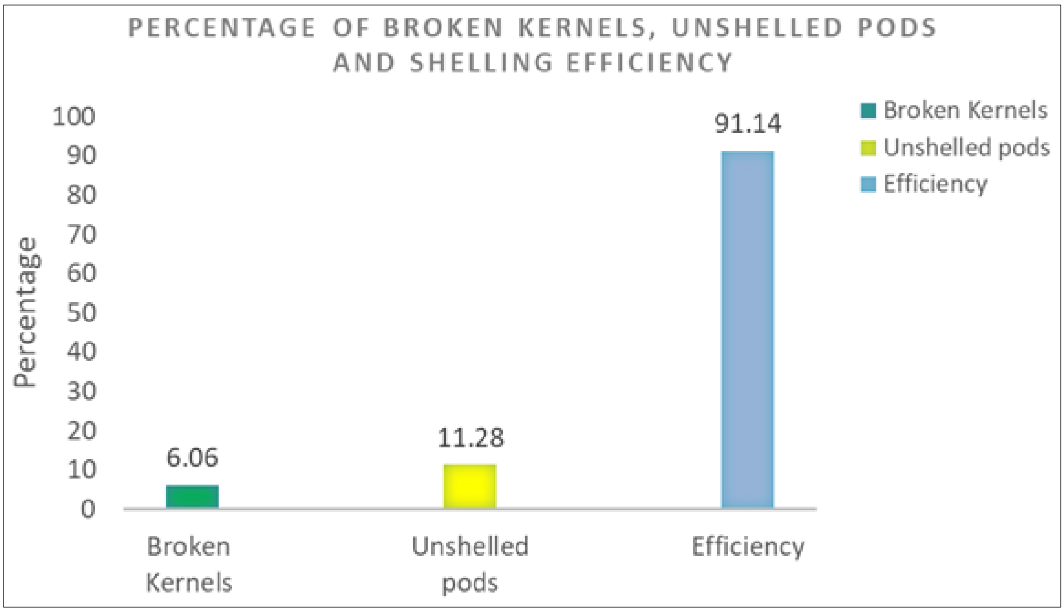


**Fig 2:** Effect of Concave Clearance on shelling efficiency, percentage of unshelled and broken Kernels, in pedal operated Peanut Decorticator

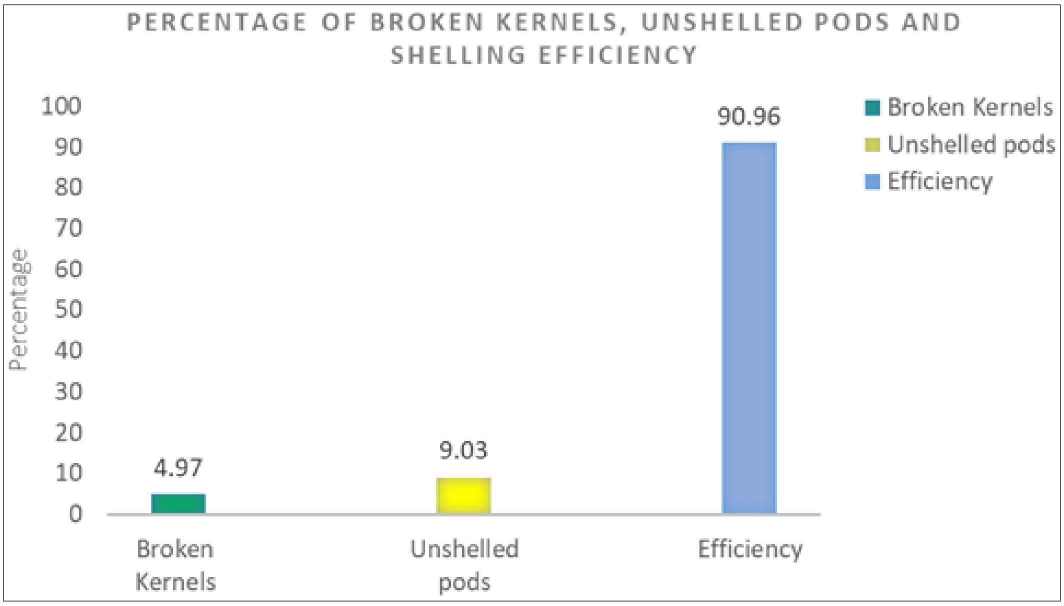


**Fig 3:** Effect of Concave Clearance on shelling efficiency, percentage of unshelled and broken Kernels, in Power operated Peanut Decorticator

