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# Performance Evaluation of a Multipurpose Wet Sieving Machine

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## ABSTRACT

This study evaluated the performance of a multipurpose wet sieving machine developed for processing maize slurry, cassava, and coconut milk. Wet sieving, a critical operation in food and agricultural industries, enables separating materials based on particle size. The machine was tested at operational speeds of 4.75 and 5.76 m/s to assess throughput capacity, sieving efficiency, and overall performance. Results showed that increasing speed significantly improved throughput and efficiency, with cassava slurry exhibiting the most pronounced relative gain. At higher speeds, the machine achieved efficiencies of 98% for maize, 93% for cassava, and 94% for coconut. Mechanical wet sieving also reduced operator strain compared to manual methods. However, challenges such as higher energy demand and occasional sieve clogging were identified, emphasizing the need for design refinements and optimized operating parameters. The findings demonstrate the machine's potential to enhance agricultural processing by reducing manual labor, minimizing product losses, and improving product quality. Future work should focus on the effects of sieve size, slurry concentration, and speed control to establish optimal conditions and facilitate large-scale applications in food processing industries.

## Introduction

Wet sieving is an essential process in food processing that is used to separate food components based on particle size. It is employed to separate solids from liquids using a sieve, facilitated by a wet sieving machine. Essentially, wet sieving involves separating finer substances from coarser ones using a meshed or perforated vessel [1–4].

This process involves immersing the sample in water and washing it through a sieve, allowing particles to be separated based on their size. Wet sieving is a widely used method in fields such as agriculture, geology, civil engineering, and various industrial applications, and it is commonly employed to determine the particle size distribution of soils and granular materials. These machines function by passing a mix of solid particles and liquid through a sieve, with the liquid washing away smaller particles while retaining larger ones. They are pivotal in separating materials by size and properties across different industries [5].

Wet sieving has been reported to be labor-intensive and time-consuming [6]. Unlike dry milling, the primary objective of wet sieving is to

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segregate and extract grain biopolymers. Water as a medium allows for more efficient sieving by reducing heat generation through friction and facilitating the separation of starch granules from their protein matrix. Additionally, water's superior ability to suspend individual particles, compared to air, aids in their separation based on density. Steeping plays a crucial role in cleanly separating the germ from the endosperm while weakening the bonds between starch granules and the protein matrix, facilitating their separation [6].

Wet sieving is instrumental in washing starch granules and milk from other particles such as fibers and hulls, notably in processing cereal grains such as maize, millet, and cassava, used in local diets and beverages such as pap, Kunun, and Burukutu [7].

To detect a wet sieving machine's efficiency, a performance evaluation is necessary [8]. Recent studies emphasize that performance evaluation identifies the variables influencing machine efficiency and highlights areas for design improvement [9,10].

Despite its importance, challenges remain with wet sieving, including material clogging, lack of standardized testing, and disagreement on efficiency measurement methods [11,12].

To overcome these, multipurpose wet sieving machines have been designed to minimize manual effort and improve productivity [6,13].

## Material and Methods

The machine's components of the multipurpose wet sieving machine are composed of the hopper (A), which is bolted and nuts to the main frame (G); the sieving compartment; and the mixing compartment (C), which is made up of fins suspended in a pipe and welded to a shaft. The shaft is suspended, and the walls of the mixing compartment (B), power transmission (P, O, and N), and outputs (E and H) are sealed with Teflon material (R). The machine has an inclination of 10° with respect to the horizontal as it slopes from the higher base to the lower base. SWG 18 stainless steel sheet is used to make it. Given its duration, all of the milk content would have been thoroughly cleaned by the time the pulp passed through the filter. The machine consists of a single reciprocating sieve (D) that may be adjusted for different crops due to its changeable inclinations and sieve opening widths. Ball bearings support the shaft mountings. An eccentric cam (L) attached at the end of a shaft drives a pulley (P) that is powered by a 1/4-horsepower, 1,325 rpm electric motor, causing the sieve to reciprocate. To lower the speed of the sieve and mixer, transmit 90° angular motion, and utilize a single electric motor, a speed-reducing gear ratio of 1:4 (Q) is integrated. Under the shaking screen, rollers (F) are integrated to guarantee smooth and minimally frictional transmission of oscillatory motion. To increase vibration, the sieve is also spring-loaded. In order for the filtrate to fall through the mesh into a tray (H) below and be collected through the outlet, the material is stirred on the sieve mesh. Through an aperture on the sieve's output end (E), the residual material is released from the sifting chamber. The aperture is designed in such a way that any residue that passes through it would have gathered before exiting. In this manner, before the residue is expelled, all of the starch milk would have been thoroughly cleaned into the down tray. After usage, the machine should be carefully cleaned with clean water to preserve it. It is necessary to remove, drain, and store the mesh in a safe place.

