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Performance Evaluation of a Modified Mobile Melon Depodding Machine

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Abstract
Melons, a vital crop rich in proteins and oils, are predominantly cultivated in West Africa and used extensively in local cuisines. This study focused on the performance evaluation of a modified mobile melon depodding machine, designed to overcome the limitations of stationary, electricity-dependent machines through enhanced mobility and a petrol engine. The machine's efficiency was assessed at various operating speeds (230, 255, 272, 287, and 310 rpm), examining metrics such as seed and pulp discharge efficiencies, depodding efficiency, material discharge efficiency, and overall efficiency. Results revealed that seed discharge efficiency ranged between 66.50% and 70.61%, and pulp discharge efficiency increased with speed, reaching up to 90.18%. The optimal performance was noted at 272 rpm with a depodding efficiency of 89.05% and an overall efficiency of 69.10%. These findings underscore the modified machine's capacity to enhance melon seed extraction processes significantly, providing a robust solution for agricultural productivity in areas lacking electrical infrastructure.

Keywords: Melon, depodding, operating speeds, material discharge, pulp discharge, efficiency

INTRODUCTION
Melon is a protein and oil rich crop that is majorly found in West Africa. Its botanical name is *Citrullus lanatus thumb masf* , it belongs to the gourd family of plants and is popularly known locally as *Egusi*. Physically it resembles watermelon in appearance. When a typical melon pod is bisected both transversely and longitudinally, it would be observed that in the transverse section of the pods, the seeds are arranged in a circular manner while in the longitudinal section, the seeds are arranged in a way that looks like an oval shape. The seed coats are flattened, reddish brown, black or white at the edges depending on the variety. They are covered with a thin shell having a thick ring around the edges (Okokon *et al*, 2015). The seeds are extracted and used for food. The crop is also an important component of the traditional cropping system and it is usually interplanted with staple crops such as maize, cassava, sorghum, etc. (Omidiji *et al.,* 1985).

Melon seeds have high protein and fat content. The oil content range from 30 to 50% which is comparable to other oil plants (Omidiji, 1997). Oil can also be extracted from the seeds when it is roasted and grounded. The solid portion that is left after the extraction of oil is used to make snacks. The oil and solid portion are also used for preparation of local soup or stew.

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(Agbetoye *et al*, 2013). Egusi melon pods have an almost spheroidal external shape and an ellipsoidal seed cavity (*Nwosu*, 1988 and Chen *et al*., 1996) . Processing operations performed on melon after harvesting include cleaning, fermenting, depodding, washing, drying and shelling (Jackson *et al*, 2010). Most of these operations have still been done manually.

Depodding is the process of separating the seeds from the seeds bearing melon pods. When this operation is done manually, it is tedious and time consuming. Several researchers have designed and fabricated different melon depodding machines. These include Oloko and Agbetoye (2016), Akubuo and Odigboh (1999), Oloko *et al*, (2002), Nwakuba (2016) , Agbetoye *et al*, (2013), Adebayo and Olaoye (2020) and Ogiemudia *et al*, (2020). These existing machines are powered by electric motors which make their use to be stationary and limited to areas where there is availability of electricity. A modification of existing melon depodding machine that is powered by a petrol engine was therefore designed and fabricated at the Department of Agricultural and Bio-resources Engineering, Federal University of Agriculture, Abeokuta. The machine can be used on the field and in areas where there is no electricity. Wheels were also added to make it mobile so that it can be pushed form one place to the other on the field. This study was therefore carried out to evaluate the performance of the modified mobile melon depodding machine. It introduces an innovative modified mobile melon depodding machine tailored for field operations, circumventing the constraints of stationary, electricity-dependent alternatives. Distinguished by its petrol engine and mobility-enhancing design, the machine significantly elevates depodding performance across a range of operating speeds. This modified mobile melon depodding machine not only surpasses previous stationary models in operational flexibility but also in efficiency metrics, marking a pivotal advancement in melon depodding technology and offering substantial productivity gains for agriculture in regions lacking electrical infrastructure.

METHODOLOGY

Description of the machine

The melon depodding machine (Figs. 1 and 2) consists of the following components the hopper, the deppoding chamber, discharge outlets (upper and lower outlets), a 7:1 speed reduction gear , a petrol engine of 6.5 horsepower and the frame. The hopper was a hollow frustum of a triangular prism with top dimension of 350 mm X 350 mm and base diameter of 60 mm X 60 mm. It has a height of 300 mm. It serves as inlet for admitting the fermented pods into the depodding chamber. The depodding chamber is cylindrical in shape. It is of diameter 350 mm and 1270 mm long. It houses a shaft of diameter 30 mm that bears spirally arranged spikes. The lower outlet is where the extracted seeds are collected while chaff and pulp are collected in the upper outlet. The petrol engine is the power source and the reduction gear helps to reduce the speed output of the engine. The frame serves as the support on which all the components are mounted.

