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EVALUATION OF PHYSIO-MECHANICAL PROPERTIES OF PELLETS DERIVED FROM CASSAVA CHIPS AND MASH

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Abstract

The cassava pellets used in this study were produced with NCAM Pelleting Machine powered by a 5hp electric motor, die diameter of 1.4 cm and a fixed speed of 290 rpm. Pellets samples were produced through two treatments: cassava dough (chips) and mash. The pellets from the cassava dough (CDP) was produced by chipping, drying, milling, conditioning then pelleting, while the cassava mash into pellets (CMP) was processed by grating, dewatering then pelleting. Test results showed that Durability index of 99.7 %, Hardness test average of 9.78 N/mm^2 for CDP while Durability index of 92.7 % and Hardness test of 11.98 N/mm^2 %, for CMP respectively. Average lengths of 2.78 cm and 2.22 cm, diameters 1.28 cm and 1.23 cm fall within the standard for Pellets.

Keywords: *Cassava Pellets, Mechanical Properties, Physical Properties, Chips, Mash, Durability and Hardness.*

1.0 INTRODUCTION

The production and processing of cassava roots have now become a major economic activity due to the encouragement given by the government through the Root and Tuber Expansion Programme (RTEP).

Pellets, a product of high market value from cassava root are dried and hardened cylindrical particulate materials about 2-3 cm long 0.4 – 0.8 cm in diameter and uniform in appearance and texture (Olm-Olyne, 2004) and 9 % moisture content wet basis, which makes for good storability

(Onyekwere et al, 1994). The production of pellets as the most important form into which cassava root could be processed stimulated the need to improve the uniformity in the shape and size of cassava chips required by the users as Cassava pellets are obtained from dried and broken roots by grinding and hardening into a cylindrical shape. Pellets are produced by feeding dried chips into the milling machine, after which they are screened, conditioned and re-pressed into pellets. (FAO/IFAD, 2001). The most acceptable and commonly used method involves the conversion of peeled cassava roots into pellets (see flow chart in figure 2). The process involves feeding dried and milled flour into a pelleting machine, which presses the chips/mash before extrusion through a large die.

It is important to note that acceptability of the product in the international market is an important factor that requires extensive study on processing, handling, time and cost of production although significant efforts have been made to improve the physical quality of pellets (fine reduction) and increase throughput to make pelleting process more economical.

The objectives of this study were to determine the effect of each of the processing methods (Chips and Mash) on the Physical and Mechanical properties of Pellets produced and recommend for adoption the most appropriate Cassava Pellets Processing Method.

2.0 MATERIALS AND METHODS

The study was carried out at the National Centre for Agricultural Mechanization (NCAM) Ilorin. Fresh Sweet Cassava roots (Manihot Palmata) were purchased from the market, sorted, peeled and washed with clean water. The roots were then converted into chips and grated mash using NCAM Chipping machine powered by a 5Hp prime mover and NCAM Motorized grater powered by a 7Hp prime mover respectively. The mash was dewatered with a screw press designed and fabricated in NCAM. Drying operations were done using NCAM designed kerosene fired batch dryer. Sample from chips was milled and conditioned, also sample from mash was gathered and pelleting was done using a Pelleting Machine (available in NCAM), powered by a 5Hp electric motor with fixed speed of 290 rpm and fixed die diameter of 1.40 cm.

