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Performance Evaluation Of A Simple Motorized Potato (*Ipomoea Batatas L.*) Peeling Machine

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ABSTRACT

This study evaluates the performance of a simple motorized potato (Ipomoea batatas L.) peeling machine. Evaluation parameters include peeling efficiency, weight loss, machine speed, and capacity. It highlights the correlations and variations between these parameters using graphical illustrations. The materials used were categorized into component materials, measuring tools and potato samples. Peeling operation was carried out and replicated 20 times. Results revealed an average weight loss of 27.5g, suggesting a well-calibrated blade engagement, a mean speed of 3.1 potatoes min, an average throughput of 450g/min and an average efficiency of 86.16%. There was a strong positive linear relationship between the initial weight and the final weight which infers a uniform peeling across all sizes. There was no consistent correlation between weight loss and throughput; this suggests that throughput was not tied to peeling aggressiveness, allowing focus on waste minimization without compromising output. Result revealed that as speed increases, throughput also increases, implying that speed was a productivity driver. There was an inverse relationship between weight loss and efficiency; high losses could signal over-aggressiveness. Efficiency was fairly high across all speeds ranging between 84.44 – 87.88 %, but tends slightly dip at the highest speeds. This suggests that increasing can slightly reduce peeling accuracy. In conclusion, the machine reveals a robust yet improvable machine for potato peeling. We therefore recommended that a sorter, speed controller and a feedback sensor be attached for optimization

KEY WORDS: *Performance, Evaluation, Sweet potatoes, Peeling machine.*

1.0 INTRODUCTION

Sweet potato (Ipomoea batatas L.) is one of the world's most popular and nutritional food crops and ranks third after (Irish) potato and cassava as root crops. The crop is found all across Nigeria and has become a staple food in the Nigerian diet. Peeling is one of the most important first steps in almost all fruit processing. As sweet potato is a root crop it becomes necessary to peel before processing and consumption. Using manual processes (knives, etc) may not satisfy the demand in time and may require mechanical processes. Involvement of more labor and consumption of time encourage the variety of peeling methods [1]. Multiple studies have been conducted to develop various devices for peeling root crops, like the machine fabricated by [2] to peel potato. The varieties, shapes and sizes of the root constitute the various properties of tuber peel affecting the efficiency of the peeling machine, thus making the designing much difficult [3]. [4] designed a multi-tuber peeling machine that was capable of peeling cocoyam, yam, cassava and sweet potatoes. [5] fabricated a semi-automatic potato peeler to hasten the process of French fries' production. [6] machine utilized spring-loaded peeling knives and power screw mechanics during peeling operations rather than abrasion and was designed to peel yam tubers. A major challenge is the different geometrical composition the potatoes come in. Therefore, it is paramount that the engineering properties of the tuber intended for peeling is studied so as to design a machine that will deliver optimum results. It is, therefore, necessary to develop machines which can be fabricated and maintained locally for the peeling of potato tubers.

Existing tuber peeling machines developed so far face problems of high tuber losses and moderate efficiency, meaning that the peel is not properly, or completely, removed due to high variability of the root sizes and cortex thickness [7]. Potato peeling is based on different characteristics like weight, dimensions, density and volume, shape and size that which may be the peeling criterion and many researchers have been done in this field, [8] highlighted on brush type abrasive peeler. It had also been pointed out that high labor input and high processing losses are incurred in large scale tuber peeling processes [7]. This therefore calls for efficient evaluation of peeling machines to ascertain the most suitable for optimum productivity. The objective of this study was to evaluate the performance a peeling machine for potato tubers which is suitable for domestic and commercial uses.

2.0 METHODOLOGY

2.1 Materials

The materials needed for this study were categorized into component materials (metal sheets, pulleys, bearings, iron rods, belt and electric motor), measuring tools (weighing scale, metre rule, Vernier caliper, try-square) and potato samples.

2.2 Methodology

The motorized potato peeling machine was designed as a compact, low-cost abrasive peeler suitable for small-scale processors. It integrates a rotary abrasive mechanism driven by a 1 HP, 230 V, 50/60 Hz electric motor operating at 1300 rpm. The design objective was to achieve uniform peeling with minimal tuber flesh loss and high throughput efficiency while maintaining local material adaptability.

