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Comparative Evaluation of Some Peeling Parameters of a Rotary Cassava Peeling Machine with Manual Knife Peeling

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Abstract:

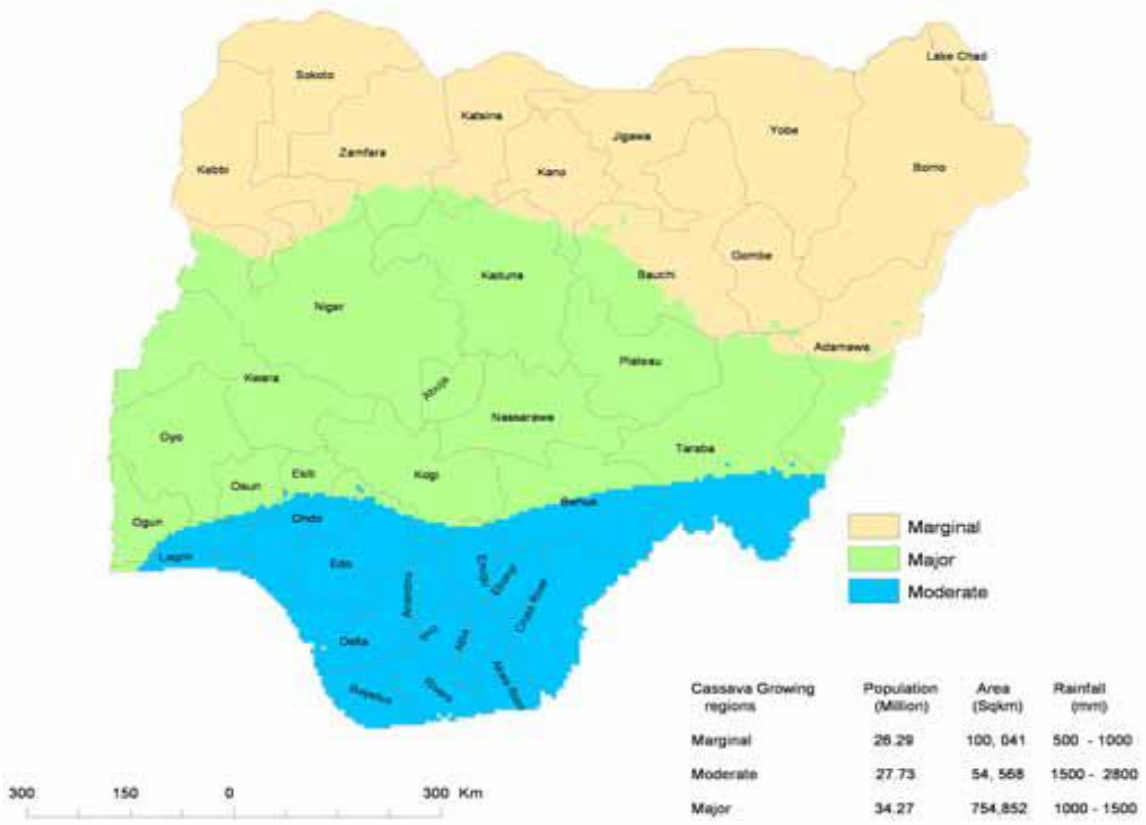
Cassava is grown and consumed in all agro-ecological zones of Nigeria; it is a draught resistant crop rich in carbohydrates and other nutrients. Nigeria is the world's highest producer. With its potentials, if well mechanized, cassava can improve food and nutritional security. The root is highly perishable with a span of 48 to 72hours after harvest. The more need for it to be processed timely to prevent wastage. It provides food for human and livestock; the edible starch is also useful for manufacturing and pharmaceutical industries as raw materials. Virtually all aspect of its propagation and processing have been successfully mechanized, but the peeling part is largely research in progress which has led to the design and fabrication of simple peeling tools to motorized peeling machines to ease the operation.

The traditional method of peeling is laborious and time consuming; the reason why NCAM has been working on ways of mechanizing this aspect of cassava processing. The design and fabrication of rotary cassava peeling machine was a huge success; the comparative performance evaluation of the machine and the conventional manual knife peeling was carried out using the following parameters: peeling time, peeling rate, peeling efficiency, and peeling capacity to ascertain the usefulness of the machine. It was concluded that the machine performed well.

