Evaluation of a photovoltaic-powered maize shelling machine for smallholder farmers in Rwanda

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I. INTRODUCTION

Maize is a staple crop essential to food security and income for many smallholder farmers in Rwanda.

Traditional shelling is unperforming, labor-intensive, and leads to significant losses.

Mechanisation is constrained by limited access to grid electricity in rural areas, thus solar power offers a clean energy source for shelling mechanization.

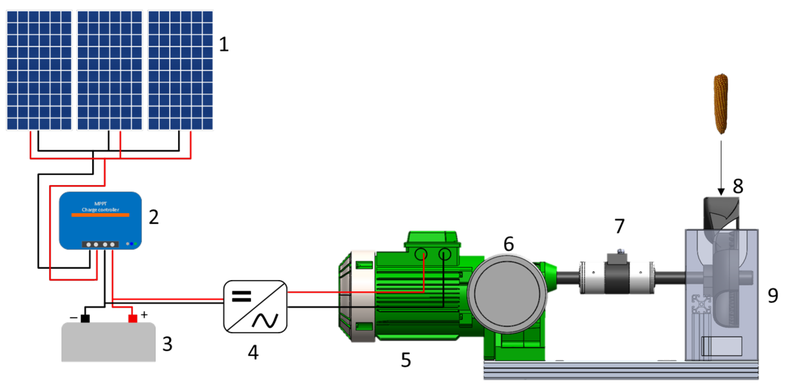

Fig. 1: Schematic description of the solar powered maize shelling machine.

This study evaluated the performance of a photovoltaic-powered maize shelling machine (Fig. 1) for smallholder maize farmers in Rwanda.

II. MATERIAL AND METHODS

1. Maize cobs

Maize cobs of variety KWS Otto were used in the test runs.

Three moisture contents levels were compared: low moisture at 9 %, medium moisture at 13 %, and high moisture content at 21 %.

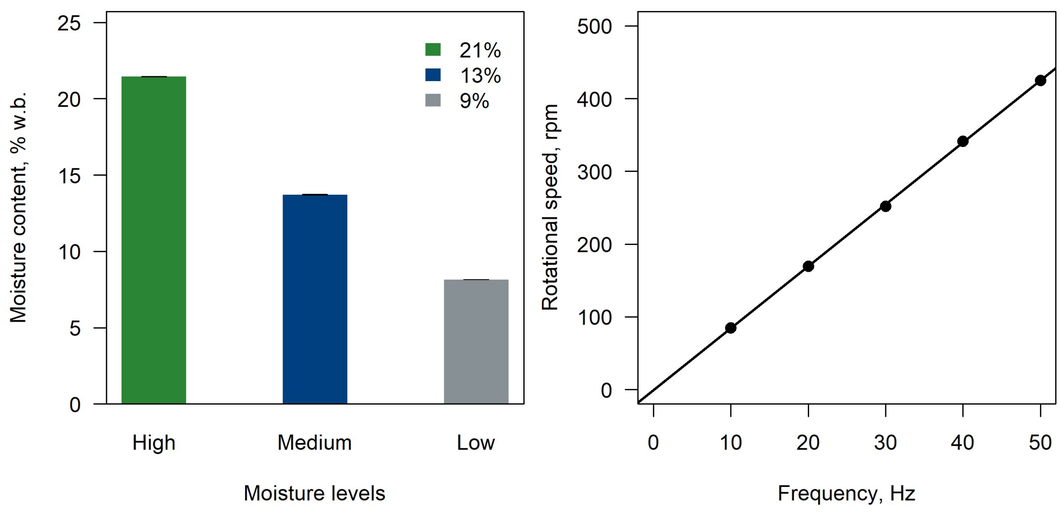

Fig. 2: Moisture content of low, medium and high moisture content kernels and the rotational speeds of the sheller as a function of frequencies.

Physical and mechanical properties of maize were analysed.

2. Shelling experiments

Five rotational speeds ranging from 85 to 450 rpm were tested by comparing the percentage broken grains as a measure for shelling quality.

III. RESULTS AND DISCUSSION

Physical properties are summarized in Table 1.

Table 1: Physical properties of maize kernels at different moisture contents

Moisture content	Diameter (m)	Area (m^2)	1000 kernel mass (kg)
9 %	7.92×10^{-3}	1.97×10^{-4}	0.197
13 %	7.97×10^{-3}	2.00×10^{-4}	0.214
21 %	7.61×10^{-3}	1.82×10^{-4}	0.196

Thousand kernel mass was not significantly influenced by moisture content (p-value = 0.685).

Mechanical properties of maize kernels depended significantly on the moisture content.

