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Akanbi O.P.

Performance and Sensitivity Evaluation of a Developed Cassava-Grating Machine

Performance and economic returns of developed cassava-grating machine was investigated. The equipment has a realistic functional efficiency of 71.5% and the discharge capacity 4.04 tons per day. Simulation of its economic analysis shows that $26.3 could be saved while using cassava grater over convection system for 1-ton of cassava tuber. At 0.01 and 0.05 level of significance, it showed that the machine has a good economic potential over the convection method of grating. It saves time and labor requirements by a factor of 0.67.

Keywords: *Cassava, Grating, Convectional, Efficiency, Economic, Potential, Ton, Discharge*

1. Introduction

Cassava (Manihot esculenta Crantz) is a very important crop in Nigeria deriving from the extensive use of the various products and by-products as staples to most Nigerians. The consumption of cassava cuts across all parts of the country. Its adaptability to climatic and soil conditions even in marginal soils has endeared cassava to most people that have to do continuous cultivation on limited available land. Cassava is a shrubby, tropical, perennial plant that is not well known in the temperate zone. For most people, cassava is most commonly associated with tapioca. The plant grows tall, sometime reaching 15 feet, with leaves varying in shape and size. The edible parts are tuberous root and leaves. The tuber (root) is somewhat dark brown in color and grows up to 2 feet long. Cassava (manihot esculenta), has its origin as South America, presumably Eastern Brazil. It thrives better in poor soils them any other major food plants.

Nigeria has been world-leading producer of cassava with an estimated annual production of 2.6 million tons from an estimated area of 1% million hectares of land (IITA, 1990) and (Agbetoye, 2005). The major problem of cassava is that it is extremely perishable and the harvested tuber must be process to curb post-harvest losses (Davies, 1991). According to food and Agriculture Organization

(FAO, 2007) the estimated industrial cassava use was approximately, 16 percent of cassava root production and was utilized as an industrial raw material in 2001 in Nigeria. Around the world, cassava is a vital stable for about 500 million people. Cassava's starching roots produce more food energy permit of land than any other staple crop.

Nigeria is currently the largest cassava producer in the world with estimated annual production of about 40 million metric tons. About 90% of this is however, consumed as food. The country is yet to fully harness the socio-economic potential of cassava that world translate to higher ranking of cassava next to petroleum as major contributor to the Goss Domestic Product (GDP). However, the need to mechanize cassava processing is enormous. The convectional cassava processing has a number of disadvantages and requires human energy and time and this has necessitated the design and development of mechanically-operated cassava grating machine. Mechanized cassava grater has been a point of focus for the research as far back as 1960 and effort at improving grating efficiency and mode of operation are still on going. Therefore, the research study is focused on carrying out a sensitivity evaluation on the mechanical cassava grating in order to improve on its functional efficiency for maximum optimization.

2.1. Materials and methods

2.1.1. Grater efficiency

The machine was designed to accommodate a maximum of 4 tubers of 1.1kg each in its hopper. The functional capacity of the hopper is 5.0 kg.

Therefore, the functional efficiency of the machine is expressed as follows:

$$GFE = \frac{CPOG}{LCTG} * 100 \qquad (1)$$

Where:

CPOG = Cassava pulp output from the grating machine
LCTG = Loaded cassava tuber from the grating machine.

2.1.2. Machine capacity

The discharge rate of the machine is determined using the expression in equation (2) as follows:

$$QRM = \frac{TNT}{Tt} \quad \text{(kg/min)} \qquad (2)$$

Where:

QRM = Discharge rate of the machine (Kg/min)
TNT = Total number of tubers (Kg)
Tt = Time taken (min).

The machine capacity is estimated using the relationship in equation (3):

$$MC = QM \quad (3)$$

Where;
MC is the machine capacity (Kg/hr)
Q is the discharge rate
M is the mass of cassava tuber.

Plate 1 shows developed cassava grating machine and its specification is shown in table 1.

Plate 1. Cassava grating machine

Table 1. Machine specification

Capacity:	449kg/hour
Mode:	5.5 HP Petrol Engine or Electric
Feature:	Production of fine marsh suitable for the production of high quality cassava flour and starch grain. Robust, Portable machine. Ease of maintenance and operation. Economy of operation.