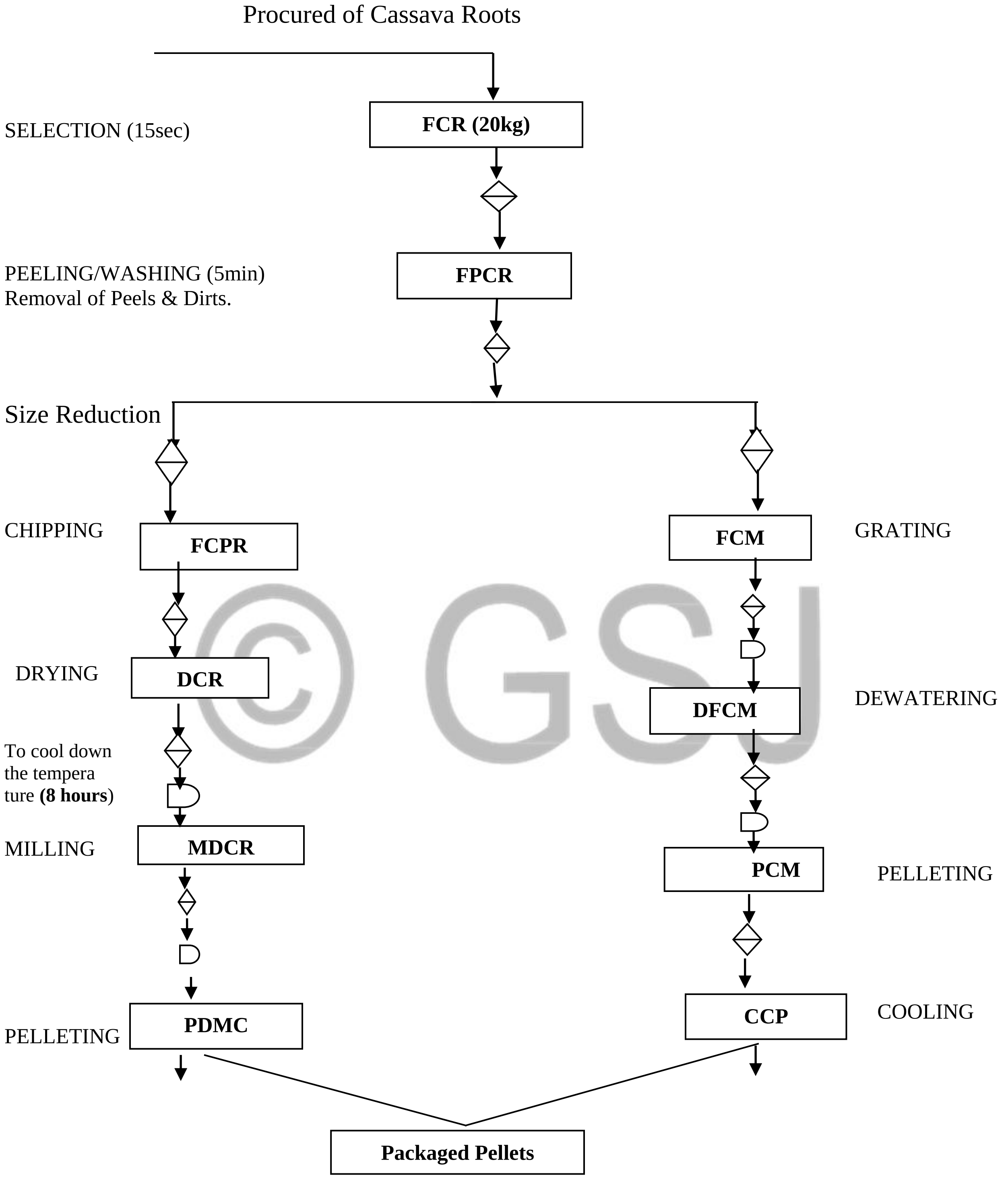
2.1 Sample Preparation

Two processing methods were used to prepare the pellet samples for this study.

Method A: 20 kg of peeled and washed roots (Manihot Palmata) were weighed and chipped then dried in NCAM kerosene fired dryer for 8hours at a maximum temperature of 85 ^{o}C until it attained a moisture content of 10 % moisture content, which makes for good storability. The samples were allowed to cool then milled into flour and condition with clean water to 39.6 % moisture content at which it can pellet appropriately. This was then fed gradually into the pelleting machine to produce pellets which were then sun dried to 10.54 % (moisture content at which it can be stored). The flowchart for this method is shown in Figure 2. Pellets produced from this method are labeled as Cassava Dough Pellets (**CDP)**. (Raji *et al*., 2008).

Method B: 20 kg of washed cassava roots were grated into pulp, dewatered to 40.1 % moisture content using a screw press and then pelletized to produce pellets. The pellets were sun dried to 10.34 % moisture content (moisture Content at which it can be stored). The flow chart for this method is shown in Figure 2 and the pellet produced from this method is described as Cassava Mash Pellets (**CMP**). (Raji *et al*., 2008).