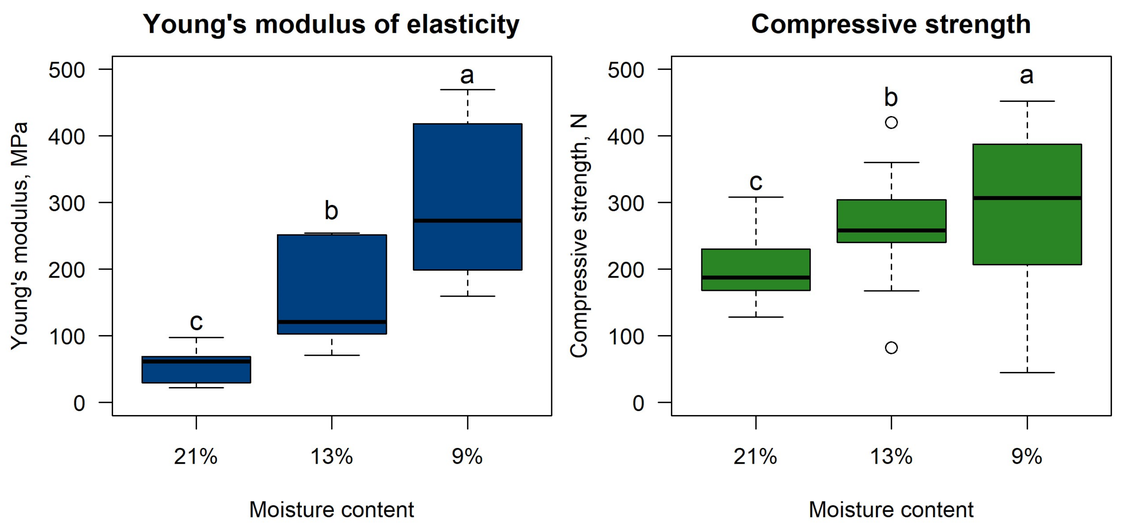

Fig. 3: Mechanical properties of maize kernels dependent on moisture content.

The hardness of kernels increased with the decreasing moisture content (p-value = 0.0023).

Table 2: Results of performance of the shelling machine at different rotational speeds

Rotational speed (rpm)	Average power (W)	Torque (Nm)	Throughput (kg/h)
85	165.3	135.7	66.0
200	248.8	199.1	79.2
250	294.9	280.8	99.0
350	357.8	423.5	132.0
450	406.3	425.0	158.4

The average power, torque and throughput increased with increasing rotational speed

Based on the obtained results, the maximum energy necessary to thresh one ton of maize was found to be 3.14 kWh.

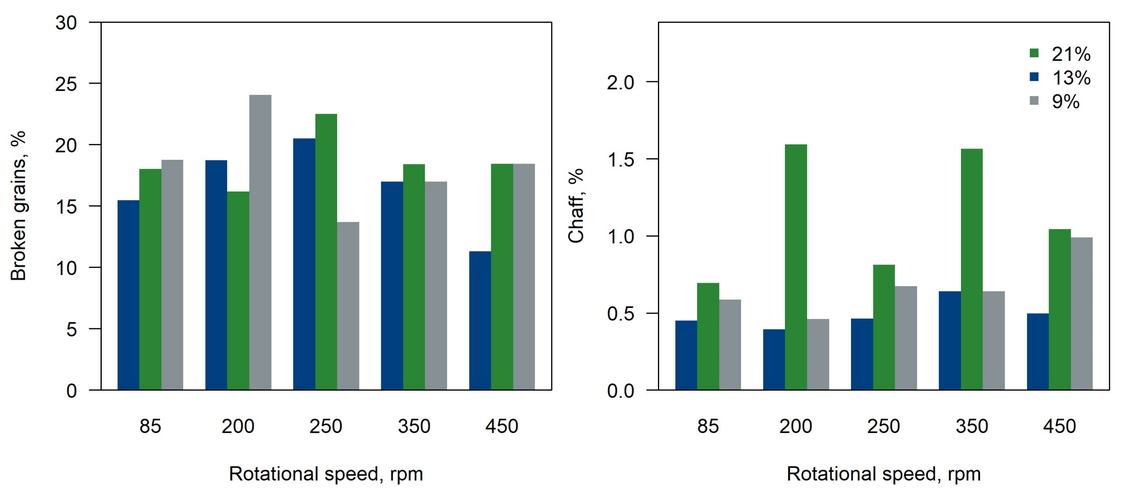

Fig. 4: The percentage broken grains and chaff in maize shelled at various rotational speeds

The percentage broken grains were slightly lower at high rotational speed and the percentage chaff were higher.

IV. CONCLUSION

The optimal conditions were achieved by shelling maize at a moisture content of 9 % and a rotational speed of 420 RPM, which resulted in an average power consumption of 400 W and a broken grain percentage of 17.3 %.
The energy consumption for shelling one ton was 3.14 kWh.
The analysis of the estimated energy consumption demonstrated the feasibility of powering the shelling machine with a cost-effective PV-system.
Accordingly, the shelling machine represents an affordable option for smallholder farmers in tropical regions to minimize postharvest losses.

References

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