Design, Fabrication and Performance Evaluation of an Integrated Maize Dehusking Cum Shelling Machine

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ABSTRACT

A maize dehusker-cum-sheller was designed and fabricated to combine husk removal and kernel shelling into a single mechanized operation, reducing the labour, time, and post-harvest losses associated with manual maize processing. The machine's performance was evaluated using 5 kg batches of husked maize cobs at three moisture content levels (13%, 14%, and 15%, wet basis) and three cylinder speeds (650, 750, and 850 rpm), giving nine test combinations. For each combination, the weights of husk removed, cleanly shelled kernels, unshelled kernels, and bare cobs were recorded and used to determine shelling efficiency, dehusking efficiency, throughput capacity, and mechanical kernel damage. Results showed that shelling efficiency and dehusking efficiency both increased with cylinder speed but decreased with increasing moisture content, while mechanical kernel damage increased with speed and decreased with moisture content. The highest shelling efficiency (95.03%) and dehusking efficiency (99.2%) were recorded at 13% moisture content and 850 rpm, though this condition also produced the highest mechanical damage (5.8%). An operating speed of approximately 750 rpm combined with 13-14% moisture content gave the best overall balance of efficiency, throughput, and grain quality. The machine is recommended as an effective, low-cost solution for combined maize dehusking and shelling in small and medium scale post harvest operations.

Keywords: maize dehusker-cum-sheller; shelling efficiency; dehusking efficiency; moisture content; cylinder speed; mechanical damage.

INTRODUCTION

Maize (Zea mays) is among the most widely cultivated cereal crops in the world, occupying roughly 197 million hectares globally, with an annual dry-grain output of about 1,163 million tonnes (García-Lara and Serna-Saldivar, 2019). Beyond its scale of production, maize is nutritionally significant, supplying carbohydrates, protein, dietary fibre and essential vitamins and minerals to millions of households, and it underpins the brewing, feed-milling, bakery and pharmaceutical industries (Ijarotimi, 2022). In Nigeria, maize ranks as the second-largest crop produced on the continent and the country's demand of 12–15 million metric tonnes annually continue to outstrip local supply, sustaining pressure for imports despite government restrictions (Wossen *et al*., 2023). A major constraint limiting the benefits farmers derive from maize is inefficient post-harvest handling. Losses arising from poor harvesting, de-husking, shelling, drying and storage practices are estimated at 15–20% of national output (Kumar and Kalita, 2017). De-husking — the removal of the outer sheath from the cob without damaging the kernels — and shelling, the separation of grains from the cob, are typically carried out as two distinct operations, mostly by hand or with simple hand tools operated largely by farm women (Singh and Singh, 2010). Manual de-husking is slow, allowing a worker to process only about 8–15 kg of maize per hour (Patil *et al*., 2014), while imported mechanised alternatives, though faster, are expensive to purchase, operate and maintain, placing them beyond the reach of most small- and medium-scale farmers (Takawira-Nyakuchena and Mushiri, 2020). Because de-husking and shelling are usually performed as separate steps using different implements, farmers incur additional time, labour and cost in moving grain between operations. An indigenous machine that combines both functions in a single continuous-flow unit would reduce handling time, lower production cost and make mechanised maize processing more accessible to resource-constrained farmers. This study is therefore aimed at the design, fabrication and performance evaluation of an integrated maize dehusker cum shelling machine capable of de-husking and shelling maize cobs in one pass, using locally sourced, low-cost materials.