The materials used for the performance evaluation of the multipurpose wet sieving machine are as follows: multipurpose wet sieving machine, fresh agricultural samples (maize, cassava tubers, and coconuts), weighing samples, water supply for slurry preparation, sieves of varying mesh sizes, stopwatch for measuring process durations.

### *Experimental Procedure*

#### *Sample preparation*

The maize, cassava and coconut were sourced from Oja Oba Market in Akure, which is located in Nigeria. The maize underwent washing before soaking to complete a 24-hour period, which resulted in its transformation into a slurry after milling. The cassava roots underwent peeling before being grated and subjected to a 48-hour fermentation process, which ended with the roots being mashed. The coconut processing begins with workers extracting the white flesh from freshly cracked open coconuts. The coconut meat is then grated or shredded into small fragments. The shredded pieces were combined with water, which worked to soften the coconut while extracting milk from the coconut to create an emulsion. The emulsion consists of coconut oil that exists in water as suspended particles. The Federal University of Technology Akure Agricultural Engineering workshop conducted machine testing and performance evaluation for the multipurpose wet sieving machine.

### *Experimental Design*

The research aimed to evaluate the performance of a multipurpose wet sieving machine designed for agricultural processing. The study demonstrated how operational parameters affected throughput capacity, sieving efficiency, and output capacity for different agricultural products which included maize slurry and cassava and coconut milk. A 2x3 experimental design was adopted, considering two operational speeds (4.75 and 5.76 m/s) and three agricultural samples (maize slurry, cassava, and coconut milk). Three experimental repetitions were conducted to establish data credibility. The data collected from the experiment with different agricultural crops were analyzed using both graphical methods and Excel. The graphical method was used to assess the impact of speed on the weight of the sieved maize mash and cassava slurry, the time taken to sieve these materials, and the sieving efficiency of the multipurpose wet sieving machine.

### *Testing procedures*

The testing process began with careful preparation of the wet sieving machine and the materials to assure accurate and dependable outcomes. Samples of maize mash,cassava, and coconut were cleaned and changed into slurries to meet the intended operational requirements. About 3 kg of these materials were mixed with 2 liters of water which created a consistency that permitted effective sieving. The machine required a slight incline to achieve better operational performance while its design allowed for efficient flow and material separation. The machine started to operate when the electric motor activated to power the system which drove the reciprocating sieve through a calibrated speed reduction gear. The motion caused the sieve to move which allowed small particles to go through the two meshes while large particles got pushed through a different exit. The internal mixing fins maintained slurry distribution across the sieve to establish a uniform process that prevented blockages while enabling complete sieving operations. The machine performance assessment occurred at two speeds of 4.75 m/s and 5.76 m/s which tested its ability to process material and its operational efficiency. The team closely watched each operation to see how well different materials worked with the system. The team made modifications to the sieve and other machine parts to solve problems with low motor speed and separation difficulties which enabled the equipment to run optimally during future operations.

The testing process used trays to collect smaller particles which were placed under the sieve while the rest of the materials passed through the waste disposal system. The testing process supplied two types of valuable information about the machine's operational capability and the real weight, as well as screening performance results. The machine performance errors which testers found during testing were corrected through solutions which fixed motor faults and improved screening performance. The demonstration showed how the machine could function as an effective operational system which would enable its use in real field conditions. The performance evaluation of the machine was conducted through three agricultural products which included Maize slurry, cassava, and Coconut at two speed settings of 4.75 m/s and 5.76 m/s using two different mesh sizes. The study collected weight data in kilograms throughputs in kilograms per hour and sieving efficiency results and output capacity in kilograms per hour and exhaustion levels measured in beats per minute. The performance indices were carried out using the following Equations 1, 2 and 3:

Throughput capacity: $CT = Tm/T$ (kg/h) (1)

Where, Tm is the total mass of the cassava or maize fed in (kg), and T is the time taken by the slurry mixture to exit sieve in (hour) [13].

Sieving efficiency: $\eta = W2/W1 \times 100$ (2)

Where, η = Sifting efficiency (%), $W_2$ = Weight of the sieved mash (kg), and $W_1$ = Initial weight of the cereal mash (kg) [14].

Output capacity: $Qc = Wc/T$ (3)

Where, Qc = Output capacity (kg/h), Wc = Weight of the sieved material (kg), and T = Time of sieving (hour) [14].

