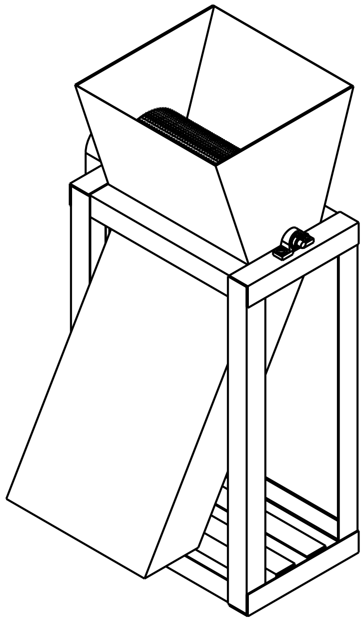
CAVA2
CASSAVA: ADDING VALUE FOR AFRICA PHASE II

How to evaluate the performance of CASSAVA GRATERS

Aditya Parmar & Marcelo Precoppe



Booklet 2

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Preface

This booklet is the second of a 6-part series of booklets on performance evaluation of cassava processing equipment. These technical booklets are developed keeping in mind their target audience of local equipment manufacturers in developing countries, particularly Sub-Sharan Africa. The purpose is to determine the various performance parameters with simplistic techniques requiring no sophisticated instruments.

The online version of these booklets is available at: www.cassavatech.com.

At cassavatech.com we help cassava processors to learn how to choose suitable equipment and what performance parameters to ask for. These booklets series are a complement to that information provided, where equipment manufacturer can demonstrate to their potential customers the performance of the machine regarding the listed performance parameters.

A list of all the booklets in this series is provided below.

Booklet Number	Name
1	How to evaluate the performance of CASSAVA PEELING MACHINES
2	**How to evaluate the performance of CASSAVA GRATERS**
3	How to evaluate the performance of CASSAVA PRESS
4	How to evaluate the performance of CASSAVA PNEUMATIC DRYERS
5	How to evaluate the performance of CYCLONES
6	How to evaluate the performance of HAMMERMILLS

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CAVA II

Cassava: Adding Value for Africa (CAVA II) is a project led by the Federal University of Agriculture Abeokuta, Nigeria, working closely with the Natural Resources Institute. CAVA II aims to improve the livelihoods of smallholder farmers and processors in Nigeria, Ghana, Tanzania, Uganda, and Malawi.

CAVA II works across the value-added cassava chain, it interacts directly with farmers to improve the profitability of cassava sales, both through increasing overall market demand and through boosting farmer yields.

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How to evaluate the performance of

CASSAVA GRATERS

Aditya Parmar & Marcelo Precoppe

Contents

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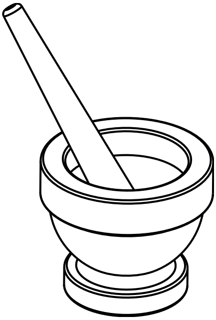
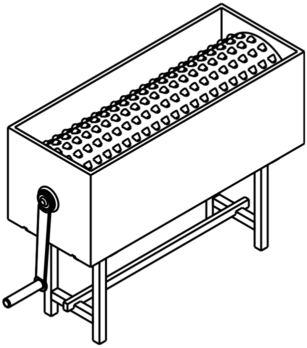
Grating in the food industry

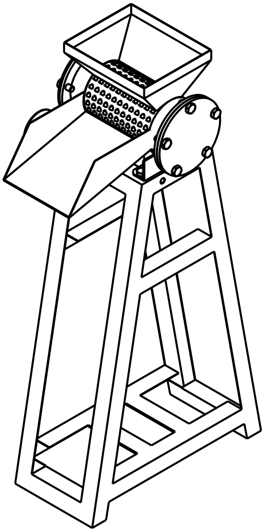
Grating is the process of subdividing larger masses of raw material into smaller units suitable for further processing. A wide variety of size reduction equipment is available, and they can be classified based on their primary mechanical action. For grating, the two most common mechanical actions are impact (e.g. hammer mills) and shear force (e.g. revolving abrasive cylinder, discs, or blades).

