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COMPARATIVE STUDY OF CASSAVA CHIPS PRODUCED FROM CHIPPING PLATES OF VARIED PUNCHED UP DIAMETERS

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Abstract:

Cassava chips are products derived from freshly harvested cassava roots. It is a non-fermented cylindrically shaped product of about 3mm to 5mm in diameter. Cassava chips are often used as a carbohydrate base in the animal feed industry particularly in Europe and in production of biofuels. In addition, cassava chips can be milled into flour for other uses such as in the production of ethanol, cakes and biscuits.

The machine was constructed and made use of fabricated chipping plates of 5mm, 6mm, 7mm and 8mm punched up diameters and a comparative study of chips produced from the plates were carried out. The result showed that 8mm chipping plate has the highest chipping efficiency and capacity of 94.1% and 103kg/hr. The chips are between 51mm to 87mm long.

Keywords: **cassava, cassava chips, chipping plates, efficiency**

1.0 Introduction

Cassava (Manihot esculenta Crantz) is a perennial woody shrub with an edible root which grows in tropical and sub-tropical areas of the world. Cassava originated from tropical America and was first introduced into Africa in the Congo basin by the Portuguese around 1558. It is rich in carbohydrates, calcium, vitamins B and C, and essential minerals. However, nutrient composition differs according to variety and age of the harvested crop, soil conditions, climate and other environmental factors during cultivation. It contributes significantly to the nutrition and livelihood of 800 million around the world. It serves as a raw material in the manufacture of processed foods, animal feed and industrial products [Balagopalan (2002), Aloy and Mings (2006), Taiwo (2006)].

Cassava tubers once harvested begin to deteriorate and cannot be stored for more than a few days. Thus, there is a need for rapid processing of the tubers into a more shelf stable form. Processing the tubers into dried chips reduced the moisture content to a very low level and reduced postharvest losses [IITA (1990), Ugwu (1996)]. Cassava can be dried naturally in the sun or artificially in the oven [FIIRO, (2005), Irinkoyenikan et al (2008)] to produce dried cassava chips. Chips are commonly used in animal feed production. However, several studies have shown that cassava chips can be converted to desired products such as starch, flour [Famokunwa (1994), Olomo and Ajibola (2006)], fufu and garri. Cassava processing is constrained by a lack of steady supply of tubers throughout the year, high transport cost to processing centres, inadequate processing equipment and low returns from small-scale processing [RTEP, (2003), Asiedu, (1989)]. World production of cassava is around 250 million tonnes

(Mt) a year with Africa contributing to more than half of the global supply.

Nigeria produces the largest cassava in the world (UNCTAD, 2013). Nigeria produces a third more than Brazil and almost double the production capacity of Thailand and Indonesia but despite this, Nigeria is not an active participant in International markets when compared with these countries. Although, the cassava crop has relatively few problems in production, its problem seems to multiply at the post-harvest stage. Storage of fresh tuber, mechanization of harvesting and mechanized processing are areas which pose the greatest challenges. The processing of cassava tubers for industrial or human use involves different operations of which chipping is an important one when exports are considered. The study was carried out with the aim of producing chips using freshly cassava harvested tubers with moisture content ranging between 68.5% and 81.2%

2.0 Materials and methods

The material selected for the construction of the chipping plate is stainless steel, due to its high tensile strength (210MN/m2) and its unique corrosion resistance. The material gives a better quality chips compare with its counterpart iron alloys such as mild steel. Mild steel is not suitable for making the chipping plate due to it corrosive nature, hence it decolourized the chips.

Riveting was used as the fastening device for firm fastening of the chipping plate to the mould to withstand the stress generated during operation and for easy removal of the chipping plate from mould to facilitate the mounting of new plate. The outer diameter of the plate and the inner diameter are 375mm and 70mm respectively. A total of 128 holes were drilled on each plate using drill bits of 5mm, 6mm, 7mm and 8mm respectively before punched up. The chipping plate has a constant pitch of 8.5mm.

3.0 Results and Discussions

3.1 Comparative analysis of the chips produced from the chipping plates

The chips produced from the chipping plates were analyzed quantitatively and the following tables were generated in the course of the analysis.

Table 1. Percentage moisture content from 8mm punched up diameter chipping plate.