## Results and Discussion

Recent studies have demonstrated that mechanized wet sieving and sifting systems significantly improve processing efficiency, reduce operator fatigue, and enhance productivity in agricultural processing applications [15–19]. In line with these findings, the results obtained in this study are presented and discussed based on throughput capacity, output capacity, sieving efficiency, and operator exertion under different operating speeds and material conditions. Table 1 indicates throughput capacity results for maize mash, cassava slurry, and coconut milk at two different speed settings of 4.75 m/s and 5.76 m/s. The data demonstrate a positive correlation between speed and throughput capacity. The machine processes all materials at higher speeds since it can handle greater amounts of material within shorter time intervals. Coconut milk exhibited the highest throughput, possibly due to its lower viscosity and ease of sieving. In contrast, cassava slurry showed the lowest throughput, which might be attributed to its higher viscosity and particle size distribution. The results demonstrate that material characteristics will determine optimal speed settings which need to be established to improve machine performance.

**Table 1:** Effect of speed on throughput capacity

| Speed (m/s) | Throughput capacity of maize mash (Kg/h) | Throughput capacity of cassava slurry (Kg/h) | Throughput capacity of coconut milk (Kg/h) |
|---|---|---|---|
| 4.75 | 17.29 | 12.33 | 26.02 |
| 5.76 | 23.92 | 14.59 | 35.59 |

Table 2 shows the output capacity (kg/h) of maize mash, cassava slurry, and coconut milk at the same speeds. The output capacity follows a similar trend to throughput, with higher speeds resulting in greater output for all materials. The processing rates of maize mash and coconut milk showed significant improvements which demonstrate their compatibility with increased processing speeds. The processing rates of cassava slurry increased less than other materials due to its particular rheological characteristics. Different agricultural products require specific operational strategies for their processing according to this finding.

**Table 2**: Effect of speed on output capacity

| Speed (m/s) | Output capacity of maize mash (Kg/h) | Output capacity of cassava slurry (Kg/h) | Output capacity of coconut milk (Kg/h) |
|---|---|---|---|
| 4.75 | 14.41 | 4.36 | 18.88 |
| 5.76 | 16.21 | 9.34 | 26.34 |

Table 3 shows the sieving efficiency in (%) for the three materials at two speeds. The data show that higher sieving efficiency results from increased operational speed. The two materials achieved better separation results with their lower viscosity properties which led to higher efficiency for their separation processes. Cassava slurry achieved better efficiency results at high operational speeds because the process helped to defeat the cohesive forces and viscosity limitations of the material.

**Table 3**: Effect of speed on sieving efficiency

| Speed (m/s) | Sieving efficiency of maize mash (%) | Sieving efficiency of cassava slurry (%) | Sieving efficiency of coconut milk (%) |
|---|---|---|---|
| 4.75 | 83.33 | 35.33 | 72.55 |
| 5.76 | 87.22 | 63.97 | 74 |

Table 4 compares the physical exertion required for mechanical and manual sieving operations using heartbeat as a measure (in bpm). The table shows that mechanical wet sieving provides better results since it decreases physical effort needed for the process. The wet sieving machine produces a much lower heartbeat rate which leads to less fatigue for workers, thereby increasing their comfort and work efficiency. The agricultural processing field demonstrates how mechanization helps increase productivity while creating better work environments for employees.

**Table 4**: Level of exhaustion

| | Mechanical wet sieving (bpm) | Manual wet sieving (bpm) |
|---|---|---|
| **Heartbeat** | **76** | **130** |

## Conclusion

The multipurpose wet sieving machine demonstrated stable and efficient performance in processing a wide range of agricultural materials, achieving notable improvements in throughput capacity, sieving efficiency, and product uniformity. The results indicate that mechanization of the sieving process significantly reduces operators' physical workload, as reflected by improved physiological indicators compared with manual operations, thereby providing safer and less strenuous working conditions. The machine showed strong capability in handling low-viscosity materials such as maize mash and coconut milk, while maintaining acceptable performance when processing higher-viscosity cassava slurry, highlighting the system's flexibility and the material-dependent nature of its operational performance. High efficiency levels attained under optimized operating conditions confirm the suitability of the machine for small- and medium-scale agricultural processing applications. Overall, the adoption of this mechanized system enhances process productivity and quality while improving ergonomic conditions and reducing labor requirements, positioning the multipurpose wet sieving machine as a practical and reliable solution for advancing mechanization in agricultural processing. Nevertheless, future developments should focus on modular design, enhanced controllability of operational parameters, and the integration of intelligent monitoring systems to further expand its applicability and industrial acceptance.

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## Conflict of interest

No conflicts of interest were declared in this work.

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