Cassava grating

Traditionally peeled cassava roots were pounded into a dough with a mortar and pestle or grated with a hand-powered machine. Nowadays **motor-powered graters** are used to reduce root size and produce cassava mash.

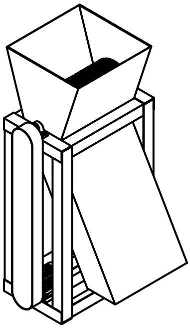


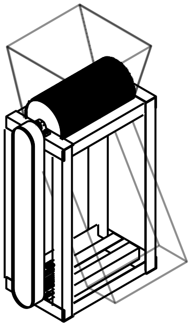




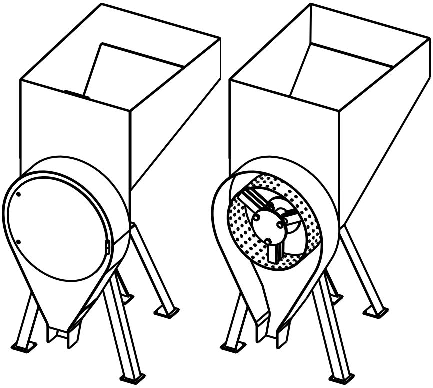
Motor-powered graters can run on **electric motor** or **internal combustion engine**. Their grating mechanism can be based on an **abrasive cylinder** or on a **hammer mill.**

The **abrasive cylinder** graters are easier to fabricate and have lower power requirements when compared with hammer mill type grater. However, it requires more maintenance, particularly the abrasive surface, that needs to be frequently replaced due to rapid wear.





The **hammer mill** type grater has hammers attached to a rotatory shaft that revolves at high speed inside a hard casing. The material reduced by the impact of the hammers and leaves the casing when it is small enough to pass through the screen mesh at the bottom. The major disadvantage of hammer mills is their higher cost of manufacture and operation.



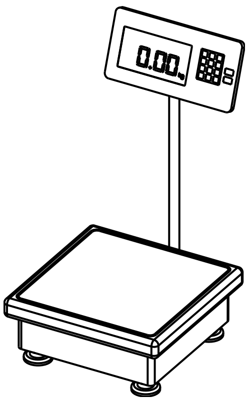
Performance assessment

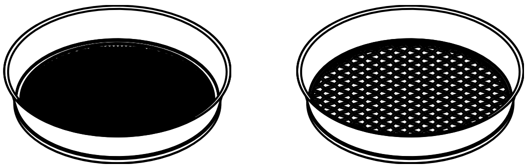
The performance of a cassava grater can be assessed by its **throughput** and **energy consumption.** Particle size is the main factor affecting these performance indices: lower the particle size, greater the energy consumption and lower the throughput. Material hardness and moisture content also affects throughput and energy consumption, but not as significant as particle size. Particle size can be measured with a set of sieves of known opening sizes.

Throughput at a desired particle size range

The throughput at the desired particle size range is the amount of material obtained per unit time at the required particle size range; it is expressed in kilograms per hour (kg/h). The desired particle size is obtained with two sieves, one with the minimum particle screen size opening, and other with the maximum. To measure **throughput at a desired particle size range** it is necessary to have:

- Peeled cassava
- Two sieves, one with 0.5 mm openings and other with 5 mm openings
- Weighing scale
- Stopwatch or a regular watch





Step 1. Select enough roots to run the grater for at least 30 minutes.

Step 2. Start the stopwatch when grating starts.

Step 3. Stop the stopwatch when all the roots have been grated and record the time taken.

Step 4. Sieve the grated material using the 5 mm strainer and discard the portion **retained** by the sieve.

Step 5. Now sieve the remaining material with the 0.5 mm strainer and discard the portion that **passed through** the sieve.