S/N	WET MASS (grams) w	DRY MASS (grams) d	DIFFERENCE (w-d) (grams)
1.	0.90	0.40	0.50
2.	0.80	0.40	0.40
3.	0.80	0.40	0.40
4.	0.60	0.30	0.30
5.	0.70	0.30	0.40
6.	0.80	0.40	0.40
7.	0.50	0.20	0.30
8.	0.70	0.30	0.40
9.	0.80	0.40	0.40
10.	0.90	0.50	0.40

Mean percentage moisture content removed: %MCR

Using the formula:

$$\% MCR = \frac{\sum w - d}{\sum w} \times 100\%$$

$$\% MCR = \frac{3.9}{7.5} \times 100\%$$

$$\% MCR = 52.0\%$$

Therefore the percentage moisture content is 52.0%

Table 2. Percentage moisture content from 7mm punched up diameter chipping plate

S/N	WET MASS (grams) w	DRY MASS (grams) d	DIFFERENCE (w-d) (grams)
1.	0.70	0.30	0.40
2.	0.70	0.30	0.40
3.	0.60	0.30	0.30
4.	0.70	0.30	0.40
5.	0.70	0.30	0.40
6.	0.80	0.40	0.40
7.	0.60	0.30	0.30
8.	0.70	0.30	0.40
9.	0.80	0.40	0.40
10.	0.80	0.30	0.50

Mean percentage moisture content removed: %MCR

Using the formula:

$$\% MCR = \frac{\sum w - d}{\sum w} \times 100\%$$

$$\% MCR = \frac{3.9}{7.1} \times 100\%$$

$$\% MCR = 55.0\%$$

Therefore the percentage moisture content is 55.0%

Table 3. Percentage moisture content from 6mm punched up diameter chipping plate

S/N	WET MASS (grams) w	DRY MASS (grams) d	DIFFERENCE (w-d) (grams)
1.	0.70	0.30	0.40
2.	0.80	0.30	0.50
3.	0.70	0.30	0.40
4.	0.70	0.30	0.40
5.	0.70	0.30	0.40
6.	0.60	0.30	0.30

7.	0.60	0.20	0.40
8.	0.60	0.20	0.40
9.	0.60	0.20	0.40
10.	0.70	0.30	0.40

Mean percentage moisture content removed: %MCR
Using the formula:

$$\% \, MCR = \frac{\sum w - d}{\sum w} \times 100\%$$

$$\% \, MCR = \frac{4.0}{6.7} \times 100\%$$

$$\% \, MCR = 60.0\%$$

Therefore the percentage moisture content is 60.0%

Table 4. Percentage moisture content from 5mm punched up diameter chipping plate

S/N	WET MASS (grams) w	DRY MASS (grams) d	DIFFERENCE (w-d) (grams)
1.	0.70	0.30	0.40
2.	0.70	0.30	0.40
3.	0.60	0.20	0.40
4.	0.70	0.30	0.40
5.	0.60	0.20	0.40
6.	0.60	0.20	0.40
7.	0.60	0.20	0.40
8.	0.60	0.20	0.40
9.	0.50	0.20	0.30
10.	0.50	0.20	0.30

Mean percentage moisture content removed: %MCR
Using the formula:

$$\% \, MCR = \frac{\sum w - d}{\sum w} \times 100\%$$

$$\% \, MCR = \frac{3.8}{6.1} \times 100\%$$

$$\% \, MCR = 62.3\%$$

Therefore the percentage moisture content is 62.3%

3.2 Statistical analysis of the results

Statistical analysis involves the collection and scrutinizing of a set of data in order to come to a conclusion on the implications and general overview of the data. Confidence interval has been employed in the analysis of the data collected from the chipping plates.

Table 5. Chipping plate one (8mm punched up diameter)

$$\bar{x} = \frac{\sum xi}{n}$$

$$\bar{x} = \frac{524.28}{10}$$

$$\bar{x} = 52.428\%$$

$$\sigma^2 = \frac{\sum (x-\bar{x})^2}{n}$$

$$\sigma^2 = \frac{204.85}{10}$$

$$\sigma^2 = 204.85$$

$$\sigma^2 = \sqrt{20.485}$$

$$\sigma^2 = 4.526$$

$$\bar{x} - t\frac{a}{2}\frac{\sigma}{\sqrt{n}} < \mu < \bar{x} + t\frac{a}{2}\frac{\sigma}{\sqrt{n}}$$