### 3.2 Effect of the feed-rate on the decorticating efficiency, unshelled and broken kernel

The relationship between the feed-rate and decorticating efficiency are presented in Table 3 and 4, at constant rate of oscillations and concave clearance. It was clear from the figure 4 and 5, that with the higher feed-rate, the shelling efficiency increases in the initial stages but as the process continues the shelling efficiency fall back to lower values. This was found to be due to the compaction between the concave and rasp-bar, at 60 kgh$^{-1}$. it was also noticed that the unshelled pod percentage gradually decreased up to a certain value i.e. at limit value of 9.94%, beyond which the value increased. Since compaction was less during the initial stages (50 kgh$^{-1}$), after which the value gradually increased at 65 kgh$^{-1}$, beyond this value the compaction was not possible and the pods passed through the sieve without undergoing decortications. It was noticed from the graph that the broken kernels percent gradually increased with increase in the feed-rate. This behavior was perhaps due to fact that with higher feed-rate, the broken kernels percentage increased.

Table 3: Feed rate on the shelling efficiency, percentage of unshelled pods and broken kernels of pedal operated

| Feed rate (kg/h) | Weight of peanut fed (kg) | weight of Decorticated peanut (kg) | Weight of Kernels (kg) | Weight of broken kernels (kg) | Percent Broken Kernels (%) | Avg. Percent Broken Kernels (%) | weight of Unshelled Peanut (kg) | Percent of Unshelled Peanut (%) | Avg. Percent of Unshelled Peanut (%) | Shelling efficiency (η) | Average percent of shelling efficiency (ηA) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.5 | 0.457 | 0.354 | 0.012 | 3.39 | | 0.043 | 8.6 | | 91.4 | |
| 50 | 0.5 | 0.45 | 0.38 | 0.018 | 4.73 | 4.47 | 0.05 | 10 | 8.53 | 90 | 91.47 |
| | 0.5 | 0.465 | 0.34 | 0.018 | 5.29 | | 0.035 | 7 | | 93 | |
| | 0.5 | 0.423 | 0.345 | 0.021 | 6.08 | | 0.077 | 15 | | 84.6 | |
| 55 | 0.5 | 0.448 | 0.396 | 0.023 | 5.8 | 5.2 | 0.052 | 10 | 11.45 | 89.6 | 88.4 |
| | 0.5 | 0.427 | 0.375 | 0.014 | 3.73 | | 0.073 | 14.5 | | 91 | |
| | 0.5 | 0.455 | 0.378 | 0.029 | 7.67 | | 0.045 | 9 | | 90 | |
| 60 | 0.5 | 0.45 | 0.38 | 0.024 | 6.31 | 7.99 | 0.05 | 1 | 10.53 | 87 | 88.14 |
| | 0.5 | 0.437 | 0.33 | 0.033 | 10 | | 0.063 | 12 | | 87.4 | |
| | 0.5 | 0.433 | 0.346 | 0.019 | 5.49 | | 0.067 | 13 | | 86.6 | |
| 65 | 0.5 | 0.435 | 0.339 | 0.019 | 8.55 | 7.55 | 0.065 | 13 | 12.03 | 87 | 87.07 |
| | 0.5 | 0.438 | 0.36 | 0.031 | 8.61 | | 0.062 | 12.4 | | 87 | |

Table 4: Feed rate on the shelling efficiency, percentage of unshelled pods and broken kernels of power operated

| Feed rate (kg/h) | Weight of peanut fed (kg) | weight of Decorticated peanut (kg) | Weight of Kernels (kg) | Weight of broken kernels (kg) | Percent Broken Kernels (%) | Average Percent Broken Kernels (%) | weight of Unshelled Peanut (kg) | Percent of Unshelled Peanut (%) | Average Percent of Unshelled Peanut (%) | Shelling efficiency (η) | Average percent of shelling efficiency (ηA) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.5 | 0.441 | 0.349 | 0.014 | 4.01 | | 0.064 | 12.8 | | 88.2 | |
| 50 | 0.5 | 0.427 | 0.332 | 0.02 | 6.02 | 5.04 | 0.079 | 15.8 | 12.07 | 85.4 | 89.33 |
| | 0.5 | 0.472 | 0.373 | 0.019 | 5.09 | | 0.034 | 7.6 | | 94.4 | |
| | 0.5 | 0.452 | 0.351 | 0.018 | 5.13 | | 0.055 | 12.17 | | 90.4 | |
| 55 | 0.5 | 0.458 | 0.36 | 0.016 | 4.44 | 5.03 | 0.047 | 10.26 | 10.04 | 91.4 | 91.93 |
| | 0.5 | 0.469 | 0.381 | 0.021 | 5.51 | | 0.036 | 7.68 | | 93.8 | |
| | 0.5 | 0.47 | 0.351 | 0.023 | 6.55 | | 0.061 | 12.95 | | 94 | |
| 60 | 0.5 | 0.471 | 0.342 | 0.024 | 7.02 | 6.28 | 0.047 | 9.98 | 9.94 | 94.2 | 93.73 |
| | 0.5 | 0.465 | 0.398 | 0.021 | 5.28 | | 0.032 | 6.88 | | 93 | |
| | 0.5 | 0.458 | 0.378 | 0.031 | 8.2 | | 0.047 | 6.88 | | 91.6 | |
| 65 | 0.5 | 0.439 | 0.351 | 0.027 | 7.69 | 7.91 | 0.082 | 18.68 | 13.07 | 87.8 | 89.6 |
| | 0.5 | 0.447 | 0.382 | 0.03 | 7.85 | | 0.01 | 13.65 | | 89.4 | |