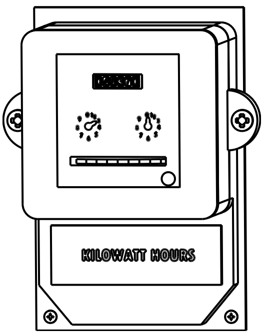
Step 6. Measure the weight of the material retained by the 0.5 mm sieve. This is the **weight at the desired particle size range**.

Step 7. Now divide the weight at desired particle size by the recorded time (in hours). This is **throughput at a desired particle size range**.

Specific energy consumption at a desired particle size range

The specific energy consumption at a desired particle size range is the amount of energy needed to grate a certain quantity of material at the required particle size. It is expressed in kilowatt-hour per kilogram (kWh/kg) for machines running on electric motors, and in litres of fuel per kilogram (L/kg) for those running on internal combustion engines. To measure **specific energy consumption at a desired particle size range of a grater running on electric motor** it is necessary to have:

- Peeled cassava
- Two sieves, one with 0.5 mm openings and other with 5 mm openings
- Weighing scale
- Electricity meter



The **electricity meter** (also called kilowatt-hour meter or energy meter) is a device that measures the amount of electric energy consumed.

Step 1. Select enough roots to run the grater for at least 30 minutes.

Step 2. Switch-off all electric appliances and keep them off until the end of the measurements.

Step 3. Note down the **initial reading** in kWh from the electricity meter.

Step 4. Grate the roots.

Step 5. Note down the new **final reading** from the electricity meter.

Step 6. Sieve the grated material using the 5 mm strainer and discard the portion **retained** by the sieve.

Step 7. Now sieve the remaining material with the 0.5 mm strainer and discard the portion that **passed through** the sieve.

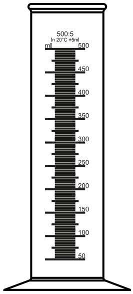
Step 8. Measure the weight of the material retained by the 0.5 mm sieve. This is the **weight at the desired particle size range**.

Step 9. Subtract from the final electricity reading (Step 5) the initial reading (Step 3). This is the amount of **electric energy consumed**.

Step 10. Now divide the electric energy consumed by the weight at the desired particle size (Step 8). This is the **specific energy consumption at a desired particle size range**.

To measure **specific energy consumption at a desired particle size range of a grater running on internal combustion engine** it is necessary to have:

- Peeled cassava
- Two sieves, one with 0.5 mm openings and other with 5 mm openings
- Weighing scale
- Graduated cylinder



A **graduated cylinder**, also known as measuring cylinder, is a piece of equipment used to measure the volume of liquids.

Step 1. Select enough roots to run the grater for at least 30 minutes.

Step 2. Fill the fuel tank of the peeling machine to the maximum level.

Step 3. Grate the roots.

Step 4. Sieve the grated material using the 5 mm strainer and discard the portion **retained** by the sieve.

Step 5. Now sieve the remaining material with the 0.5 mm strainer and discard the portion that **passed through** the sieve.

Step 6. Measure the weight of the material retained by the 0.5 mm sieve. This is the **weight at the desired particle size range**.

Step 7. Using the graduated cylinder, measure the amount of fuel needed to bring the level back to its maximum. This is the **amount of fuel consumed**.

Step 8. Divide the amount of fuel consumed by the measured weight at the desired particle size range (Step 6). This is the **specific energy consumption at a desired particle size range**.

Specific energy cost

To compare the energy consumption of a grater running on an electric motor with one running on an internal combustion engine it is necessary to convert it to **specific energy cost.** To calculate, simply multiply the specific energy consumption at a desired particle size range by the cost of electricity or fuel. For example, if the specific energy consumption is 0.02 kWh/kg and the price of 1 kWh is $0.50, the specific energy cost will be: 0.02 kWh/kg × 0.50 $/kWh = 0.01 $/kg.