The value of **t** is given as 2.09 from statistical table

$$52.43 - 2.09\frac{4.526}{\sqrt{10}} < 52.43 + 2.09\frac{4.526}{\sqrt{10}}$$

$$52.43 - 2.99 < \mu < 52.43 + 2.99$$

S/N	WET MASS (grams) w	DRY MASS (grams) d	DIFFERENCE (w-d) (grams)	% mcr (x)	$(x-\bar{x})^2$
1.	0.90	0.40	0.50	55.56	9.80
2.	0.80	0.40	0.40	50.00	5.90
3.	0.80	0.40	0.40	50.00	5.90
4.	0.60	0.30	0.30	50.00	5.90
5.	0.70	0.30	0.40	57.14	22.20
6.	0.80	0.40	0.40	50.00	5.90
7.	0.50	0.20	0.30	60.00	57.34
8.	0.70	0.30	0.40	57.14	22.20
9.	0.80	0.40	0.40	50.00	5.90
10.	0.90	0.50	0.40	44.44	63.81
Total	7.5	3.6	3.9	524.28	204.85

$$49.44 < \mu < 55.42$$

Therefore the percentage moisture content removed from chips generated using this plate (8mm punched up diameters plate) is between the intervals 49.44% and 55.42%, leaving the chips with moisture content of between 12.78% and 18.76% (since raw cassava contains 68.20% moisture)

Table 6. Chipping Plate (7mm punched up diameter)

S/N	WET MASS (grams) w	DRY MASS (grams) d	DIFFERENCE (w-d) (grams)	% mcr (x)	$(x-\bar{x})^2$
1.	0.70	0.30	0.40	57.14	5.38
2.	0.70	0.30	0.40	57.14	5.38
3.	0.60	0.30	0.30	50.00	23.23
4.	0.70	0.30	0.40	57.14	5.38
5.	0.70	0.30	0.40	57.14	5.38
6.	0.80	0.40	0.40	50.00	23.23
7.	0.60	0.30	0.30	50.00	23.23
8.	0.70	0.30	0.40	57.14	5.38
9.	0.80	0.40	0.40	50.00	23.23
10.	0.80	0.30	0.50	62.50	58.98
Total	7.1	3.2	3.9	548.2	178.8

$$\bar{x} = \frac{\sum xi}{n}$$
$$\bar{x} = \frac{548.20}{10}$$
$$\bar{x} = 54.82\%$$
$$\sigma^2 = \frac{\sum(x-\bar{x})^2}{n}$$
$$\sigma^2 = \frac{178.80}{10}$$
$$\sigma^2 = 17.88$$
$$\sigma^2 = \sqrt{17.88}$$
$$\sigma^2 = 4.23$$
$$\bar{x} - t\frac{a}{2}\frac{\sigma}{\sqrt{n}} < \mu < \bar{x} + t\frac{a}{2}\frac{\sigma}{\sqrt{n}}$$

The value of **t** is given as 2.09 from statistical table

$$54.82 - 2.09\frac{4.23}{\sqrt{10}} < 54.82 + 2.09\frac{4.23}{\sqrt{10}}$$
$$54.82 - 2.80 < \mu < 54.82 + 2.80$$
$$52.02 < \mu < 57.62$$

Therefore the percentage moisture content removed from chips generated using this plate (7mm punched up diameters plate) is between the intervals 52.02% and 57.62%, leaving the chips with moisture content of between 10.58% and 16.18% (since raw cassava contains 68.20% moisture)

Table 7. Chipping plate three **(6mm punched up diameter)**

S/N	WET MASS (grams) w	DRY MASS (grams) d	DIFFERENCE (w-d) (grams)	% mcr (x)	$(x-\bar{x})^2$
1.	0.70	0.30	0.40	57.14	7.18
2.	0.80	0.30	0.50	62.50	7.18
3.	0.70	0.30	0.40	57.14	7.18
4.	0.70	0.30	0.40	57.14	7.18
5.	0.70	0.30	0.40	57.14	7.18
6.	0.60	0.30	0.30	50.00	96.43
7.	0.60	0.20	0.40	66.67	46.92
8.	0.60	0.20	0.40	66.67	46.92
9.	0.60	0.20	0.40	66.67	46.92
10.	0.70	0.30	0.40	57.14	7.18

$$\bar{x} = \frac{\sum xi}{n}$$
$$\bar{x} = \frac{598.21}{10}$$
$$\bar{x} = 59.82\%$$
$$\sigma^2 = \frac{\sum(x-\bar{x})^2}{n}$$
$$\sigma^2 = \frac{154.27}{10}$$
$$\sigma^2 = 15.43$$
$$\sigma^2 = \sqrt{15.43}$$
$$\sigma^2 = 3.93$$
$$\bar{x} - t\frac{a}{2}\frac{\sigma}{\sqrt{n}} < \mu < \bar{x} + t\frac{a}{2}\frac{\sigma}{\sqrt{n}}$$