Figure 1. Picture of the Melon depodding machine

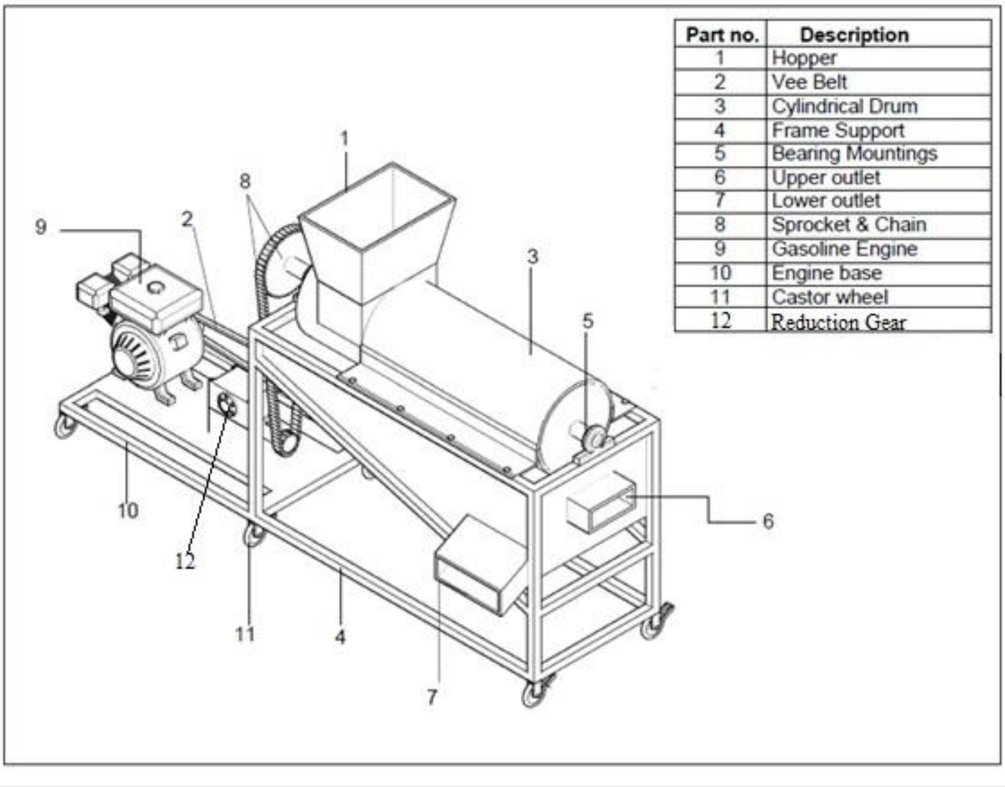

Figure 2. Isometric drawing of the machine

Mode of operation of the melon depodding machine

Fermented melon pod is fed into the machine through the hopper. The rotating spikes apply impact forces on the pods and in the process separating the seeds from the pulp and pods. Water is manually added to aid the separating process. The separated seeds find their way through perforations in the concave below the spikes and are collected in the lower outlet. The spiral spikes also convey the pulp to the upper discharge outlet.

Performance Test of the machine

The performance test of the machine was done using 'bara' variety of melon. 5 kg of fermented 'bara' pods was fed into the machine at five different speeds of 230, 255, 272, 287, and 310 rpm. The different speeds were obtained by adjusting the choke of the petrol engine into five different marked positions and checking the corresponding output speed of the shaft of the machine using a digital Tachometer DT – 2234A. The machine was operated for about six minutes after which the materials collected at the two outlets were weighed. This was replicated thrice for each speed level. The seed discharge efficiency (Es), deppoding efficiency (Ed) and material discharge efficiency were then calculated using the following expression (Oloko and Agbetoye , 2016; Agbetoye *et al*, 2013).

$$E_S = \frac{M_3}{M_1 x R_S} \quad (1)$$

$$E_d = \frac{M_3 + M_4}{M_1 x R_S} \quad (2)$$

$$E_M = \frac{M_2}{M_1} x\ 100 \quad (3)$$

$$E_P = \frac{M_5}{M_1 - M_1 x R_S} \quad (4)$$

$$E_O = E_d x\ E_M \quad (5)$$

Where,

M_1 is the Mass of fermented melon pod fed into the machine, M_2 is Mass of materials (seed and pulp) discharged after depodding, M_3 is Mass of seeds discharged, M_4 is Mass of depodded but undischarged seeds, M_5 is Mass of pulp discharged, E_S is Seed discharged efficiency, E_P is pulp discharged efficiency, E_d is Depodding efficiency, E_M is material discharged efficiency and E_O is overall efficiency.