Worked examples

Throughput at a desired particle size range

To measure the throughput of a grater, a certain amount of freshly peeled cassava was separate and grated. It took **30 minutes** to grate them. After grating, the material was sieved with a 5 mm strainer. The material retained at the strainer was discarded and the remaining material sieved with a 0.5 mm strainer. The weight of the material retained on the 0.5 mm strainer, was **50 kg**. What is the throughput at the desired particle size range?

$$\text{Throughput at desired partice size range} = \frac{\text{Weight at desired particle size range}}{\text{Time needed to grate it}}$$

$$\text{Throughput desired partice size range} = \frac{50\text{ kg}}{30\text{ min}} = \frac{50\text{ kg}}{0.5\text{ hour}} = 100\text{ kg/hour}$$

*The throughput at the desired particle size range is **100 kg/hour**.*

Specific energy consumption at a desired particle size range

To determine the specific energy consumption of a grater running on electric motor, a certain amount of freshly peeled cassava was separated. All electric appliances and equipment were switched-off and a reading of **12540.0 kWh** was taken from the energy meter. All other electric equipment remained switched-off. The grater was switched-on, and the cassava was grated. A new reading of **12542.0 kWh** was taken from the energy meter. The grated material was sieved with a 5 mm strainer. The material retained at the strainer was discarded and the material that passed through was sieved with a 0.5 mm strainer. The weight of the material retained at the 0.5 mm strainer, was **50 kg**. What is the specific energy consumption at a desired particle size range of this grater?

$$\text{Specific energy consumption} = \frac{\text{Final electricity reading - Initial electricity reading}}{\text{Weight of material at desired particle size range}}$$

$$\text{Specific energy consumption} = \frac{12542.0 \text{ kWh} - 12540.0 \text{ kWh}}{50 \text{ kg}} = \frac{2.0 \text{ kWh}}{50 \text{ kg}} = 0.04 \text{ kWh/kg}$$

*The specific energy consumption at a desired particle size range of this grater is **0.04 kWh/kg**.*

To determine the specific energy consumption of a grater running on an internal combustion engine, a certain amount of freshly peeled cassava was separated, and the equipment's fuel tank was filled to its maximum level. The grater was switched-on, and the cassava grated. The grated material was sieved with a 5 mm strainer. The material retained at the strainer was discarded and the material that passed through was sieved with a 0.5 mm strainer. The weight of the material retained at the 0.5 mm strainer was **100 kg**. Using a graduated cylinder, the fuel tank of the grater was refuelled. To fill it up to its maximum level, **5 litres** of diesel was required. What is the specific energy consumption at the desired particle size range for grater?

$$\text{Specific energy consumption} = \frac{\text{Amount of fuel consumed}}{\text{Weight of material at desired particle size range}}$$

$$\text{Specific energy consumption} = \frac{5 \text{ litres}}{100 \text{ kg}} = 0.05 \text{ L/kg}$$

*Specific energy consumption at a desired particle size range is **0.05 L/kg**.*

Specific energy cost

Calculate the specific energy cost of a grater running on an electric motor that has a specific energy consumption at a desired particle size range of **0.04 kWh/kg**. Also, calculate the specific energy cost of a grater running on an internal combustion engine with specific energy consumption at a desired particle size range of **0.05 L/kg**. Consider the cost of electricity **$0.50 per kWh** and the cost of fuel is **$2.00 per litre**.

$$\text{Specific energy cost} = \text{Specific energy consumption} \times \text{Fuel cost}$$

$$\text{Specific energy cost} = \frac{0.04\ \text{kWh}}{1\ \text{kg}} \times \frac{\$0.50}{1\ \text{kWh}} = 0.02\ \$/\text{kg}$$

$$\text{Specific energy cost} = \frac{0.05\ \text{L}}{1\ \text{kg}} \times \frac{\$2.00}{1\ \text{L}} = 0.10\ \$/\text{kg}$$

*The specific energy cost of the machine running on electric motor is **0.02 $/kg** and the specific energy cost of the machine running on internal combustion engine is **0.10 $/kg**.*

Grating is an important step in cassava processing. The most commonly used grating equipment are motor-powered graters with a rotatory abrasive drum, or with swinging hammers. Grating is an energy-intensive operation and this booklet describes its most important performance indices. In addition, provides a step-by-step guide to calculating them along with worked examples.

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