Key Words: *Comparative, Evaluation, Rotary, Peeling and Machine.*

1. INTRODUCTION

Cassava (*Manihot esculenta crantz)* is a tuberous root crop that is grown and consumed across all the agro-ecological zones in Nigeria (Ezedinma, 2006). With an annual production of about 50 million metric tons, Nigeria is widely acknowledged as the largest producer in the world, contributing up to 20% of world's production, 34% of Africa's and 46% of West Africa's (FAO, 2019). Cassava is produced across virtually all of Nigeria's agro-ecological zones (NBS, 2007). However, the major growers are the Middle Belt states of the Federation. The root is viable for 48 to 72 hours after harvest before it gets worse due to fermentation or injuries sustained during and after harvest.



Cassava Growing regions	Population (Million)	Area (Sqkm)	Rainfall (mm)
Marginal	26.29	100, 041	500 - 1000
Moderate	27.73	54, 568	1500 - 2800
Major	34.27	754,852	1000 - 1500

Figure 1: Cassava growing regions in Nigeria (Source: Ezedinma, 2006).

Cassava is very rich in edible starch and other nutrients. It is a draught resistant crop that can boost food and nutritional security. Aside from being a source of carbohydrate for both human and livestock, it is useful in the production of starch and ethanol for manufacturing and pharmaceutical industries. Post harvest handling of cassava is essential to reduce losses. Processing of cassava into finished or semi-finished products often involves all or some of the following operations, depending on the desired end-product: peeling, washing, grating/chipping, dewatering, fermentation, pulverizing, sieving, pelletizing, and drying/frying (Oriola and Raji, 2013).

Peeling, which is the removal of periderm and cortex from the root is still largely done manually. This is laborious and time consuming; also the quality of the end product is low due to contaminations. Hence, the effectiveness is low and not suitable for commercial purposes.

Research efforts have been devoted to the development of peeling machines by many research institutes and individual researchers since when the search for effective peeling mechanisms really started; the peeling tools of the National Centre for Agricultural Mechanization (NCAM) were invented to substitute for primitive knives, and it proved effective but still manually operated. Currently, some peeling machines have been developed, and these include continuous process cassava-peeling machine, horizontal cassava peeler, rotary cassava peeler, etc.

A most recent effort by the Centre to improve mechanical peeling is the design and fabrication of a motorized rotary cassava peeler. The machine was tested and some peeling parameters such as peeling rate, tuber loss, peeling time and peeling capacity were evaluated in comparison with the conventional manual knife peeling to ascertain its efficiency.

2.0. MATERIALS AND METHODS

2.1. Machine Description

The rotary peeling machine is cylindrical in shape; made of mild steel. The surface diameter is about 100Cm. The inner part is made of galvanized mild steel perforated to give abrasion. It has a rigid vertical wall and a rotary circular base. It has three discharge outlets: the peeled cassava discharge outlet and the other two for peel discharge. The machine is powered by a 6hp diesel engine connected to a speed reduction gear of ratio 1:40 through the shaft at the base of the machine.

2.2. Working Principle

The machine works by abrasion; the perforated inner surface gives the needed abrasion for peeling through the rotary base which spins the loaded tubers. Washing is done concurrently by intermittent flushing during operation to remove peels.

Plate 1: Pictorial view of the motorized Rotary Cassava peeling machine.

2.3. Materials

i. Cassava: The cassava used for this evaluation was sourced from NCAM cassava farm.
ii. Analog weighing scale
iii. Tachometer
iv. Stopwatches
v. Sacks
vi. Water

vii. Bowls and pales
viii. Kitchen knives

2.4. Experimental Procedures

Tubers of irregular shapes were used for the testing; 30kg of Cassava was weighed out in three replicates each for both mechanical and manual peeling operations. The speeds of both the unloaded and loaded motorized peeling machine were read and recorded.

Three individuals were used for the manual knife peeling; the operations (manual and mechanical peeling) were started concurrently and timed. The weight of peels gotten was taken and recorded from the outlet chute of the machine. The procedure was repeated for the three replicates for the machine. The weight of peel from the manual knife peeling was taken and recorded for each of the replicates as well.

Plate 2: Machine Peeled cassava

Plate 3: Manual knife peeling.

2.5. Evaluated Parameters

The evaluation was carried out using formulae (modified) by Olukunle and Jimoh, 2012 as follow:

1. Peeling Rate (P_r): $$P_r = \frac{W_C}{P_t}$$

Where,

P_r is the peeling rate in kg/s;

W_C is the weight of tuber fed into the machine (kg);

P_t is the time of operation in (s).