Similarly, the ratio or percentage of extractable seed, R_S, per given mass of the melon pod used was determined by manually extracting the seeds in 5 kg of fermented pod. The ratio R_S was then calculated as (Oloko and Agbetoye ,2016);

$$R_S = \frac{\text{mass of seeds manually extracted}}{\text{Mass of fermented melon pods used (kg)}} \text{ X } 100 \quad (6)$$

This was replicated three times and the average taken.

The study meticulously applied methodologies derived from a spectrum of preceding research to evaluate the modified mobile melon depodding machine. Specifically, the performance test protocols and efficiency calculations were guided by methods previously outlined by Oloko and Agbetoye (2016) and Agbetoye *et al.* (2013), ensuring a rigorous and scientifically grounded approach to data analysis. This adherence to established methodologies not only underscores the study's scientific rigor but also situates its findings within the broader context of agricultural engineering research. The innovative adaptation of these methodologies to the machine's evaluation—highlighting its mobility, petrol engine power source, and the addition of wheels for field usability—demonstrates a significant leap in the mechanization of melon depodding processes. Furthermore, the decision to measure a comprehensive range of efficiencies, including seed discharge, pulp discharge, depodding, material discharge, and overall efficiency, reflects a holistic approach to understanding the machine's performance, directly contributing to the advancement of agricultural practices in regions where electric power access is limited.

RESULTS AND DISCUSSIONS

Seed and pulp discharge efficiency

The average seed discharge efficiency obtained at the different speeds ranged from 66.50 to 70.61 rpm. Variation of the speed discharge efficiency with speed shown in Figure 3 shows that speed discharge efficiency increased from 66.50% at 230rpm to 70.61% at 287rpm after which it declined to 69.38 at 310 rpm. Similarly the average pulp discharge efficiency ranged from 62.78 to 80.19%. Variation of the pulp discharge efficiency with speed shown in Figure 4 shows that the lowest was obtained at 230 rpm while the highest was obtained at 310 rpm. This implies that the pulp discharge efficiency increased with increase in speed. This may be due to the fact that the higher the speed the more the materials are conveyed to the pulp discharge outlet. Even at high speed seeds that supposed to pass through seed discharge outlet are conveyed to the pulp discharge outlet. Similar observation was made by Oloko and Agbetoye (2016) with an existing melon depodding machine.