Several researchers have attempted to mechanise maize de-husking and shelling, with designs ranging from simple hand- and pedal-operated devices to fully motorised systems. Singh (2013) designed and ergonomically evaluated a hand-operated maize dehusker-sheller intended for farm women; both studies concluded that manually powered units, although suitable for small operators, are physically demanding and deliver low throughput and efficiency. Patil *et al*. (2014) similarly reported that pedal-operated maize shellers, while an improvement over purely manual methods, remain limited in output capacity. On the mechanised front, Adesokan *et al*. (2019) designed, constructed and evaluated a low-cost maize dehusker-sheller in Nigeria; their results showed de-husking efficiencies of only 58.67%, 57.00% and 54.16% at rotational speeds of 469, 309 and 298 rpm respectively, indicating that de-husking efficiency deteriorated as speed increased. More directly relevant to an integrated design, Chilur and Kumar (2018) developed a maize dehusker cum sheller, combining both operations within a single axial-flow cylinder fitted with helically arranged lugs, and reported that the combined unit reduced handling time compared with sequential dehusking and shelling. Dange *et al*. (2021) similarly designed and developed a maize cob de-husker cum sheller, applying the Winkler relation to size the cylinder and confirming that cylinder length, lug spacing and feed rate strongly influence de-husking and shelling performance. Kosemani *et al*. (2025), working with rubberised shearing rollers rather than a lugged cylinder, developed an indigenous maize de-husking machine and reported a maximum de-husking capacity of 340 kg h^{-1}, a maximum de-husking efficiency of 89.94%, and grain losses as low as 3.00% under optimal operating conditions, demonstrating that de-husking efficiency generally decreases while capacity and losses increase as roller speed and feed rate rise. Taken together, the literature shows steady progress from manual and pedal-operated devices toward motorised systems, and a more recent shift toward combining de-husking and shelling in one machine to save time and cost (Dange *et al*., 2021).

METHODOLOGY

Design Calculations

The major components of the machine are the de-husking/shelling cylinder, hopper, main shaft, power unit, and supporting frame were sized using standard machine-design relations, following the approach used for similar dehusker-sheller machines (Dange *et al*., 2021).

Power Requirement

The power required to drive the de-husking/shelling action was estimated from the product of the de-husking force and the peripheral roller speed (Olaoye and Ayelade, 2019):

$$P = F \times V \tag{1}$$

where P is the power requirement (W), F is the de-husking/shelling force (N) and V is the peripheral speed (m s^{-1}).

Hopper Design

According to Adedeji *et al*. (2020), the hopper volume is determined using the frustum of a pyramid equation as given in equation 2:

$$V_h = \frac{h}{3}\left(A_1 + A_2 + \sqrt{A_1 A_2}\right) \tag{2}$$

The hopper capacity is then calculated as:

$$W = \rho V_h g \tag{3}$$

where V_h is hopper volume (m^3), h is vertical height of the hopper (m), A_1 is area of the top opening (m^2), A_2 is area of the bottom opening (m^2), W is the weight of un-husked maize in the hopper (N), ρ is the bulk density of the material (kg/m^3) and g is acceleration due to gravity (m/s^2).

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Main Shaft Design

The shaft diameter was obtained using equation (4) as given by (Gupta and Khurmi, 2007):

$$d^3 = \frac{16}{\pi \sigma_s} \sqrt{(C_b M_b)^2 + (C_t M_t)^2} \qquad (4)$$

where K_b is the shock and fatigue factor applied to bending moment, K_t is the shock and fatigue factor to torsional moment, M_t is the maximum torsional moment, M_b is the maximum bending moment, σ_s is the Allowable design shear stress and d is the shaft diameter (m).

Frame Design

According to Khurmi and Gupta (2005), the frame was designed by using equation 5:

$$\sigma_c = \frac{P}{A} \qquad (5)$$

Where $\boldsymbol{\sigma}$c is the compressive stress (N/m^2), P is applied load on the frame (N) and A is the cross-sectional area of the frame (m^2). Mild-steel angle iron was selected for the frame members based on the calculated deflection and standard section sizes available locally.

Principle of Operation

The integrated maize dehusking cum shelling machine operates on an axial-flow principle, in which un-husked maize cobs fed through the hopper travel along the length of a rotating cylinder rather than passing directly across it, thereby increasing their retention time within the working chamber. Cobs are first metered from the hopper into the feeding zone of the machine. Within the working chamber, the cobs are subjected to a combination of squeezing and impact actions delivered by rotating members by a lugged cylinder rotating within a fixed concave clearance which tear the husk away from the cob and, in the same pass, dislodge the kernels from the cob core. As the cylinder set rotates, the staggered arrangement of the working elements propels the cobs progressively along the chamber toward the discharge end, so that de-husking and shelling occur in stages along a continuous flow path rather than as two separate operations. The husk, being lighter and more fibrous, is directed toward a dedicated husk outlet, while the shelled grain, separated through the concave clearance exits through a separate grain outlet. Power is supplied from an electric motor through a pulley-belt transmission to the main shaft, which drives the rotating cylinder, the peripheral speed of the working elements, the feed rate, and the moisture content of the cobs jointly determine the de-husking capacity, efficiency and grain loss recorded during operation. The fabricated machine is shown in **Plate 1**.