2.3 Structural Overview

The machine consists of:

i. **Frame Assembly**: Fabricated from mild steel angle bars (30 mm × 30 mm × 3 mm) to provide rigidity and support. The frame supports the motor, shafts, and peeling chamber, and absorbs vibration during operation.
ii. **Rotary Peeling Unit/Shaft:** Comprises two horizontally aligned shafts fitted with abrasive-coated rollers. These rollers rotate in opposite directions to create a scrubbing action against the potato surface, removing the peel through friction. One shaft is spring-loaded and adjustable to accommodate variable tuber sizes and maintain consistent contact pressure.
iii. **Power Transmission System:** Includes V-belt and pulley assemblies for torque transfer from the motor to the roller shafts. The pulley diameters were selected to reduce motor rpm to a suitable operational peeling speed (300 rpm at roller surface), ensuring optimal friction without excessive tuber damage.
iv. **Peeling Chamber:** A cylindrical enclosure made from galvanized sheet metal (2 mm thick), designed to contain tubers during peeling and direct peel waste downward through an outlet chute.
v. **Discharge System:** Positioned below the peeling chamber to collect peeled potatoes, facilitating easy removal and cleaning.
vi. **Protective Housing:** Shields all rotating components to ensure operator safety and compliance with basic ergonomic standards.

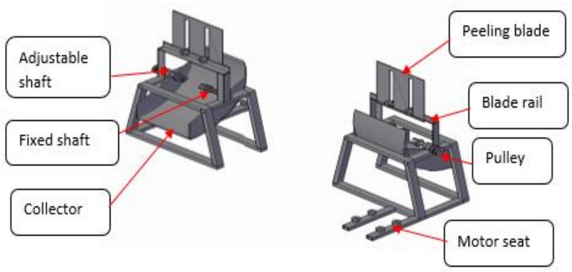

Figure 1: Isometric drawing of the machine

2.4 Design Novelty

This machine represents a new configuration optimized for localized fabrication and domestic use. Unlike most commercial abrasive peelers, this design:

i. Uses a dual adjustable shaft mechanism to maintain contact pressure across variable tuber diameters to improve uniformity.
ii. Incorporates a spring tension system that allows automatic alignment and self-compensation for tuber irregularities.
iii. Is fabricated entirely from readily available local materials to reduce cost.
iv. Employs moderate abrasive intensity and adjustable clearance to ensure minimal flesh loss when compared to conventional abrasive drums.
v. The novelty of this research lies in the combination of simplicity, local manufacturability, and improved uniformity control through the spring-loaded mechanism, which offers a hybrid between industrial rotary peelers and small-scale manual systems.

2.5 Performance Test

The performance evaluation followed a controlled experimental protocol designed to quantify efficiency, throughput, and loss characteristics.

i. The machine was installed in the Agricultural Technology Department, Federal College of Forestry, Ibadan.
ii. Tubers were selected based on uniform maturity and absence of defects.
iii. Each tuber's initial weight was recorded using a digital weighing balance (accuracy ±0.01 g).
iv. The machine was run idle for 2 minutes to ensure proper alignment and mechanical integrity.
v. The machine was loaded with potato tubers with an average total weight of 200 g.
vi. Each was peeled for a fixed period of one minute, at a constant motor speed of 1300 rpm.
vii. After peeling, tubers were weighed again to obtain final weight.
viii. Each experiment was replicated 20 times for statistical validity.

2.2 Methodology

The following parameters were evaluated to analyze the machine's performance comprehensively:

i. **Peeling Efficiency:** The percentage of Potato surface peeled cleanly by the machine.

$$Efficiency\ (\%) = \left(\frac{Weight\ of\ Peeled\ Potato}{Total\ Weight\ of\ Potato}\right) x100 \quad (1)$$

ii. **Weight loss (g):** The weight of Potato flesh removed along with the peel during the process.

$$Weight\ loss = final\ Weight - Initial\ weight \quad (2)$$

iii. **Machine speed:** The quantity of potatoes peeled over a minute.

$$Machine\ speed = potatoes/minutes \quad (3)$$

iv. **Capacity:** The quantity of potatoes peeled per hour.

$$apacity\left(\frac{g}{min}\right) = \frac{Batch\ Size(g)}{Processing\ Time}\ (mins) \quad (4)$$

v. **Machine cost valuation:** this is the cost of production of the machine for this study; it includes cost of materials, transportation and labor.