2.1.3. Economic evaluation

The economic evaluation of using the cassava-grating machine was evaluated as follows: The service capacity per day is evaluated using the expression in equation (4):

$$SCD = 0.001Q \quad (4)$$

Where,
SCD = Service capacity/day
Q = Discharge rate
Factor *0.001* = Working hour (9hrs.) per day

Therefore, the machine service capacity per year is evaluated as follows:

$$SCY = 0.43Q \quad (5)$$

Where,

SCD = Service capacity/year;

Factor *0.43* = Working hour (9hrs.) per day for 365-day.

3.1 Result and discussion

3.1.1 Materials selection and cost

Creating equipment that perform their function effectively, safely, at acceptable cost must be well structured. The set of properties for a particular material is called the "material attributes" which includes both structured and non-structured information on the material –materials selection involves seeking the best match between the design requirements and the materials attributes. Materials were selected based on the function each of the components was designed to perform. The specification and cost of each selected component is shown in below:

Table.2. Material selection

S/N	Qty	Description	Size	Amount ($)
1	1	Galvanized steel 2mm	750 x 2250	12
2	1	Metal shaft	30 x 500mm	15
3	1	Wood	250 x 400mm	9.2
4	2	2 inches angle bar	2mm x 2mm	9.0
5	2	Bearings (pillow block)	6207	13.4
6	2	Bearing cases		11.0
7	1packet	Electrodes	G12	6.5
8	1	Cutting disc		10.0
9	1	Grater		9.5
10	40	Nails	3	2.5
11	12	Bolts and Nuts	M16	2.5
12	1	Electric motor	220-420v	74
13	2	Pulley		15.5
14	2	Sand paper		2.5
15	1	Wooden plank	2 x 12 ft	6
16	1	Flat belt		5.5
17		Miscellaneous		5.5
			Total	28,750

Source: Field study, 2008

3.1.2. Analysis and evaluation of cassava grating cost

Production cost

The production cost of the machine is the sum of the total material cost, labour, and transportation/handling cost. The three cost variables are mathematically related in equation (6) as follows:

$$PCM = (tM_c + tL_c + tT_c)\mu \tag{6}$$

Where,

PCM = Production cost of the machine
tMc = Total cost of materials
tT = cost of transportation/materials handling
μ = cost index (0.99)

Materials selection is a central aspect of design. Converting selected materials to developed cassava grating machine, some input expenses on the part of human operation and component machinery cost would have been expended. Table 3 shows the cost analysis

Table 3. Cost analysis

S/N	Description	Amount($)
1	Cutting, welding and nailing	100
2	Machining	120
3	Assembling	140
	Total	**360**

Source: Field study, 2008

Cassava tubers of varying sizes were used for experimental operation. Table 4 shows various weights of the cassava tuber used for the simulation. Table 5 shows the output of cassava grating machine using various number, size and weight of cassava tuber.

Table 4. Weight of cassava

S/N	**Mass of Tuber (KG)**
1	1.4
2	1.78
3	1.20
4	1.60
5	1.00
6	0.89
7	1.48
Total	**9.35**

Source: Field study, 2008

Table 5. Output of cassava grating machine

S/N	NTP	TG(s)	MGCT
1	1	11	1.40
2	2	12	1.78
3	1	10	1.20
4	2	12	1.60
5	1	0.9	1.00
6	1	10	8.89
7	2	11	1.48
Total	**13**	**75.5**	**9.35kg**

Source: Field study, 2008

Note:

NTP = No of cassava tuber
TG = Grating time (s)
MGCT = Mass of grated cassava tuber

The output from the table 4 above shows that 13 tubers of cassava were grated within 76 seconds.

4. Conclusion

The functional efficiency and economic returns of cassava grating machine were evaluated using different technical-based techniques. It was deduced that the equipment has a grating and working capacity of 449 kg/hr of cassava tuber to pulp and 9-hour per as operation period. It shows that the instrument grates 4,041(4.04 tons) kg/day and 15,776,064kg (15,776.1 tons) per year respectively. Application of cassava grating machine greatly reduces drudgery and saves time over the conventional method of grating. In addition operation cost of $26.3 is being saved over the convectional system for grating 2-ton of cassava tuber. The equipment is very easy to operate and the maintenance is very low because of its indigenous technological base and has realistic functional efficiency of 71.5%. In view of this, the machine is recommended for both farmers and cassava-based manufacturing industries for higher grating efficiency.

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Address:

- Akanbi O.P., Department of Chemical Engineering, Auchi Polytechnic, Auchi, Nigeria.

Corresponding Author:engrakanbiolusola@yahoo.fr