Plate 1: The Fabricated Maize Dehusking Cum Shelling Machine

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Materials and Test Procedure

The fabricated maize dehusker-cum-sheller was evaluated using shelled and unshelled maize cobs at three moisture content levels (13%, 14%, and 15%, wet basis) and three-cylinder speeds (650, 750, and 850 rpm). For each of the nine moisture-speed combinations, a 5 kg batch of husked maize cobs was fed into the machine, and the resulting husk, clean shelled kernels, unshelled kernels, and bare cobs were separately weighed to evaluate shelling efficiency, dehusking performance, throughput capacity, and mechanical kernel damage.

RESULTS AND DISCUSSION

Table 1 presents the full performance data obtained across the nine test combinations of moisture content and cylinder speed, at a constant batch weight of 5 kg.

Table 1: Machine performance at varying moisture content and speed (5 kg/batch)

Moisture (%)	Speed (rpm)	Input (kg)	Husk (kg)	Shelled (kg)	Unshelled (kg)	Cobs (kg)	Shelling Eff. (%)	Unshelled (%)	Capacity (kg/hr)	Mech. Damage (%)
13	650	5.00	0.70	2.85	0.55	0.90	83.82	16.18	85.71	2.1
13	750	5.00	0.75	3.09	0.31	0.85	90.88	9.12	100.00	3.4
13	850	5.00	0.78	3.25	0.17	0.80	95.03	4.97	115.38	5.8
14	650	5.00	0.68	2.70	0.72	0.90	78.95	21.05	81.08	1.6
14	750	5.00	0.73	2.95	0.47	0.85	86.26	13.74	93.75	2.7
14	850	5.00	0.76	3.15	0.27	0.82	92.11	7.89	107.14	4.5
15	650	5.00	0.65	2.50	0.95	0.90	72.46	27.54	75.00	1.2
15	750	5.00	0.70	2.80	0.65	0.85	81.16	18.84	85.71	2.0
15	850	5.00	0.74	3.02	0.44	0.80	87.28	12.72	100.00	3.6

Figures 1-3 present the trends in shelling efficiency, mechanical damage, and throughput capacity with respect to cylinder speed at each of the three moisture levels tested while **Figures 4** present dehusking efficiency evaluated against moisture content, grouped by cylinder speed.