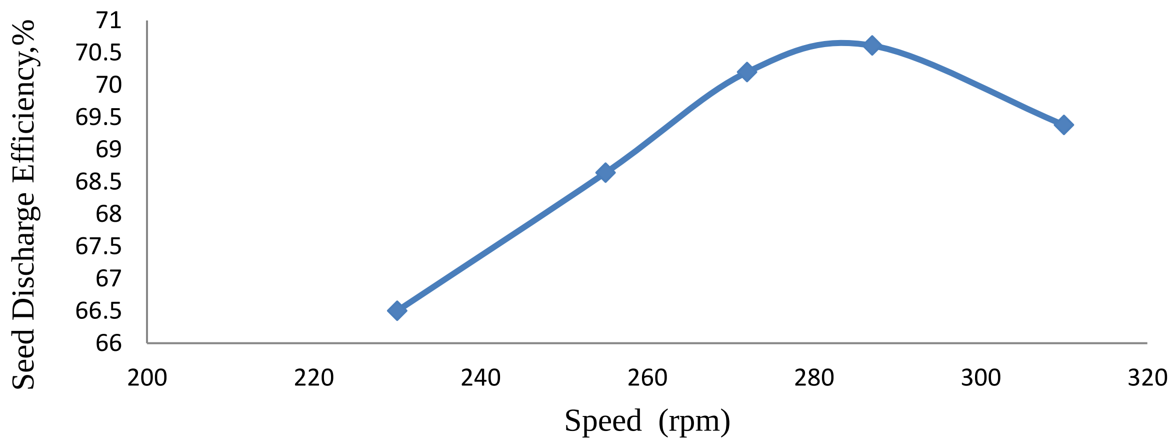

Figure 3. Variation of speed discharge efficiency with speed

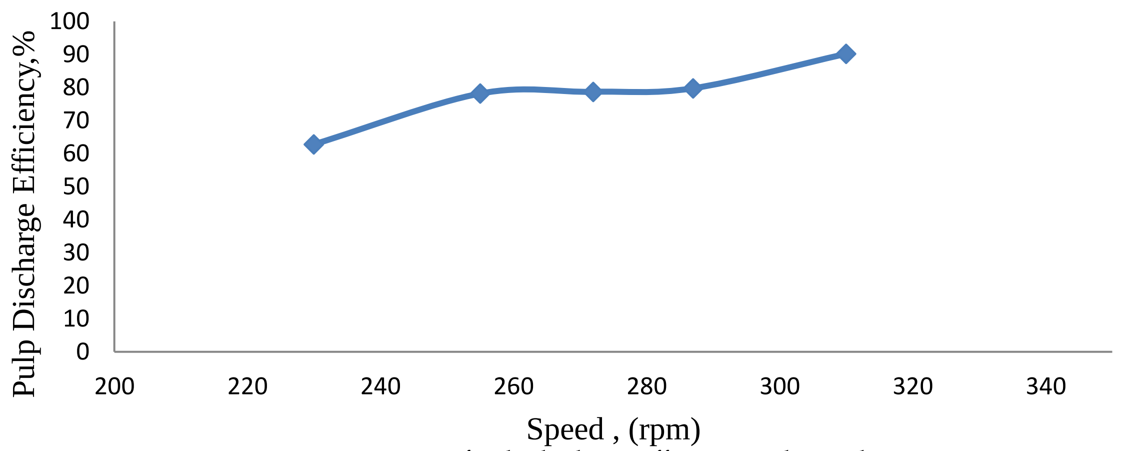

Figure 4. Variation of pulp discharge efficiency with speed

Depodding efficiency

The average depodding efficiency obtained for the machine ranged from 77.69 to 89.05%. Variation of deppoding efficiency with speed shows that depodding efficiency increased as the speed increased from 230 to 272 rpm from 77.69 to 89.05% (Figure 5). It later declined to 78.02% at 310 rpm. This may be due to the fact that at lower speeds (below 272 rpm), the fermented pods had adequate contact with the impact forces of the spikes but at higher speeds (above 272 rpm) the fermented pods are conveyed away to the discharge outlet faster than the impact forces can interact with them.

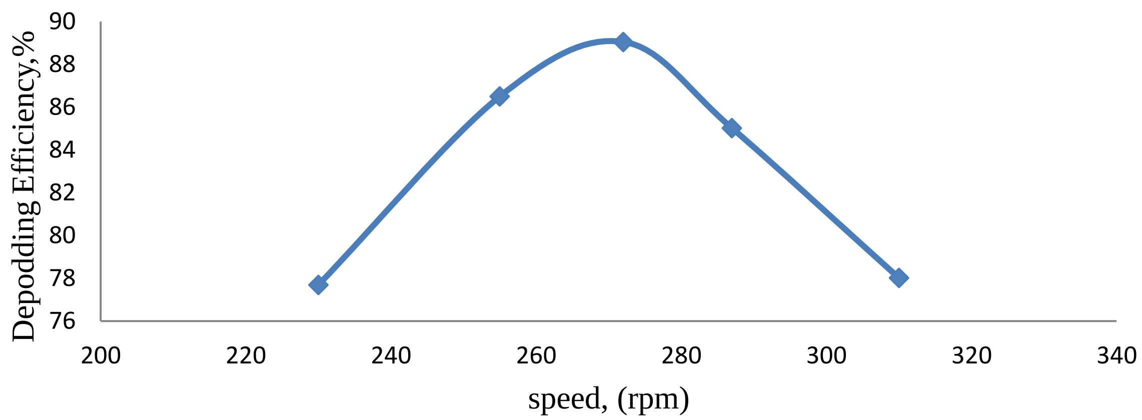

Figure 5. Variation of depodding efficiency with speed

Material discharge efficiency
The material discharge efficiency which represents the ratio of material discharged from the machine to the material fed into it ranged from 68.33 to 87.30%. It also increased as the speed of the machine increased (Figure 6). This is expected since increase in the speed of the machine also increases the speed of the conveyor which also increases the rate materials are discharged from the machine.