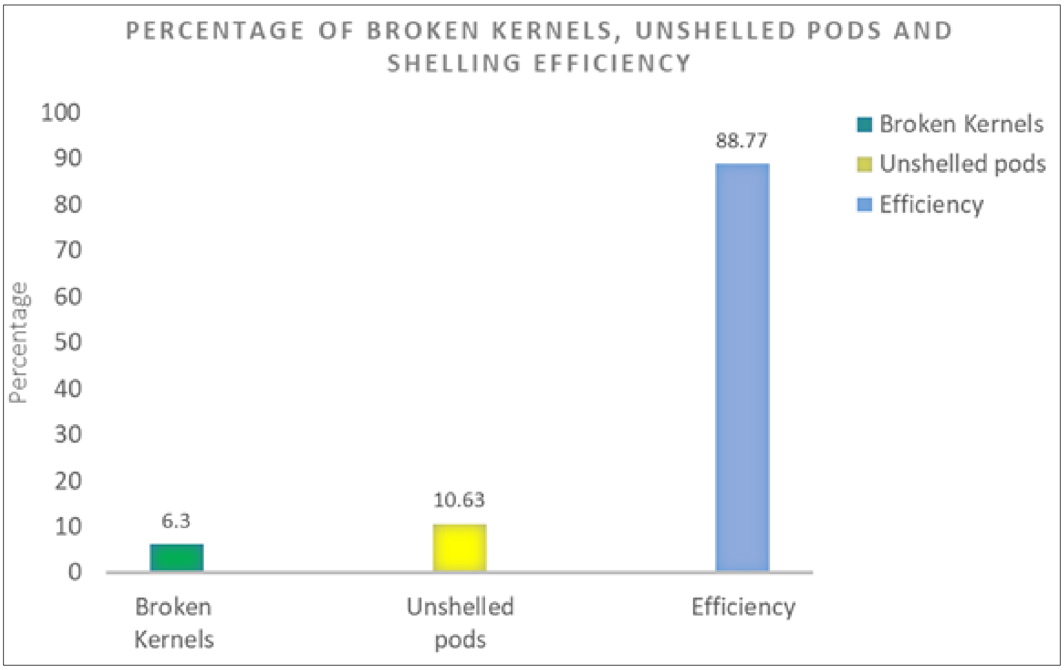


**Fig 4:** Effect of feed rate on shelling efficiency, percentage of unshelled and broken pods kernels in Pedal Operated Peanut Decorticator

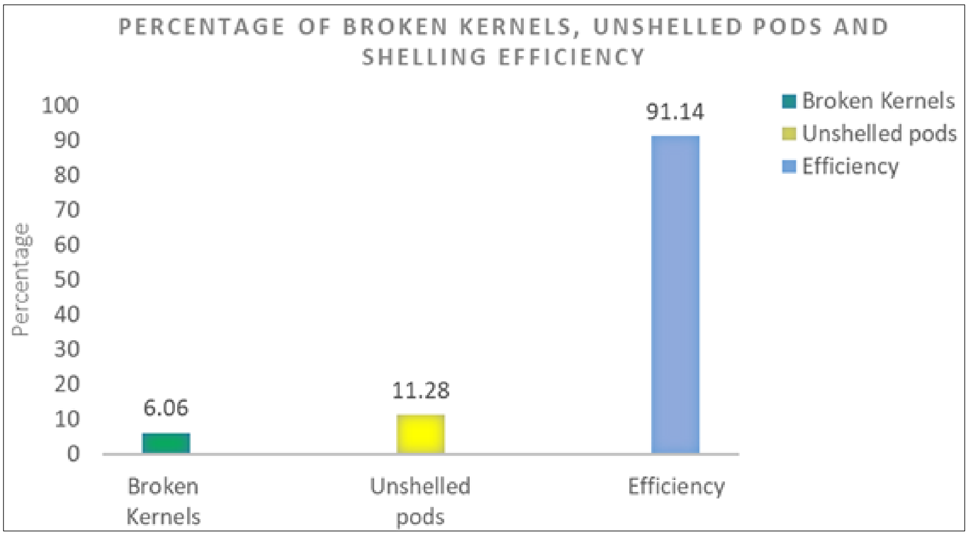


**Fig 5:** Effect of feed rate on shelling efficiency, percentage of unshelled and broken pods kernels in Power Operated Peanut Decorticator