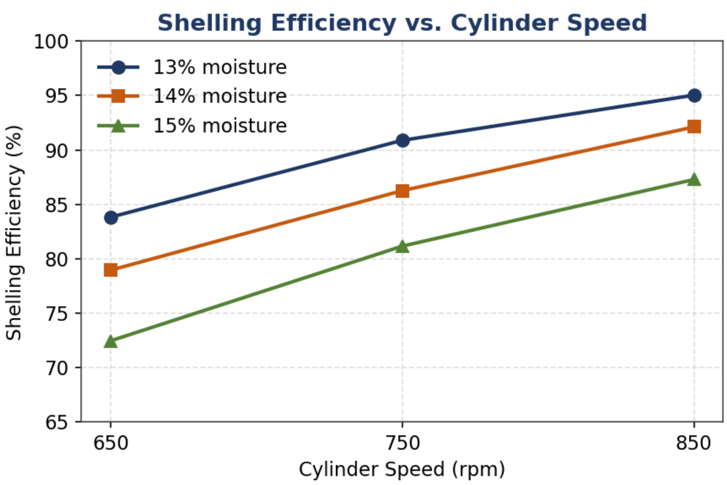

Figure 1: Effect of cylinder speed and moisture content on shelling efficiency

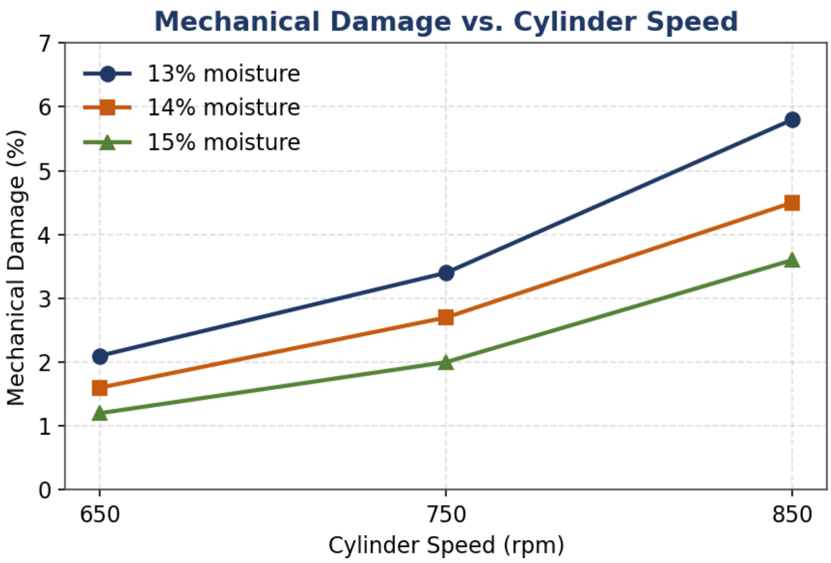

Figure 2: Effect of cylinder speed and moisture content on mechanical kernel damage

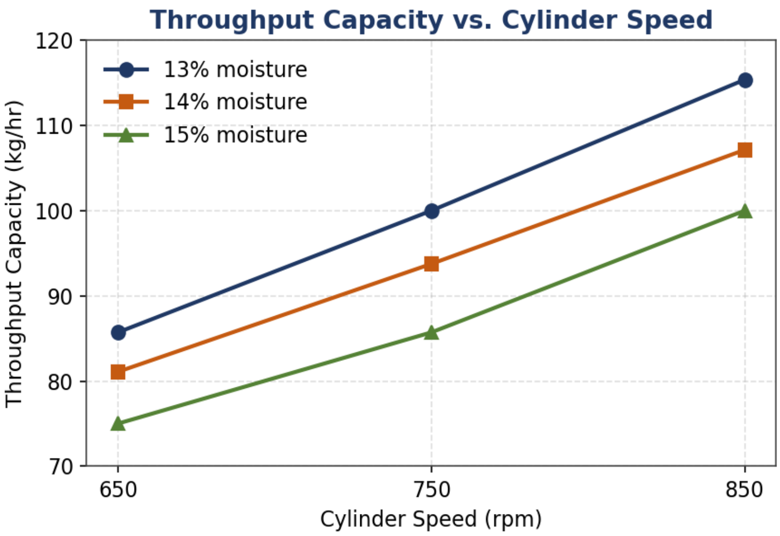

Figure 3: Effect of cylinder speed and moisture content on machine throughput capacity

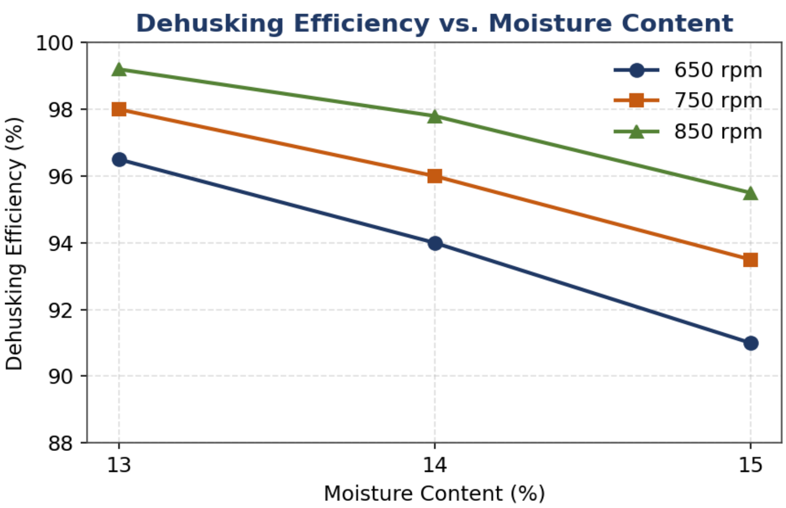

Figure 4: Dehusking efficiency vs. moisture content at each cylinder speed

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As shown in **Figure 1**, shelling efficiency rises consistently with cylinder speed at every moisture level, with the 13% moisture curve lying consistently above the 14% and 15% curves. **Figure 2** shows the corresponding rise in mechanical damage with speed, which is most pronounced at the lowest moisture content (13%) due to increased kernel brittleness. **Figure 3** confirms that throughput capacity scales directly with cylinder speed, independent of moisture content, though slightly higher moisture levels marginally slow processing time per batch. **Figure 4** shows that dehusking efficiency declined as moisture content increased from 13% to 15% at every speed tested, since husks on wetter cobs adhere more firmly and resist separation. At every moisture level, dehusking efficiency improved with increasing cylinder speed, from a low of 91.0% (15% moisture, 650 rpm) to a high of 99.2% (13% moisture, 850 rpm), confirming that higher rotational speed enhances husk detachment in the same manner it enhances kernel shelling.