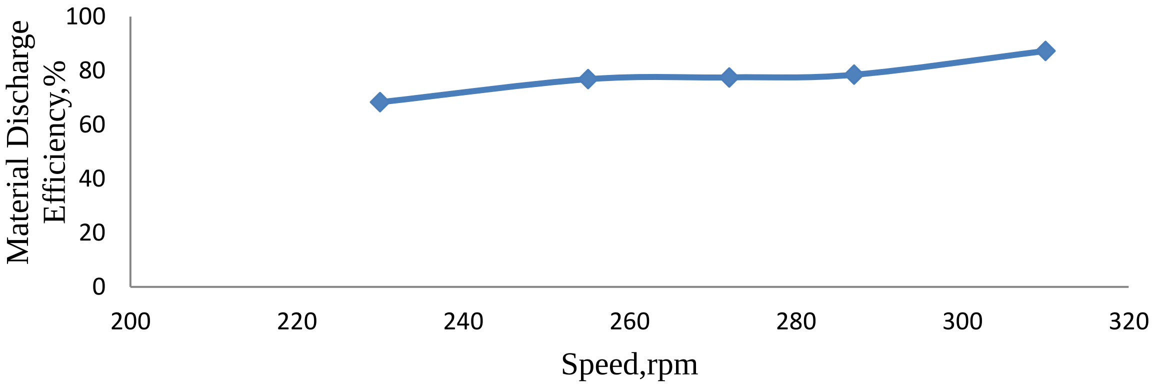

Figure 6. Variation of material discharge efficiency with speed

Overall efficiency
Figure 7 showed the variation of the overall efficiency with speed and the average overall efficiency obtained for the machine ranged from 50.30 to 69.10%. It increased from 50.30% at 230 rpm to the maximum of 69.10% at 272 rpm before declining to 68.66% at 310 rpm. Thus, the speed of 272 rpm gave the best overall efficiency. This is higher than 68.8% of Oloko and Agbetoye (2016) obtained for their machine at 300 rpm but lower than 93.4% at 229 rpm that Agbetoye *et al*, (2013) obtained for their modified machine.

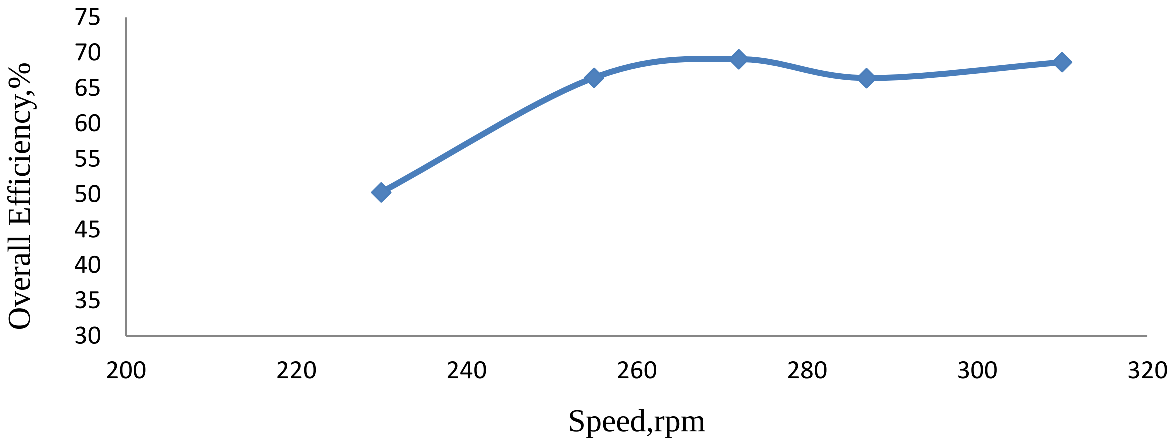

Figure 7. Variation of overall efficiency with speed

These results not only validate the effectiveness of the modified mobile melon depodding machine in enhancing the efficiency of melon seed extraction but also contribute to the broader field of agricultural machinery design and optimization. The study's reliance on established methodologies for performance evaluation, as cited from works such as Oloko and Agbetoye (2016) and Agbetoye et al. (2013), ensures the reliability of the findings and their relevance to ongoing efforts to mechanize agricultural processes, especially in contexts where electricity is not readily available.

CONCLUSION

The performance evaluation of a mobile melon depodding machine was carried out in the operating speed of 230 to 310 rpm. The maximum seed discharge efficiency of 70.20% occurs at 272 rpm. The maximum pulp discharge of 90.18% occurred at 310 rpm. The material discharge efficiency increased from 68.33 to 87.30% as the speed increased from 230 to 310 rpm. The maximum depodding efficiency of 89.05% occurred at 272 rpm while the maximum overall efficiency of 69.10% was obtained at 272 rpm.

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