The value of **t** is given as 2.09 from statistical table

$$59.82 - 2.09\frac{3.93}{\sqrt{10}} < 59.82 + 2.09\frac{3.93}{\sqrt{10}}$$
$$59.82 - 2.60 < \mu < 59.82 + 2.60$$
$$57.22 < \mu < 62.42$$

Therefore the percentage moisture content removed from chips generated using this plate (6mm punched up diameters plate) is between the intervals 57.22% and 10.98%, leaving the chips with moisture content of between 5.78% and 10.98% (since raw cassava contains 68.20% moisture)

Table 8. Chipping plate four (5mm punched up diameter)

S/N	WET MASS (grams) w	DRY MASS (grams) d	DIFFERENCE (w-d) (grams)	% mcr (x)	$(x-\bar{x})^2$
1.	0.70	0.30	0.40	57.14	28.52
2.	0.70	0.30	0.40	57.14	28.52
3.	0.60	0.20	0.40	66.67	17.56
4.	0.70	0.30	0.40	57.14	28.52
5.	0.60	0.20	0.40	66.67	17.56
6.	0.60	0.20	0.40	66.67	17.56
7.	0.60	0.20	0.40	66.67	17.56
8.	0.60	0.20	0.40	66.67	17.56
9.	0.50	0.20	0.30	60.00	6.15
10.	0.50	0.20	0.30	60.00	6.15

$$\bar{x} = \frac{\sum xi}{n}$$
$$\bar{x} = \frac{624.77}{10}$$
$$\bar{x} = 62.48\%$$
$$\sigma^2 = \frac{\sum(x-\bar{x})^2}{n}$$
$$\sigma^2 = \frac{185.66}{10}$$
$$\sigma^2 = 18.57$$
$$\sigma^2 = \sqrt{18.57}$$
$$\sigma^2 = 4.30$$
$$\bar{x} - t\frac{a}{2}\frac{\sigma}{\sqrt{n}} < \mu < \bar{x} + t\frac{a}{2}\frac{\sigma}{\sqrt{n}}$$

The value of **t** is given as 2.09 from statistical table

$$62.48 - 2.09\frac{4.30}{\sqrt{10}} < 62.48 + 2.09\,\frac{4.30}{\sqrt{10}}$$

$$62.48 - 2.84 \; < \; \mu \; < 62.48 + 2.84$$

$$59.64 \; < \; \mu \; < 65.32$$

Therefore the percentage moisture content removed from chips generated using this plate (5mm punched up diameters plate) is between the intervals 59.64% and 65.36%, leaving the chips with moisture content of between 2.88% and 8.56% (since raw cassava contains 68.20%

3.3 Capacity of the chipping plate

The capacity of the chipping plates is the amount in kilograms of cassava chipped per hour using hand to feed the tubers into the machine for chipping operation.

The chipping machine is being driven by an induction motor having an indicated maximum spindle speed of 1400rpm and one horse power rating.

Table 10. Capacity of chipping plates

Chipping plate	**Mass of cassava chipped (kg)**	**Chipping time (sec)**	**Capacity of plate(kg/hr)**
8mm CP	2.00	70.0	102.86
7mmCP	2.00	74.0	97.30
6mmCP	2.00	77.0	93.51
5mm CP	2.00	81.0	88.89