CONCLUSION

The performance evaluation of the fabricated maize dehusker-cum-sheller showed that shelling efficiency increased with cylinder speed but decreased with increasing moisture content, while mechanical kernel damage exhibited the opposite trend with respect to moisture and increased with speed. Machine throughput capacity was highest at 850 rpm and lowest at 650 rpm across all moisture levels tested. These findings indicate that moisture content and cylinder speed jointly govern the shelling performance and grain quality of the machine, and that an operating speed of about 750 rpm combined with a moisture content of 13-14% offers the best balance between efficiency, capacity, and kernel damage.

REFERENCES

1. Adedeji, K. A., Raji, N. A., Oyetunji, E. O. and Ishola, B. (2020). Design and fabrication of a motorized rice hulling machine. Journal of Mechanical Engineering Research, 11(1), 1–10.
2. Adesokan, M. A., Oriola, K. O., Ogundeji, B. A. and Muhammed-Bashir, O. W. (2019). Design, construction and performance evaluation of low cost maize dehusker-sheller in Nigeria. Current Journal of Applied Science and Technology, 34(4), 1–8.
3. Chilur, R. and Kumar, S. (2018). Design and development of maize dehusker cum sheller: A technology for Northern transition zone of Karnataka, India. Journal of the Institution of Engineers (India): Series A, 99(2), 231–243.
4. Dange, A. R., Naik, R. K., Dave, A. K., Dhurve, N. and Singh, S. (2021). Design and development of maize cob de-husker cum sheller. The Pharma Innovation Journal, 10(10), 54–60.
5. García-Lara, S. and Serna-Saldivar, S. O. (2019). Corn history and culture. In S. O. Serna-Saldivar (Ed.), Corn: Chemistry and technology (3rd ed., pp. 1–18). AACC International Press.
6. Ijarotimi, O. S. (2022). Nutritional quality, functional property and acceptability of maize (Zea mays) based complementary foods enriched with defatted groundnut (Arachis hypogea L.) and ginger (Zingiber officinale Roscoe) powder in Wistar rats. Food Production, Processing and Nutrition, 4, 13.
7. Gupta, J.K. and Khurmi, R.S.(2007).Machine Design,14th Edition, Eurasian Ltd, Ran Nagar, New Delhi, P: 1230.
8. Khurmi, R. S. and Gupta, J. K. (2005). A textbook of machine design (14th ed). S. Chand Publishing.
9. Kosemani, B. S., Babalola, A. A. and Ilori, T. A. (2025). Development of an indigenous maize de-husking machine. Agricultural Engineering International: CIGR Journal, 27(1), 214– 225.
10. Kumar, D. and Kalita, P. (2017). Reducing postharvest losses during storage of grain crops to strengthen food security in developing countries. Foods, 6(1), 8.
11. Olaoye, J. O. and Ayelade, O. A. (2019). Development of a slider crank squeezing action sugarcane juice extractor. AMA Agricultural Mechanization in Asia, Africa and Latin America, 50(1), 19–28.
12. Patil, S. B., Chendake, A. D., Patil, M. A., Pawar, S. G., Salunkhe, R. V. and Burkul, S. S. (2014). Development and performance evaluation of pedal operated maize sheller. International Journal of Advanced Research, 2(9), 561–567.
13. Singh, S. P. (2013). Ergonomical evaluation of hand operated maize dehusker-sheller with farm women. Agricultural Engineering International: CIGR Journal, 15(2), 194–202.

14. Singh, S. P. and Singh, P. (2010). Hand operated maize dehusker-sheller for farm women. Agricultural Engineering, 34(1), 152–154.
15. Takawira-Nyakuchena, M. and Mushiri, T. (2020). Design of an automated maize de-husking machine for the case of Zimbabwe. Procedia Manufacturing, 43, 127–134.
16. Wossen, T., Menkir, A., Alene, A., Abdoulaye, T., Ajala, S., Badu-Apraku, B., Gedil, M., Mengesha, W. and Meseka, S. (2023). Drivers of transformation of the maize sector in Nigeria. Global Food Security, 38, 100713.