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PERFORMANCE EVALUATION OF AN IMPROVED CASSAVA PELLETING MACHINE

***Ikejiofor, M.C[1*] and Agu, V.C[1]**

[1]Engineering Research Division, National Root Crops Research Institute, Umudike, Umuahia, Abia State, Nigeria

**Corresponding Author's E-mail: mauikejiofor@yahoo.com*

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ABSTRACT

Pelleting is an important postharvest process that prepares agricultural products in cylindrical shaped forms for better storage, export and in the production of animal feed. The current high cost of feed has necessitated the crucial need to develop an efficient pelleting machine that will assist farmers to formulate their own feed for local consumption and export. The performance evaluation of an improved cassava pelletizer with mixing and conditioning section was evaluated at the operational speed of 250 rpm. The machine was powered by a 3.730 kW (5 h.p) electric gear motor and it comprises of hopper, barrel, mixer, screw conveyor, electric steam boiler, compression / extrusion plates, cutter, supporting frame and a power transmission unit. The extruding plate has die openings of 4 mm to produce the recommended cassava pellet size suitable for export. The average moisture content of the dewatered cassava mash used for the evaluation was 25 %. Also, the steam boiler used for the conditioning produced saturated steam at a temperature of about 103 ºC. The result of the machine performance test indicates that the machine has average throughput capacity and efficiency of 151.74 kg/hr and 94.48 % respectively. The average diameter and length of the cassava pellet produced was 3.96 and 9.76 mm, respectively. The machine can be further optimized for cottage industry applications.

Keywords: Evaluation, Improved, Pelletizer, Cassava, Feed

1.0 INTRODUCTION

Cassava is an important raw material in the production of livestock and fish feed, which are mostly preferred in their pellet form both for local consumption and export. Cassava pellet is a processed cassava product obtained by compressing cassava mash or milled dried chips under appropriate processing conditions in the formation of dried cylindrical product suitable for animal feed and raw materials for easy transportation and export (Fast and Coldwell, 1990). Some of the advantages derived from processing cassava roots into pellet which make them suitable for export include: uniformity of quality, strength, light weight, less storage volume as well as retention of quality during shipment (Rajamma *et al*., 1994). Jekayimfa, *et al*. (2024) reported that pelletization reduces the bulk density of biomass. Pellet samples can be produced through the conventional or modified process. The conventional process involves peeling, washing, chipping, drying, milling and pelleting with or without steaming, while the modified process involve peeling, washing, grating, dewatering and pelleting with steam. The modified process was reported by Raji *et al.* (2008) to have advantage of reduced processing time, energy and better quality product. In Nigeria, the major problem facing local fish production is the high cost of pelleted feed. Most of the imported machines for pelletization process have high initial and maintenance costs and requirement for highly skilled maintenance engineers. Ugoamadi (2012), developed cassava pelleting machine with capacity of 80.46 kg/hr and efficiency of 80.31 % using pre-conditioned cassava mash. Alonge, *et al*. (2012), reported on the development of a cassava pelleting machine with capacity and efficiency of 80 kg/hr and 98.66 % respectively also using pre-conditioned cassava mash. Ani, *et al.* (2023) reported on the development and evaluation of a poultry feed pelleting machine. The study showed that for optimal pellet production, the appropriate moisture condition for the feed materials is considered ranging from 20 – 30%. Babalola and Ndirika (2006) also reported on the development of a manually operated poultry feed pelleting machine. The highest pelleting efficiency, throughput capacity and the percentage of broken pellets obtained was 55%, 592.59 kg/hr and 2.04% respectively. The development of a livestock feed pelleting machine was also reported by Orisaleye, *et al.* (2009). The machine was tested with broiler's mash at different levels of moisture containing water and starch binder as preconditioners.