Figure 1: Process Flowline for the Production of Pellets from Cassava Chips and Mash



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Legend for figure 1

↓	: Transfer
▭	: Operation
◇	: Inspection
D	: Delay
FCR	Fresh Cassava Root
FPCR	Fresh Peeled Cassava Root
FCM	Fresh Cassava Mash
DCR	Dried Chipped Root
DFCM	Dewatering of Fresh Cassava Mash
MDCR	Milled Dried Cassava Root
PCM	Pelleted Cassava Mash
PDCM	Pelleted of Dewatered Cassava Mash
CCP	Cooling of Cassava Pellet

2.2 Measured Parameters from the Pellets

2.2.1 Product Size

The uniformity of sizes of pellets produced was determined to obtain the degree of variation of dimension of individual pellets from the generally acceptable dimension. One Hundred Pellets were selected at random from each of the two samples. The length and diameter from each pellet were measured using a digital vernier caliper. The mean and the standard deviation of the Length and Diameter of one hundred representative samples were computed. Using the following formula:

$$\text{Mean}(\overline{X}) = \frac{\sum f}{n} \quad \ldots\ldots (1)$$

$$\text{Standard Deviation (SD)} = \sqrt{\frac{\sum(X-\overline{X})^2}{n-1}} = \sqrt{\frac{\sum X^2}{n-1}} \quad \ldots\ldots (2)$$

Where: $\sum f$ = Total Frequency

n = Number of cases

x = Deviation of each of the numbers (Schaum's Statistics Outline, 1998)

2.2.2 Durability Index Measurement

Durability Index of the pellets produced was determined by using an apparatus designed and constructed as specified by the ASAE S269.2 rotating at 60 rpm for two minutes. Initial weight of a set of 5 pellets placed in the apparatus was recorded as M_{pbt} and the machine operated for 2minutes after which their final weight M_{pat} was recorded. Initial and final weights were noted and the durability/friability was expressed as the percentage of the final weight to the initial weight. These were calculated from

$$D_p (\%) = \frac{M_{pat}}{M_{pbt}} \times 100 \quad (3)$$

$$F_{p\,(\%)} = 100\% - Dp \quad (4)$$

Where, D_p = Durability of pellets in %

Fp = Friability of pellets in %

M_{pat} = Weight of pellet after tumbling, g;

M_{pbt} = Weight of pellet before tumbling, g.

(America Society of Agricultural Engineers Standard, 1998)

Plate 1: Tumbling Apparatus

2.2.3 Hardness Measurement

A Monsanto Tensometer machine was used to determine the hardness of the pellets (Adejumo, 2007). This was achieved by holding the pellets in between the spherically mounted nose piece after the mercury column that is graduated from 0 to 30 N had been adjusted to zero point and the driven gear box was operated manually to apply force by moving the spherically mounted nose piece closer to each other, the mercury column advanced and stop at the point of crack on the pellets. From the scale attached to the mercury column the reading of the force applied was taken in N/mm^2.

Plate 2: Monsato Tensometer

2.3 Experimental Analysis

Data obtained from the measured parameters were analyzed statistically at National Centre for Agricultural Mechanization using Independent Sample T-Test. This is in order to compare the means of the measured parameters for different Processing Methods.

2.4 Colour Determination

Products obtained from the two Processing methods were subjected to visual observation for colour and appearance determination.

3.0 RESULTS AND DISCUSSION

3.1 Product Size

The mean and standard deviation of one hundred pellets selected randomly from each of the two processing methods for length and diameter are presented in Table 1. The lengths of the pellets from CDP and CMP have mean and standard deviation of 2.78 cm and 0.40 cm, 2.22 cm and 0.35 cm respectively. However, the lengths of the two methods fall within standard specified length of 2.0 – 3.0 cm with low standard deviation as reported by (Raji et al, 2008). The mean and standard deviation of diameter of pellets are 1.28 cm, 0.17 cm and 1.23 cm, 0.13 cm respectively. The change in diameter is similar to the length.