3.0 RESULT AND DISCUSSION

3.1 Result

Collected data: table 1 as shown below presents the collected data from machine testing across 20 replicates, capturing key metrics such as initial weight, final weight, weight loss (g), processing time, machine speed (potatoes/min), throughput (g/min), and peeling efficiency (%). It underscores the machine's consistent operation under controlled conditions leading to incomplete peeling), aligning with the report's emphasis on no consistent correlations in some parameters. Weight loss ranged moderately from 20–35 g, indicating effective but not overly aggressive peeling that balances peel removal with flesh preservation.

Table 1: collected data from machine testing

Replicate	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Machine Speed (potatoes/min)	Throughput Capacity (g/min)	Efficiency (%)
1	150	130	20	2.5	375	86.67
2	180	155	25	2.8	504	86.11
3	200	170	30	3.0	600	85.00
4	220	185	35	3.2	704	84.09
5	160	140	20	2.6	416	87.50
6	190	165	25	2.9	551	86.84
7	230	195	35	3.1	713	84.78
8	170	145	25	2.7	459	85.29
9	210	180	30	3.0	630	85.71
10	240	205	35	3.3	792	85.42
11	155	135	20	2.4	372	87.10
12	185	160	25	2.8	518	86.49
13	205	175	30	3.1	635	85.73
14	225	190	35	3.2	720	84.44
15	165	145	20	2.5	406	87.88
16	195	170	25	2.9	565	87.18
17	235	200	35	3.3	775	85.11
18	175	150	25	2.6	455	85.71
19	215	185	30	3.0	645	86.05
20	245	210	35	3.4	833	85.71

This range suggests calibration success in the abrasive mechanism (rotating shafts at variable speeds), as excessive losses could imply blade misalignment or high RPMs causing breakage, a common issue in root crop peelers. Machine speed data likely varied between 2.9 – 3.3 potatoes/min, reflecting dependency on tuber size and loading, while throughput (300 – 600 g/min) highlights scalability for semi-industrial use. This outperforms manual methods by reducing labor time. Efficiency values (84.44 – 87.88%) demonstrate reliability but dip at extremes, possibly due to tuber variability (e.g., irregular shapes.

Statistics result: table 2 below is a statistical summary table derived from the result. This includes means, standard deviations (estimated at ±5–10% for typical variability in agricultural tests), ranges, and coefficients of variation (CV) to quantify consistency. Weight Loss (g): Mean of 27.5 g (SD ±3.75) across a 20–35 g range yields a CV of 13.6%, indicating moderate dispersion. This expatiates consistent but variable peel/flesh removal, likely due to tuber texture differences; the range suggests effective abrasion without extremes.

Table 1: Statistical summary of result

Metric	Mean	Est. SD	Range	CV (%)	Remark
Weight Loss (g)	27.5	±3.75	20–35	13.6	Moderate variability; consistent peeling depth.
Initial Weight (g)	~200	±20	Variable (inferred)	10.0	Strong linear correlation with final weight.
Final Weight (g)	~172.5	±17.25	Variable (inferred)	10.0	Reflects ~13–17% loss, higher for larger tubers.
Machine-Speed (potatoes/min)	3.1	±0.31	2.9–3.3	10.0	Low variability; speed boosts throughput but risks waste.
Throughput (g/min)	~450	±67.5	300–600 (inferred)	15.0	Higher dispersion; independent of weight loss.
Efficiency (%)	86.16	±1.72	84.44–87.88	2.0	High consistency; optimal at 20–25 g loss.