Nwokocha, *et al*. (2017) reported on the performance of a cassava pelleting machine which was powered by a diesel engine. The testing was conducted using preconditioned cassava mash and the machine has throughput capacity of 19.28 kg/hr with maximum efficiency of 89.33 %. Also, Oduntan, *et al.* (2012) evaluated a cassava pelleting machine that also used preconditioned cassava mash at varying moisture content levels of 18, 20, and 22 % w.b, and the average throughput capacity of 54 kg/hr was obtained. Ikejiofor and Agu (2022) reported on the development of a motorized cassava pelletizer for enhanced processing and export. The technical evaluation of a roll type extrusion pellet mill was conducted by Aries Rhoda and Jaime (2008), and the machine was reported to have capacity of about 76.32 kg/hr. The effect of processing conditions on the hardness of cassava pellets was studied by Adejumo and Oje (2009). The result obtained showed that the moisture content of the cassava dough, speed of the machine and die diameter as well as the interactions between them were significant at 5 % level. Factors that affect pellet quality was reported by Muramatsu, *et al.* (2015), to include the feed nutritional composition, ingredient particle size, conditioning temperature, time, feed moisture, etc. Oduntan, *et al.* (2022) also reported that pelletization parameters such as disc size, temperature and mash moisture content affect the product quality. Most of the reported existing cassava pelletizers make use of already preconditioned cassava mash as the input product for the production of cassava pellets. The present work is based on the evaluation of an improved cassava pelletizer that does not make use of preconditioned product, but rather has the capacity to condition the mash product in the mixing and conditioning section.

2.0 MATERIALS AND METHODOLOGY

2.1 Description of the Machine

The major components of the machine are the hopper, barrel, mixer, electric steam boiler, screw conveyor, compression / extrusion plates, cutter, supporting frame and the power transmission unit which consists of the pulley, bearing, belt and 5hp electric gear motor. Directly below the opening where the hopper is mounted is the mixer with 15 litres capacity steam boiler connected to it for easy conveying of the required saturated steam needed for conditioning of the mash product. The materials for construction used were all stainless. The hopper is welded at an angle of 42^o to a cylindrical based barrel which houses the mixer and the screw conveyor of varying pitch. The extrusion plate is attached to the end of the barrel by a flange welded in place with four bolts, so that the plate can be changed with other plates having different die sizes for producing different sizes of pellets. There is also a cutter in front of the extrusion plate that cuts the pellets to the required length as they come out of the machine. The machine is mounted on a stand constructed with 63.5 mm thick angle iron. The pictorial view of the batch operated type improved cassava pelletizer is shown in Figure 1.

Figure 1: Pictorial view of the improved cassava pelletizer

2.2 Working Principles of the Machine

When the 5hp electric gear motor which powers the batch operated type improved machine is turned on, the machine starts running. Then, the dewatered cassava mash when fed in directly through the hopper to the mixing section which rotates at an optimal speed of 250 rpm is conditioned as the electric steam boiler with control valves supplies the required saturated steam. The screw conveyor then transfers the conditioned product to the pelleting section where the product is compressed and forced out through the extrusion plate with 4 mm die opening, forming the pellets. The cutter which is attached in front of the extrusion plate cuts the pellets to the required length.

2.3 Samples Preparation

The matured roots of the cassava variety TME 419 were used to produce cassava mash for the evaluation. The roots were weighed, peeled, washed, grated and dewatered to about 25% moisture content using the hydraulic jack presser to obtain the mash product. The evaluation was carried out using varying input cassava mash weight of 15, 20, 25, 30 and 35 kg.

2.4 Instrumentations and Measurement

The weights of input material (dewatered cassava mash) were determined using 50kg electronic balance of the model EK 5055 and sensitivity 0.01g, whose values ranged between 0.01 g to 5000 g. Time was measured using a digital stop watch of the model KD 1069. Moisture contents of the mash were determined by oven drying the cassava mash samples at a temperature of 75^{o}C for 24 hours. The percentages of moisture content wet basis were calculated according to Kajuna *et al*. (2001) as given in equation 1:

$$\text{Mc (wb) \%} = \frac{W_w - W_d}{W_w} \text{X100} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

Where, Mc (wb) % = Moisture content wet basis; W_w is the weight of mash sample (g); W_d is the weight of the dried mash sample (g). Also, vernier caliper and meter rule were used to measure the diameter and length of the pellet produced respectively.

