COMPARISON OF PROXIMATE COMPOSITION, PHYSIO–MECHANICAL PROPERTIES AND ECONOMICS OF PRODUCTION OF CASSAVA PELLETS DERIVED FROM CASSAVA CHIPS AND MASH

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ABSTRACT

Pellet is a product of cassava root that reduces both quantitative and qualitative losses. The cassava pellets used in this study were produced with a pelleting machine powered by a 5hp electric motor, die diameter of 1.4cm and a fixed speed of 290rpm. Pellets samples were produced through two treatments: cassava dough (chips) and mash. The pellet 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. Investigation into the Proximate Composition Physico- Mechanical Properties and Economic of production of Cassava Pellets" produced from the two treatments resulted in pellets with Moisture Contents of 10.54%, Crude Protein of 1.18%, Ash Content of 3.98%, Fibre Content of 2.05%, Starch Content of 84.81%, and Sand Content of 0.85% for CDP and Moisture Content of 10.34%, Crude Protein of 1.06%, Ash Content of 3.84%, Fibre Content 1.85%, Starch Content of 85.21% and Sand Content of 0.82% for CMP respectively. These results showed a significant difference in the proximate composition of the pellets at 5% confidence level. The durability indexes are 99.7% and 92.7% for CDP and CMP while the hardness test showed average of 9.78N/mm^2 and11.98 N/mm^2 respectively indicating that both types can withstand destructive loads; Notwithstanding that there is significance difference between these mechanical properties of the pellets at 5% confidence level. Average lengths of 2.78cm and 2.22cm, diameters 1.28cm and 1.23cm fall within the standard for Pellets. The pellets produced from chips and mash satisfies the standard in terms of strength, durability and proximate composition. Results from the Economics of production showed that the fixed cost of pellets produced from cassava mash is ₦3917:00 and that of cassava chips is ₦8500:33k. Therefore, the rate of return on investment from cassava chips is 87.01% while that of cassava mash is 85.33%.

KEYWORDS: Pellets, cassava chips, mash, proximate composition, hardness, durability, return of investment.

1. INTRODUCTION

Cassava root (Manihot spp) is a staple food crop which has a major source of direct calorie (about 25-56%) with high nutrient content, especially for people in Southern Nigeria (Igbeka, 1980). According to FAO (1997) over the period of 1982-1995 the use of cassava root for human consumption and other activities in its fresh or processed form has declined. One of the greatest advantages of cassava over other starchy root crops is that the root can be put to many uses (Onyekwere et al, 1994). Cassava can be converted into a form of food products, which include gari, fufu, lafun, tapioca, starch etc. (Nweke et al, 1998). The leaves serves as green vegetable being a rich and cheap source of protein, vitamins A and B. (Hatmann, 2003; Lincoln and John, 2005).

The production of pelleted chips has recently been increasing as they meet a ready demand on the European markets. In the production of pellets there are many national and regional variations in the processing method, degree of mechanization and the quality of the finished product (Fish and Trim, 1993). They have the following advantages over chips' quality is more uniform; occupied less space, thus reducing the cost of transport and storage; handling charges for loading and unloading are also cheaper; they usually reach their destination sound and undamaged. Some other advantages derived from processing cassava roots into pellets making then suitable for export are; strength (from partial gelatinization of starch and subsequent binding of the gelled starch), lightweight, less storage volume and retention of quality during shipment. (Rajamma et al, 1994). 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 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. Pellets are dried and hardened cylindrical particulate materials about 2-3cm long 0.4 – 0.8cm 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 Objectives of this work were to: determine the effect of each of the processing methods (Chips and Mash) on the Proximate Composition of Pellets produced; determine the Economic of Production of Pellets produced from each of the Processing Methods; and determine effect of the Processing Methods on the Length, Hardness and Durability of Pellets produced.

2. 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 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 290rpm and fixed die diameter of 1.40cm.

2.1 Description and Principles of NCAM Pelleting Machine

NCAM Pelleting Machine is made up of three functional units, the feed, the conveyor and the extrusion unit. The material to be palletized is being fed through the hopper (feed unit); an auger conveys it through the barrel (transport unit) and compresses it against the die (extrusion unit) thereby producing densified substance called pellets.