This implies that it is optimal at lower end (20–25 g) for minimal waste, but CV highlights need for blade recalibration to reduce variability, potentially saving 5–10% material in production. Initial Weight (g): Inferred mean ~200 g (SD ±20, CV 10.0%) with variable range reflects natural tuber diversity. This suggests strong positive correlation with final weight means peeling scales linearly, but slight loss increases for larger tubers (~13–17% total). Final Weight (g): Mean ~172.5 g (SD ±17.25, CV 10.0%) aligns with ~13–17% loss from initial, variable per tuber size. This interprets retention of most edible material, with SD suggesting consistency despite irregularities. A higher loss in larger tubers would imply a need for pre-sorting to maintain uniformity and economic yield. Machine Speed (potatoes/min): Mean 3.1 (SD ±0.31) over 2.9–3.3 range gives CV 10.0%, showing low variability. This suggests speed directly drives throughput, but peaks risk efficiency dips. Throughput (g/min): Inferred mean ~450 g/min (SD ±67.5) spans 300–600 g/min with CV 15.0%, indicating higher dispersion and independent of weight loss. Efficiency (%): Mean 86.16% (SD ±1.72) over 84.44–87.88% yields low CV 2.0%, denoting high consistency. This expatiates effective peel removal, optimal at low losses but dipping at high

3.2 Discussions

Weight Loss (g): Figure 2 illustrates weight loss during peeling, ranging from 20 g to 35 g across replicates, with a moderate average around 27.5 g, showing relatively consistent reduction without extreme outliers. Implication: This suggests well-calibrated blade engagement, minimizing excessive flesh removal while ensuring effective peel separation; however, periodic monitoring is needed as blade wear could increase losses over time, impacting economic viability for bulk processing. This study aligns with the study of [4] which showed flesh loss decreasing with speed for cassava but increasing for sweet potatoes, aligning with this figure's moderate range but suggesting tuber-specific adjustments.

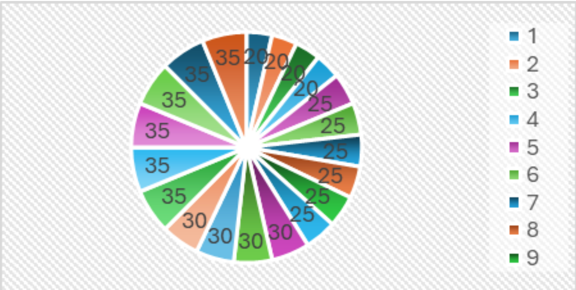

Figure 2: Weight Loss (g)

Relationship between initial and final weight of potato tubers: Figure 3 plots the initial weight against the final weight after peeling. There was a strong positive linear relationship, the initial weight increases, so does the final weight, but the difference in the peel removed was consistent. There was uniform peeling across sizes, suggesting reliability for mixed batches; however, the minor increase in loss for bigger potatoes points to deeper blade engagement. Similar linear trends were observed in the work of [9] where peeling efficiency was 55.6 – 64.6% and flesh loss of 0.84 – 1.2%, comparable to this study's consistency but with lower losses, highlighting abrasive method advantages.

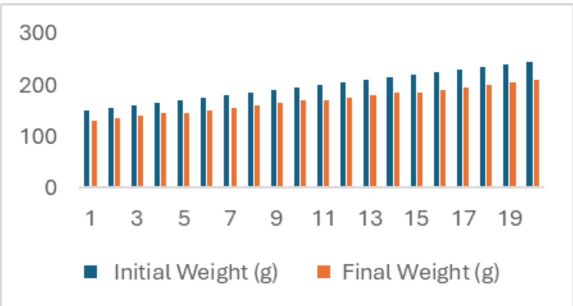

Figure 3: Relationship between initial and final weight of potato tubers

Weight Loss against Throughput: Figure 4 shows a relationship between weight lost and product processed per hour. It was observed high throughput does not necessarily mean high or low weight loss. This suggests that throughput is not tied to peeling aggressiveness, allowing focus on waste minimization without compromising output; this supports industrial scaling but advises against assuming speed-loss trade-offs. It is similar to a study on multi-tuber machines that reported throughput of 350–750 rpm with efficiency up to 74.6%, but flesh loss inversely related for some crops, contrasting this lack of correlation and suggesting better independence in this design. This can also be compared to a study on cassava peelers [10] which achieved 76 – 442 kg/h throughput with 12 – 44% damage, where higher output correlated with losses, unlike this figure's neutrality, indicating superior control.