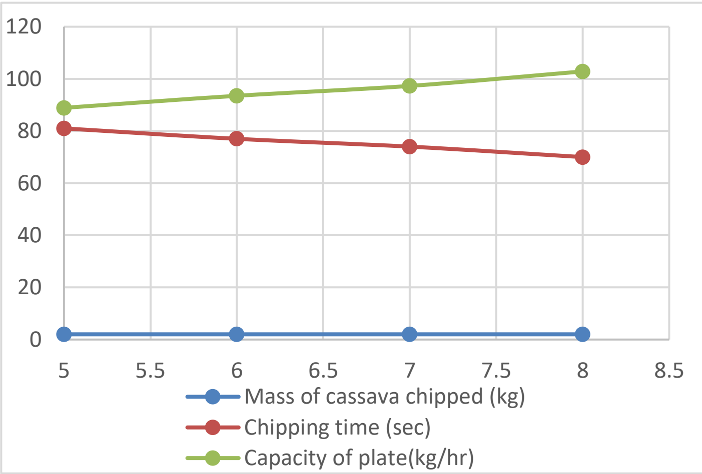

Fig. 1. Graphical Representation of Capacity of Chipping Plates

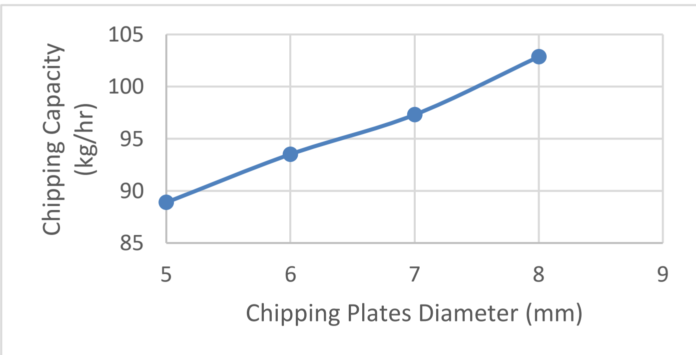

Fig. 2. Graphical Representation of Chipping Capacity and Plate Diameter

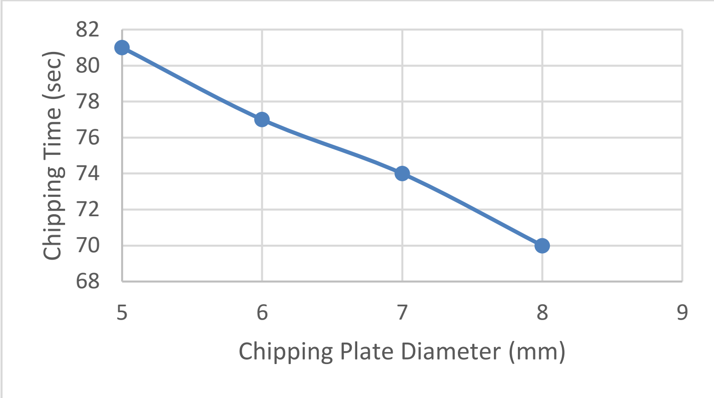

Fig. 3. Graphical Representation of Chipping Time and Plate Diameter

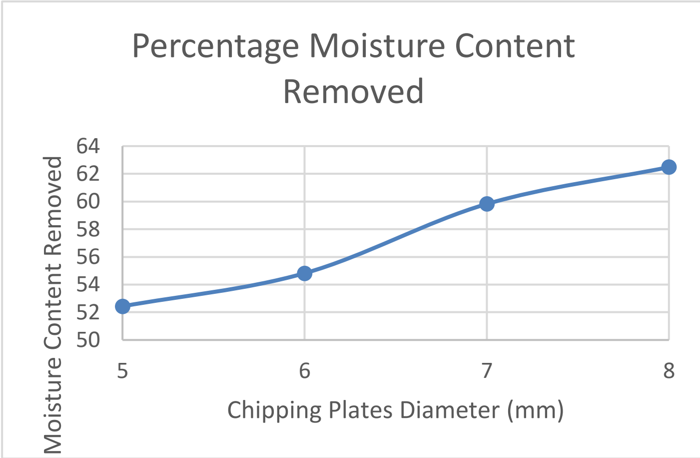

Fig. 4. Graphical Representation of percentage moisture content removed

The evaluation of the chipping capacity was carried out using 2kg of cassava for each chipping plate in turn, and from the experiment the capacities of the plates were determined by using stop watch to capture the chipping time for each plate. From the table, it is observed that the chipping plate with 8mm punched up diameters gives the highest capacity of about 102.86kg/hr and that of 5mm punched up diameters gives the least of about 88.89kg/hr.

4.0 Conclusion

The chips produced from chipping plate of 8mm punched up diameter gives longest chip and the amount of moisture content removed from these chips is the least after exposing the chips to direct sun heat for one week. Also, the 8mm chipping disc has higher chipping efficiency, while better chipping machine capacity was obtained by using the 3-phase induction motor. The highest chipping efficiency and machine capacity were 94.1% and 102.00kg/hr. respectively.

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