2.5 Experimental Procedures

Performance evaluation of batch operated type improved cassava pelletizer was carried out with TME 419 cassava varieties at machine operational speed of 250 rpm. The modified process of pellet production, which involves peeling of the harvested cassava roots, washing, grating, dewatering, and pelleting with steam, was used. Varying weights of dewatered cassava mash ranging from 15 – 35 kg were introduced in batches into the machine for mixing, conditioning, and pelleting. Evaluation of the machine performance was carried out by estimating the capacity and pelleting efficiency using equations 2 and 3, respectively as:

$$\text{Capacity of the machine (kg/hr)} = \frac{W_2}{t} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, W_2 = Total weight of normal pellet produced (kg),

t = Pelleting time (hr)

$$\text{Pelleting Efficiency (\%)} = \frac{W_2}{W_1} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where, W_2 = Total weight of normal pellet produced (kg),

W_1 = Total weight of cassava mash (kg)

3.0 RESULTS AND DISCUSSION

The cassava pelletizer developed is an improved version of the existing ones since it carries out the major required operations of mixing, conditioning, conveying, and pelleting. The machine was found to perform satisfactorily with the operating speed of 250 rpm. The steam boiler used also performed effectively and generated saturated steam, which produces heat and moisture that ensures proper conditioning of the product for good quality pellet formation. The machine produces high-quality cassava pellets of 4mm standard size suitable for both domestic and export markets. The data obtained from the evaluation test of the machine is presented in Table 1.

Table 1: Data from The Performance Evaluation of the Improved Cassava Pelletizer

S/N	Speed (rpm)	Weight of cassava mash (kg)	Average diameter of Pellet produced (kg)	Weight of normal pellet produced (kg)	Average length of pellet produced (mm)	Pelleting Time (min,)	Machine capacity (kg/hr)	Efficiency (%)
1	250	15.00	3.98	14.28	9.84	7.04	121.74	95.20
2	250	20.00	3.95	19.12	9.81	8.48	135.31	95.60
3	250	25.00	3.94	24.20	9.76	8.96	162.09	96.80
4	250	30.00	3.96	28.04	9.72	10.20	164.94	93.47
5	250	35.00	3.95	31.96	9.69	10.98	174.64	91.31

3.1 Machine Capacity

The average machine capacity of 151.74 kg/hr was obtained with the average input cassava mash of 25 kg and a machine speed of 250 rpm. The highest and lowest machine capacities of 174.64 kg/hr and 121.74 kg/hr were obtained when it took the machine 10.98 and 7.04 minutes to pelletize

35 and 15 kg, respectively, of the dewatered cassava mash fed into the machine, as shown in Table 1.

It was also observed that the machine capacity increases with the weight of cassava mash. The result is in agreement with the report by Ugoamadi (2012) that an increase in the weight of the preconditioned cassava mash used increases the pelleting time and capacity of the machine. The curve of variation of the machine capacity with the weight of cassava mash is shown in Figure 2.

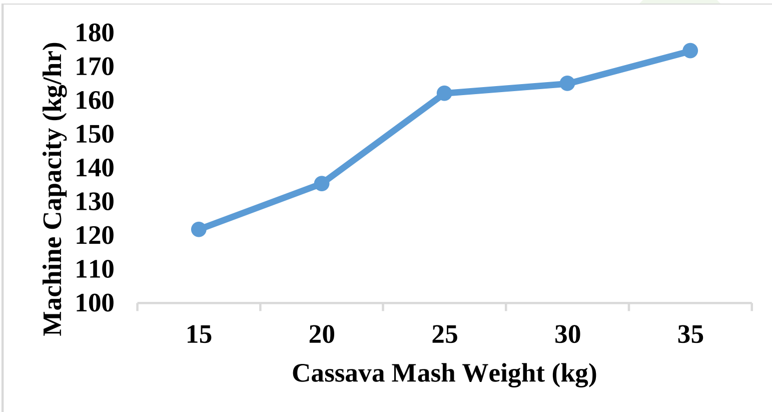

Figure 2: Machine capacity versus cassava mash weight

3.2 Pelleting Time

The average time taken for pelleting 25 kg of cassava mash was 9.13 minutes. The short pelleting time obtained for the operation indicated that the machine is capable of handling large-scale operations. As shown in Figure 3, the pelleting time increases with the weight of the pellet produced. The minimum and maximum cassava pellet weights of 14.28 and 31.96 kg were obtained with the pelleting times of 7.04 and 10.98 minutes, respectively. The results obtained are in agreement with the report from Alonge *et al*. (2012), who reported that pelleting time increases with the weight of cassava mash and the pellet produced. The pelleting time increases with the weight of cassava mash, but beyond the input weight of 25 kg, the efficiency drops because the quantity of normal pellets produced reduces, as indicated in Figure 4.