2.2 Preparation of Sample

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

Method A: A sample of 20kg 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%wb which makes for good storability. The samples were allowed to cool then milled into flour and condition with clean water to 39.6%wb 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%wb (moisture content at which it can be stored).The flowchart for this method is shown in Figure 1. Pellets produced from this method are labeled as Cassava Dough Pellets (CDP). (Raji et al, 2008).

Method B: A sample of 20kg of washed cassava roots were grated into pulp, dewatered to 40.1%wb moisture content using a screw press and then pelletized to produce pellets. The pellets were sun dried to 10.34%wb moisture content (moisture content at which it can be stored). The flow chart for this method is shown in Figure 1 and the pellet produced from this method is described as Cassava Mash Pellets (CMP). (Raji et al, 2000).

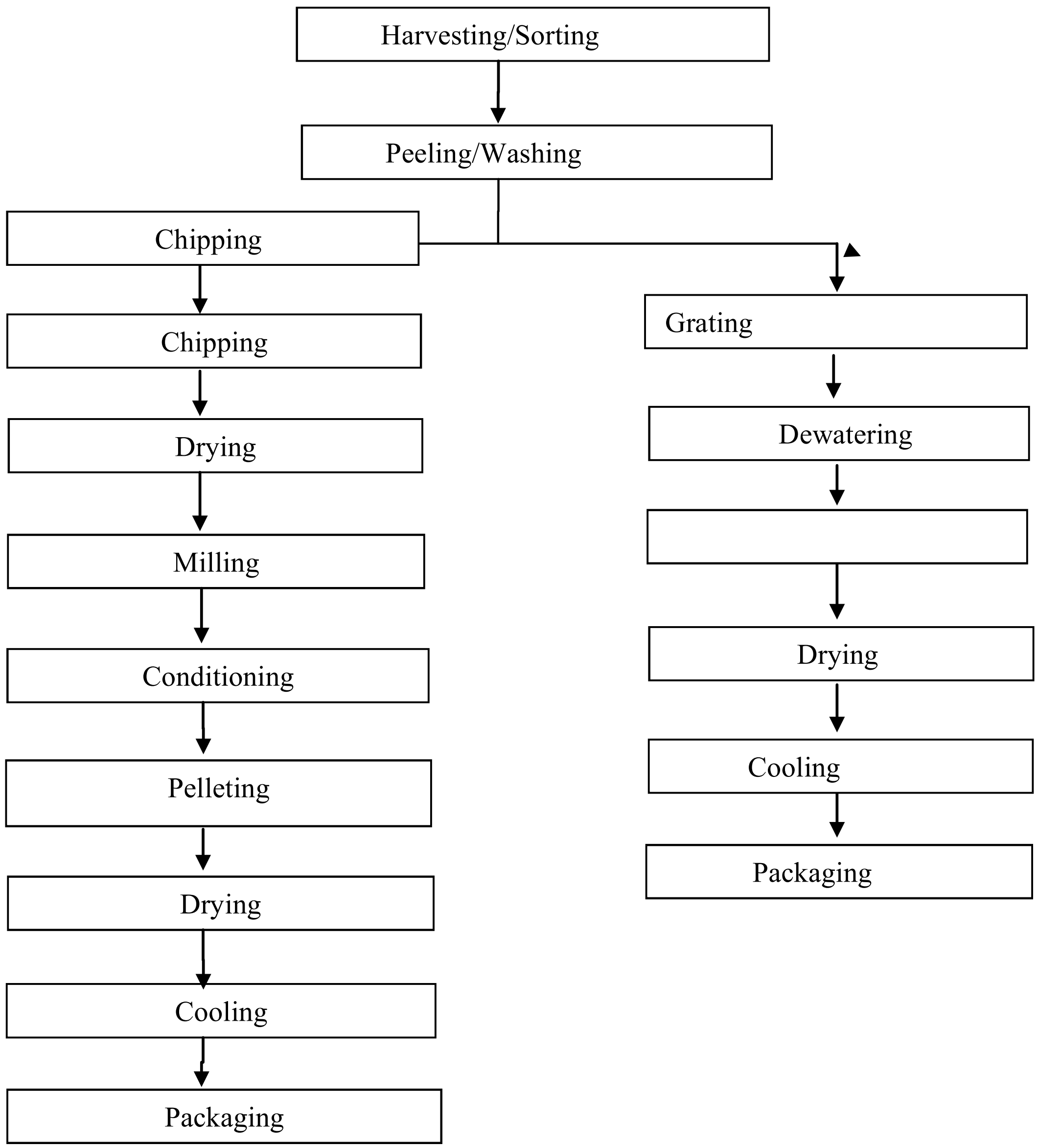

Fig. 1. Flowchart for the production of Pellets from cassava chips and mash

2.3 Measured Parameters from the Pellets

2.3.1 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 randomly 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:

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

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

Where: $\sum f$ = Total Frequency; n = Number of cases; x = Deviation of each of the numbers (Schaum's Statistics Outline, 1998)

2.3.2 Durability Index

Durability Index of the pellets produced was determined by using a tumbling 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 tumbling apparatus was recorded as M_{pbt} and the machine operated for 2 minutes 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

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

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

Where, D_p = Durability of pellets in %

Fp = Friability of pellets in %

M_{pat} = Weight of pellet after tumbling in gram (g)

M_{pbt} = Weight of pellet before tumbling in gram (g)

(ASAE Standard, 1998)

2.3.3 Hardness

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.

2.3.4 Proximate Composition of Pellets