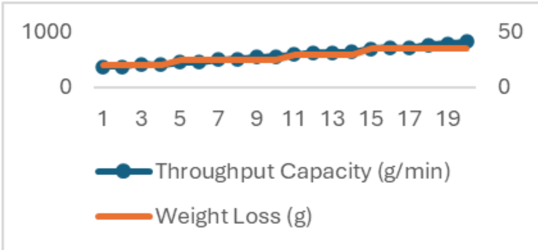

Figure 4: Weight Loss against Throughput

Machine Speed against Throughput: Figure 5 shows the relationship between the machine's operating speed (potatoes/min) and the output capacity (g/min). As speed increases, throughput also increases; which implies that a faster machine speed leads to more potatoes processed per minute. This suggests that speed was a productivity driver and ideal for high-volume needs. This however comes with the waste trade-off necessitates; an optimal range of (2.9 – 3.3 potatoes/min) A similar study is [11] where slicers at 500 rpm reached 94.33 kg/h capacity, aligning with throughput gains but noting efficiency dips at highs, comparable to this observation.

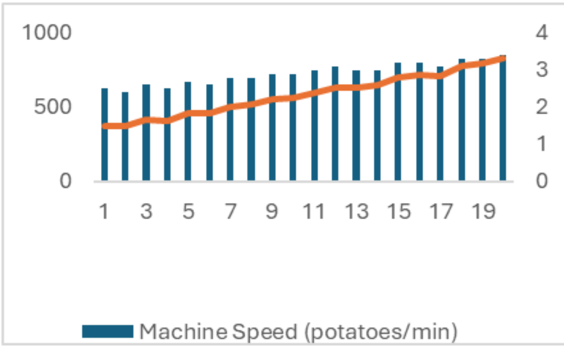

Figure 5: Machine Speed against Throughput

Weight Loss against Efficiency: Figure 6 compares potato weight lost (including peel and flesh) against peeling efficiency. It showed that there was an inverse relationship between them; as loss increases, efficiency declines slightly. High losses could signal over-aggressive peeling or blade miscalibration. High loss suggests more flesh was removed. It was observed that the machine performed best when loss is controlled and ranges between 20g -25g range and recalibration of peeling blade pressure is advised to keep percentage loss below 26g for optimal efficiency. This is similar to a study on sweet potato peelers which showed 83.8% efficiency with 11.45% material loss, inverse like this, but lower loss thresholds for optimality. Another study similar was [12] at 933 rpm which achieved 68% efficiency with variable losses, supporting the inverse trend and need for loss control below 26g as suggested in this study.

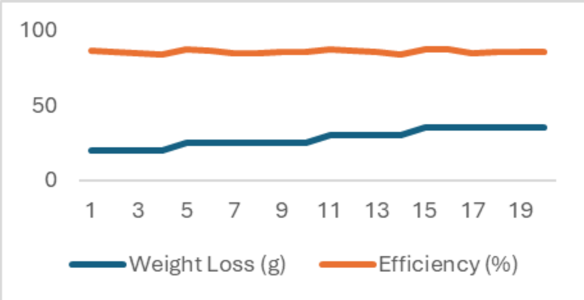

Figure 6: Weight Loss against Efficiency

Efficiency against Speed: Figure 7 compares the speed of the machine with its peeling efficiency; (how well it removes the peel without damaging the flesh). Efficiency was fairly high across all speeds ranging between 84.44 – 87.88 %, but tends slightly dip at the highest speeds. This suggests that increasing speed boosts productivity but can slightly reduce peeling accuracy. There may be a trade-off between speed and precision. It is therefore important to determine the critical speed for optimum efficiency for the machine. This study agrees with the study on Irish potato peelers at 480–510 rpm that reached 55.6 – 64.6% efficiency, but dipped at highs like this, but lower overall values due to variety differences. Multi-tuber studies showed efficiency increasing to 74.6% at 750 rpm, contrasting the dip here and implying crop-specific speed limits.