2. Determination of tuber losses (T_L): $$T_L = \frac{W_{TP}}{W_C} \times 100$$

Where,

T_L is the tuber loss (%);

W_C is a weight of tuber before peeling, kg;

M_{TP} is the total weight of peel collected from the Machine, kg;

3. Peeling Efficiency (P_E): $P_E = \frac{W_{TC}}{W_C} \times 100$

Where,

P_E is peeling efficiency (%);

W_{TC} is the weight of peeled tuber collected, kg;

W_C is a weight of tuber before peeling, kg.

4. Machine Output Capacity (M_{TC}): $M_{TC} = P_r \times 3600$

5. Peeling Time: was determined directly using the stopwatch and record.

3.0. RESULTS AND DISCUSSIONS

3.1. Results

Some parameters Evaluated from the Machine and manual knife peeling operations are presented in tables 1 and 2 respectively.

Table 1: Some Parameters Evaluated from the Rotary Peeling Machine.

Sample	W_C (kg)	W_{TC} (kg)	W_{PCH} (kg)	W_{PC} (kg)	W_{TP} (kg)	P_E (%)	T_L (%)	P_r kg/s	P_t (s)	M_{TC} (kg/hr)	Speed (rpm)
A	30.00	22.80	2.60	4.60	7.20	76.00	24.00	0.769	39.00	2768.40	503.00
B	30.00	19.25	4.45	6.30	10.75	64.17	35.83	0.577	52.00	2077.20	605.00
C	30.00	17.70	5.10	7.20	12.30	59.00	41.00	0.462	65.00	1663.20	701.00
Average	30.00	18.58	3.38	8.03	11.42	66.39	33.61	0.603	52.00	2169.60	603.00

Table 2: Some Parameters Evaluated from Manual Knife Peeling Operation.

Sample	W_C (kg)	W_{TP} (kg)	T_L (%)	P_E (%)	P_t	P_r kg/s	P_C (kg/hr)
A	30.00	23.80	20.67	79.33	54min50s	0.009	32.40
B	30.00	23.60	21.33	78.67	101min31s	0.005	18.00
C	30.00	22.60	26.00	75.33	47min5s	0.011	39.60
Average	30.00	23.33	22.67	77.78	67min49s	0.025	30.00

Notations:

W_C – Weight of fresh cassava (kg); W_{TC} – Weight of peeled tuber collected from the machine (kg); W_{PCH} – Weight of peel collected from the machine by hand (kg); W_{PC} – Weight of peel flushed out of the machine during operation (kg); W_{TP} – Total weight of peel collected from the machine (kg); P_E – Performance efficiency of the machine (%); T_L – Tuber Loss (kg); Pr – Peeling Rate (kg/s); P_t – Peeling Time (s) and M_{TC} – Machine Throughput Capacity (kg/hr).

3.2. Discussions

1. Peeling Time: The average peeling time (**tables 1 and 2**) for the machine was calculated as 52s; while that of manual knife peeling was recorded as 4069s (67min49s). This is a clear distinction that the rotary cassava peeler is time efficient compared to manual knife peeling with an operational time ratio of 1:78s. With the use of this machine, the problem of timeliness of peeling operation is solved; also spare time is created for other useful activities that can promote productivity.

2. Peeling Efficiency: an average peeling efficiency of 66.39% was recorded for the machine and 77.78% for manual knife peeling. There is a clear mark in the efficiency of the two operations; the efficiency of peeling machines among other parameters depends on the optimum operational speed as reported by Olukunle and Jimoh (2012), that the higher the operational speed, the lower the peeling efficiency. This was observed as the efficiency of the machine decreased with an increase in speed (**table 1**) for each replicate with the best result gotten at the 503rpm speed of operation.

3. Tuber Loss: The tuber loss was estimated by the weight of peel collected from each operation. Manual knife peeling had an average tuber loss of 22.67% compared to 33.61% for the rotary peeling machine. This also is distinct; the tuber loss in peelers is influenced by the speed of operation as reported by Olukunle and Jimoh (2012) that the higher the speed, the higher the tuber loss. It was observed that tuber loss increased with increase in speed of operation (**table 1**).

4. Machine Output Capacity: The output capacity which represents the output per hour of the two operations showed that the rotary peeling machine had an average output of 2169.60kg/hr (**table 1**) compared to 30kg/hr (**table 2**) for manual knife peeling. This is due to the speed of operation for the machine.

RECOMMENDATION

From the observations during this evaluation and testing, it is recommended that an optimum peeling speed is determined for the machine to help operators get the best output.

CONCLUSIONS

It was concluded that the machine average overall performance was good with peeling efficiency of 66.39%, tuber loss of 33.61%, throughput capacity of 2169.60kg/hr and average peeling time of 52s at an average speed of 603rpm.

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