Proximate compositions of pellets were analyzed to actually determine the effect of the processing methods. The compositions were determined using the method of analysis of Association of Official Analytical Chemists, AOAC, (2000). Samples were taken to University of Ilorin, for the required analysis to be carried out. The parameters measured are; Starch content, Ash content, Moisture content, Crude Protein, Fibre content, and Sand content. Carbohydrate content was determined by difference method; Crude Protein content determined by Kjeidahl process, Fat content was determined by Soxhlet continuous extraction method, Ash content and Crude Fibre were determined using AOAC (2000) standard. The methods are stated below:

Moisture Content

Moisture content (wet basis) % =

$$\frac{(B - C) - (D - C)}{A} \times 100 \quad (2.1)$$

Where A = Initial (wet) weight of sample (g); B = weight of Petri dish +sample before oven drying (g); C = weight of Petri dish (g); D = Weight of Petri dish + dry sample after oven drying (g)

Protein Content
This was determined using the micro - Kjeldahl method of AOAC (2000).

$$\text{Percentage Nitrogen} = 14 \times \frac{v}{100} \times 0.1 \times \frac{w}{100} \quad (2.2)$$

Where V = (ml of 0.1N acid added) - (ml of 0.1N NaOH used to neutralize the ammonia nitrogen); W = weight of sample (g)

Ash Content (Minerals)

$$\%\text{ Ash Content} = \frac{x-y}{w} \times 100 \quad (2.3)$$

Where X =weight of crucible + ash; Y = weight of crucible; W =weight of sample (g) before ashing.

Fat Content

$$\text{Percentage fat content} = \frac{A-B}{C} \times 100 \quad (2.4)$$

Where A = Initial weight of Sample +thimble; B = Final weight of Sample + thimble; C = Initial weight of Sample

Fiber Content
The percentage fibre is calculated thus:
Weight of fibre = ($C_1 - C_2$) g

$$\%\text{Crude fibre} = \frac{C_1 - C_2}{\text{weight of sample}} \times 100 \quad (2.5)$$

Carbohydrate Content
The total percentage carbohydrate content was determined by difference method. This involves adding the total values of protein, fat, ash and moisture content and subtracting it from 100.

2.4 Economics of Production

The data obtained in the production of cassava pellets produced from cassava chips and mash was analyzed at the University of Ilorin, Using the equations below

$$\text{Depreciation} = \frac{\cos t - salvagevalue}{lifespan} \quad (2.6)$$

Total Cost = Opportunity cost + Fixed cost + Variable cost ……… (2.7)
Gross Margin =Gross Revenue –Variable cost ………………………. (2.8)
Net Margin = Revenue –Total Cost ………………………………. ….. (2.9)

$$\text{Rate of Return on Investment (RI)} = \frac{Netm\arg in}{Total\cos t} \times 100 \quad (2.10)$$

Benefit/Cost is the ratio on the rate of return on investment.