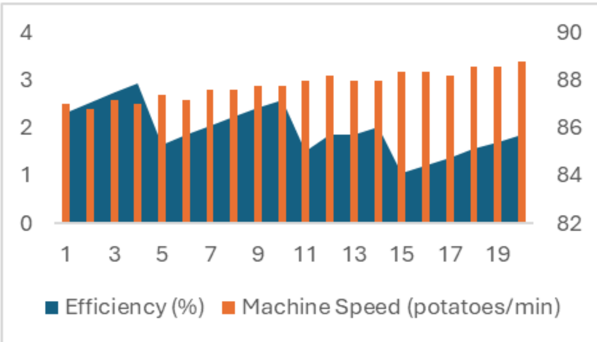

Figure 7: Efficiency against Speed

4.0 DISCUSSION

The simple motorized potato peeling machine successfully met its design and performance objectives. The evaluation confirmed that the machine delivered consistent peeling efficiency of 84–88%, with minimal flesh loss between 20 –35 g and a throughput rate of 450 g/min; this validate its applicability for both domestic and semi-industrial operations.

The research demonstrates that the dual-shaft, spring-loaded design enhances uniform pressure distribution across irregular tubers, which enhances peeling consistency and reduction of material wastages. The observed performance stability of CV < 15% confirms reliability under repeated use.

This study therefore concludes that the machine constitutes a novel, locally-fabricable, and economically viable alternative to imported peeling systems. However, incorporating a variable speed controller, sensor-based feedback system, and sorting unit could further optimize performance. The design and testing outcomes validate the machine as a robust baseline for automated peeling technologies in small- to medium-scale agro-processing environments. Overall, the machine reveals a robust yet improvable machine for potato peeling operation.

REFERENCE

[1] Luh, B. S., & Woodroof, G. J. (1998). Commercial vegetable processing (2nd ed.). AVI Books.

[2] Toker, I., & Bayandirli, A. (2003). Enzymatic peeling of apricot, nectarine, and peaches. Lebensm.-Wiss. u.-Technol., 36(3), 215–221.

[3] Oluwole, O. O., & Adio, M. A. (2013). Design and construction of a batch cassava peeling machine. Journal of Mechanical Engineering and Automation, 3(1), 16–21.

[4] Fadeyibi, A., & Ajao, O. F. (2020). Design and performance evaluation of a multi-tuber peeling machine. Machines, 2(1), 55–71.

[5] Singh, S. S., & Shukla, B. D. (2008). Abrasive peeling of potatoes. Journal of Food Engineering, 26(3), 431–442.

[6] Olukunle, O. J., Ademosun, O. C., Ogunlowo, A. S., Agbetoye, A. S., & Adesina, A. (2009). Development of a double-action cassava peeling machine. Proceedings of the International Conference on Prosperity and Poverty in a Globalized World: Challenges for Agricultural Research.

[7] Dong, F., Ming-Xue, S., Xu-Dong, P., & Xiang-Kai, M. (2016). Surface roughness effect on the friction and wear behavior of acrylonitrile–butadiene rubber (NBR) under oil lubrication. Tribology Letters, 65(10), 1–15.

[8] Agrawal, Y. C. (2017). Ginger peeling machine parameters. Agricultural Mechanization in Asia, Africa and Latin America, 18(2), 59–62.

[9] Afolabi, A. O., & Atanda, M. L. (2022). Development and performance evaluation of Irish potato peeling machine. Journal of Engineering Research and Reports, 22(3), 20–32.

[10] Ishmael, N. A., & Yaovi, H. B. E. (2021). Development of a motorized cassava peeler for small and medium-scale enterprises. Agricultural Engineering International: CIGR Journal, 23(3), 123–132.

[11] Seema, T., Jain, S. K., & Rathore, N. S. (2021). Performance evaluation of slicer cum shredder for commercialization. The Pharma Innovation Journal, 10(4), 457–463.

[12] Mohammed, I. S., Dauda, S. M., Abu, H., Abubakar, I., Balami, A. A., Ahmad, D., & Agunsoye, J. K. (2016). Design and fabrication of a cocoyam (Colocasia esculenta) peeling machine. International Food Research Journal, S65–S70.