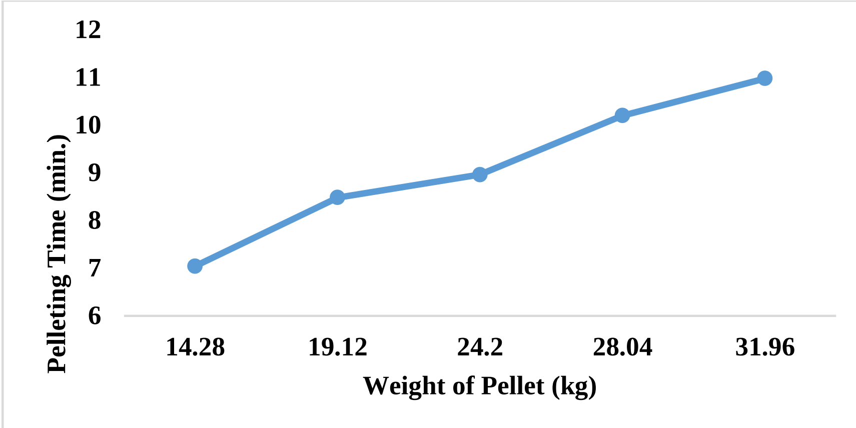

Figure 3: Pelleting time versus weight of pellet produced

3.3 Pelleting Efficiency

The average efficiency of 94.48 % was obtained at the machine speed of 250 rpm. The highest efficiency of 96.80 % was obtained when the machine produced 24.20 kg normal pellets out of 25.00 kg of the dewatered cassava mash fed into the machine to be pelletized as shown in Table 1. The lowest efficiency of 91.31 % was also obtained when the machine produced 31.96 kg normal pellets out of 35.00 kg of the mash fed into the machine. It was observed that beyond the input weight of 25 kg, the efficiency of the machine begins to fall. This agrees with the report by Ugoamadi (2012) that the efficiency of the cassava pellet machine in some cases decreased with increase in the mass of preconditioned cassava mash. The curve of variation of the machine efficiency with the cassava mash weight is shown in Figure 4.

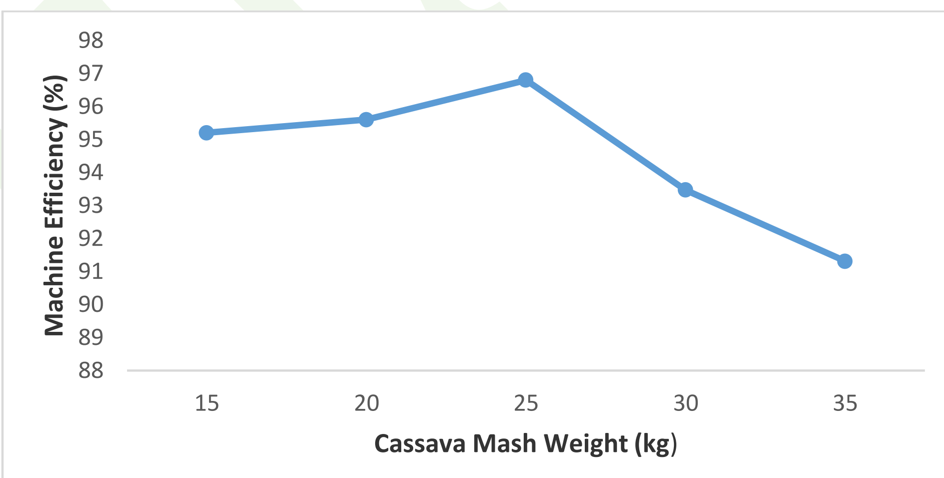

Figure 4: Machine efficiency versus cassava mash weight

4.0 CONCLUSION

The cassava pelletizer developed is an improved version with steam boiler and mixer that take care of the conditioning / mixing of the dewatered cassava mash. The machine performed satisfactorily and has average throughput capacity, efficiency and pelleting time of 151.74 kg/hr, 94.48 %, and 9.13 minutes, respectively for the 25 kg cassava mash and operating speed of 250 rpm. The short pelleting time for the operation obtained indicated that the machine is capable of handling large-scale operations. This technology should be adopted, for it will enhance the export of cassava products, and also help to meet the growing demands of the nation's feed industries. The boiler steam supply control valve needs to be automated for accurate regulation and estimation of the quantity of steam released. Petrol or diesel-powered engines can be used for the operation of the machine where there is an inadequate supply of electricity.

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