Table1. Length and Diameter of Pellets from the Two Processing Methods

	CDP		CMP	
	Length (cm)	**Diameter (cm)**	**Length (cm)**	**Diameter (cm)**
Mean	**2.78**	**1.28**	**2.22**	**1.23**
S.D	**0.70**	**0.16**	**0.35**	**0.13**

3.2. Pellet Durability Index

Durability is the ability of pellets to withstand destructive loads and forces during transportation. Result of the percentage durability is as shown in Table 2. Pellets made from chips have the highest average durability index of 99.7% and lowest average volume of fines (particles) of 0.26%. This implies that the pellets can withstand destructive loads during handling, transportation and preservation. Though the cassava roots used in the second method were grated not milled, it still turned out to have an average durability index of 92.7% and 7.31% average friability of pellets. It is noted that the mash with higher moisture content has pellets of lower durability index compared with cassava chips. This is in support of the statement made by Jennifer et al (2004) that "Increase in moisture content reduces durability. This might be because of weakness in the binding force that occurs as moisture content increases thereby reducing the durability of pellets produced (Adejumo, 2007).Independent Sample T –test analysis revealed that the durability of the two treatments is significantly different at 5% confidence level due to the difference in the mean value. It can therefore be concluded that the higher the moisture content level, the lower the binding force and the lower the durability of pellet produced.

Table2: Percentage of the Durability and Friability from the two Processing Method

	CDP		CMP	
S/N	Durability (%)	Friability (%)	Durability (%)	Friability (%)
1	99.69	0.31	92.68	7.32
2	99.80	0.20	92.88	7.12
3	99.72	0.28	92.49	7.51
Mean	**99.70**	**0.26**	**92.70**	**7.31**
SD	**0.06**	**0.06**	**0.19**	**0.19**

3.3. Colour and Appearance

Visual observation of the samples from the two processing methods showed that the pellets from chips which were dried at a maximum temperature of 85^{o}C are darker in colour than the pellets from mash. Colour difference might be attributed to the fact that the sooth settles on the chips during the drying process which results in the coloration of the chips and thereby resulted in darker colour of the pellets. The samples from mash with no heat applied during processing retained the original colour that was used to produce it.

3.4. Hardness Test

Hardness Test is carried out in order to measure the strength of the pellets. Considering the two processing methods, the values of the hardness obtained are shown in Table 3. Mash with higher moisture content has lower values for hardness while cassava chips with reduced moisture content have higher values for hardness. This might be attributed to lack of binding Vander Waal's electrostatic force present, thus making the area of contact between the particles of the pellets to be low, for mash with increased moisture content. (Adejumo, 2007).The knowledge of chemistry makes us to understand that the smaller the particle sizes the greater the surface area. This implies that the more surface area would be exposed to binder if the particle size is small. Independent Sample T-Test Statistical tool shows that, there is significant difference between the hardness of the products from each of the treatments. This might be concluded that the higher the moisture content the lower the hardness of pellets and the lower the area of contact between the particles of the pellets. From the group statistics table above, the mean for durability test for CDP is greater compare to that of CMP. The difference in the mean value could imply that Durability test is higher in CDP than CMP. Similar conclusion is drawn for the Hardness Test since the trend is the same.

Table3: Hardness Test for pellets from the two Processing methods

Replicates	**CMP** (N/mm^2)	**CDP** (N/mm^2)
1	9.80	13.40
2	10.20	11.20
3	9.92	11.20
4	9.27	12.70
5	9.70	11.40
Mean	**9.78**	**11.98**
SD	**0.34**	**1.01**

The point of interest however is to ascertain whether or not the difference in value observed between their mean is statistically significant or not. To investigate this, a two Independent Samples T Test is used and shown below.

The Independent samples test above shows that the difference in the mean values of CDP and CMP for both durability hardness tests could not be due to chance of occurrence alone. The significant value of 0.000 less than 0.05 for durability test and 0.002 less than 0.05 for hardness test respectively implies that the difference in the mean value of CDP and CMP for both tests is statistically significant.

4.0 . CONCLUSION

i. From this study, it has been observed that the two processing methods are appropriate and are recommended for adoption.

ii. It is noted that the Particle size has a key role to play in the product therefore, pellets from chips with fine particles gives better result.

iii. The production of Pellets will go a long way in economic empowerment and poverty alleviation which are tools in boosting the availability of the pellets for export market in developing countries

iv. The degree of uniformity obtained is in line with acceptable standard.

v. Finally, the processing methods had significant effects on the product size, hardness, durability and appearance.

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