2.5 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.

3. RESULTS AND DISCUSSION

3.1 Product Size

The mean and standard deviation of thirty 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 as shown in Table 3a and 3b. 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.

Table 2. Percentage of the Durability and Friability from the two Processing Methods

	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 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 3a. 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 as shown in Table 3b and 3c. 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.

Table 3a. 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

Table 3b. Difference of Two Analyses on CDP and CMP Group Statistics

Parameter	Processing Methods	N	Mean	Std. Deviation	Std. Error Mean
Durability Test	CDP	3	99. 7367	0.0569	0.0330
	CMP	3	92.6833	0.0950	0.1100
Hardness Test	CDP	5	11.9800	1.0100	0.4500
	CMP	5	9.7780	0.3400	0.1500

Table 3c. Independent sample test, T- Test for equality of means

Parameters	T	df	Sig. (2- tailed)	Mean Difference	Std. Error Difference
Durability Test	60.14	4	0.000	7.0533	0.11728
Hardness Test	4.6200	8	0.002	2.2020	0.47702

From the group statistics table, 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.

The Independent samples test above shows that the difference in the mean values of CDP and CMP for both durability and 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.

3.4 Proximate Composition

The results of the proximate composition carried out on the pellet samples are as presented in Table 4. Pellets from the two processing methods are in agreement with the specifications for pellets for Thailand. (Thailand Industrial Standards TIS 52-2516, 1997). Products from CDP and CMP had higher amount of Carbohydrate content and thus can be used mainly as a source of energy thus making the Pellets produced from the two methods safe as feed for all classes of livestock. The products equally contain low sand content which shows the hygienic condition under which the process was carried out. The presence of Ash content shows that the products contain some mineral content and this can be used for animal feeds. The results of the analysis therefore depend on the variety of cassava root used.

Table 4. Proximate composition of pellets from cassava chips and mash

Parameters	CMP	CDP
Moisture Content (%)	10.54	10.34
Crude Protein (%)	1.18	1.06
Ash Content (%)	3.98	3.84
Fibre Content (%)	2.05	1.85
Carbohydrate (%)	84.81	85.21
Sand Content (%)	0.85	0.82

3.5 Economics of Production

The essence of the economics of production of pellets, from the two processing methods is to determine the product that will satisfy the export requirement for pellets in terms of cost of production. From Table 5, the fixed cost for CMP and CDP are ₦3917:00 and ₦8500:33 respectively, the actual cost of production for CMP and CDP are ₦39, 269:05 and ₦44, 539:88. Therefore, the rate of return of investment from cassava chips is 87.01% while that of cassava mash is 85.33% and the benefit ratio for CMP and CDP are 1:85 and 1:87 respectively. This indicates that for every N1.00 invested in the production of pellets from cassava mash, there will be a benefit of 85 kobo while on the production of pellets from cassava chips a benefit of 87 kobo will be obtained, this implies that CDP has a higher benefit in terms of profit than CMP. It is also seen from the table that the Net Margin for CDP is higher than for CMP all within a production circle; this makes the investment on pellets to be more lucrative. Therefore, both production methods are profitable but production of Pellets from cassava chips (CDP) seems to have more economic worth.

Table 5. Enterprise budget for cassava pellets production

Budget item	Cassava mash	Cassava chips
Fixed Cost (₦)	3,917:00	8,500:33
Variable Cost (₦)	30,230:00	30,230:00
Opportunity cost of capital (15% for 6 months) ₦	5,122:05	5,809:55
Actual cost of production(₦)	39,269:05	44,539:88
Gross Margin (₦)	24,470:00	24,470:00
Net Margin (₦)	33,509:00	38,779:55
Returns on Investment (%)	85.33	87.01
Benefit-cost ratio	1:85	1:87

4. CONCLUSION

From this study, it has been observed that the two processing methods are appropriate and are recommended for adoption. Results from the Proximate Composition of the pellets produced using the two processing methods indicated that the processing methods had no adverse effect on the composition therefore the two processing conditions are recommended for animal feed production and are wholesome nutritionally. It is noted that the Particle size has a key role to play in the product. Finally, the processing methods had significant effects on the moisture content, hardness, durability, appearance and cost of processing of the pellets.

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