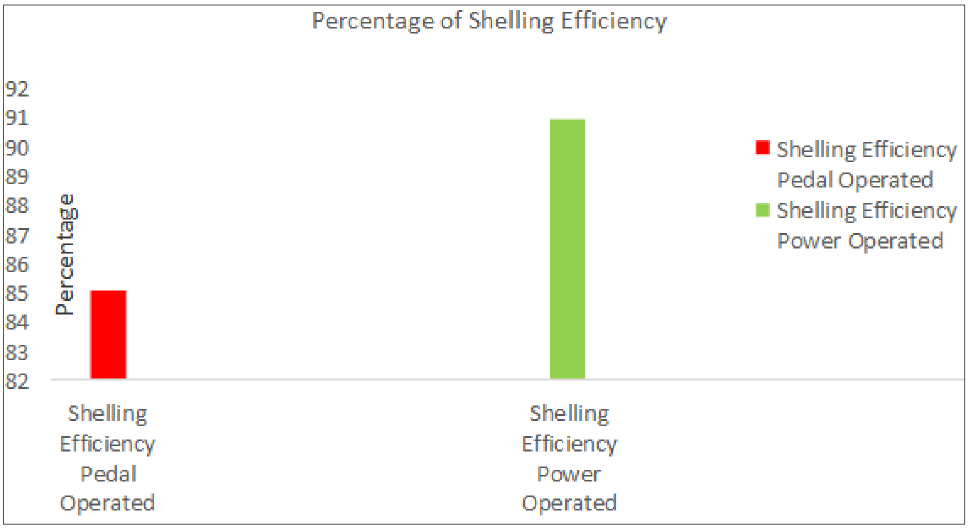


**Fig 6:** Comparison between Shelling Efficiency of hand operated Peanut Decorticator at different Concave Clearance

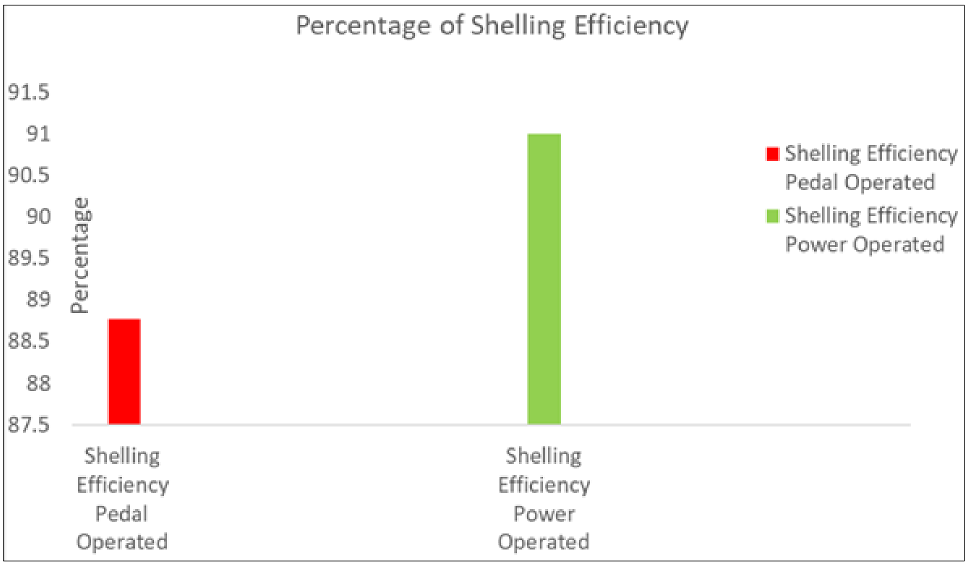


**Fig 7:** Comparison between Shelling Efficiency of Pedal operated Peanut Decorticator and Power Operated Decorticator at different Feed Rate

## 4. Conclusion

Based on the analysis of experimental data as obtained from the test conducted on the peanut decorticator, the working of all the components of the modified peanut decorticator was found satisfactory during the test.

The decorticating efficiency of the modified Pedal Operated machine was 90% at 12 mm concave clearance. The percentage of broken kernels and the percentage of unshelled pods were 10% and 15% respectively at the feed rate.

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