DEVELOPMENT OF A CASSAVA PELLETING MACHINE

A. F. Alonge, S. S. Ekanem and E. U. U Ituen
Dept. of Agricultural and Food Engineering,
University of Uyo, Uyo, Akwa Ibom State, Nigeria
Email: akindelealonge@uniuyo.edu.ng

ABSTRACT

An electrically operated cassava pelleting machine was designed, fabricated and tested. The Cassava pelleting machine was developed with efficiency and low cost in mind. It also aimed at eliminating the problem of transporting Cassava product and also for the production of pellets for animal feeds. The single screw shaft was chosen based on the ease of fabrication, availability of the components parts and simplicity of operation. The machine has an efficiency of 98.66% and the machine capacity is about 80kg.

KEYWORDS: Cassava, pelleting, development, machine, efficiency, design.

1. INTRODUCTION

Cassava is a major source of carbohydrate in most developing nations of the world. In Nigeria, the crop can be processed into 'garri', 'lafun', pellets and chops for the direct paki 'pupuru', 'fufu', cassava pellets and chips for the direct human and livestock consumption. In Ghana, it is eaten boiled. It could be pounded to be eaten with soup in addition to some of the processed form in Nigeria. Apart from human food, Cassava is also used for animal feed and alcohol production (El-Sharkawy and Cook, 1987).

Cassava pelleting is an unfermented dried cassava product obtained by compressing raw dried Cassava under appropriate processing conditions resulting in the formation of dried bulky products suitable for the animal feed industry with an average length of 3cm. The pelleting of Cassava product is becoming increasingly popular because it decreases volumes by about 25 percent.

Although there is no export-based pelleting project in Nigeria, it would be relevant to mark that over 90 percent of Cassava chips that are exported to the European Union (EU) enter as pellets. Hence as the export of Cassava increase, this should be kept in view. Thailand started cassava chips export as raw chips but because of environmental concerns most of the chips are now exported as pellets (Hillocks, 2002). Arrangements are far advanced to build the first pelleting factory in the country.

Pelleting is an extrusion process, which is simply the operation of shaping a plastic or dough-like material by forcing its through a restriction or die. Example of hand operations for pelleting food includes the rolling of noodles and pie crust dough, finger stuffing of chopped meat through animal horns into natural casing, pressing of soft foods through hand ricers to produce string-like particles, and crunking of hand-powered meat grinders. As started above a pelleting machine can be used to pellet any food items that can be formed in dough like fashion or manner (Hillocks, 2002).

Fish farming in Nigeria is an industry that is growing rapidly due to the amount of investors venturing into the industry. The major problem the local farmers face is in the rise in price of fish feed. Local farmers are now producing feed for their fishes by themselves, since they cannot afford to buy feed in the market because of the scale of their farming and the capital they are operating. But they can afford to buy cassava pellets from local producers or as will purchase a cassava pelleting machine for the production of their own pellet. Cassava pellets being one of the major feed used in the fishing and livestock industries, the need of an efficient cassava pelleting machine cannot be over emphasis. It is in the light of this that I have decided to design and fabricate a cassava pelleting machine which is very efficient and a moderately priced machine.

Pelleting is an act of making finished ground compound feed into little hard objects. With steam binders under pressure or with liquid binders (Frank, 1959). Pelleting most time has no nutritional value but is cost effective. It was introduced in the United States of America feed mill industry in the mid 1920s, so as to improve feed utilization, increase the density of the feed and improve the handling characteristics. Pellet production was stimulated by the need to improve the uniformity in the shape and size of cassava chips required by the users and animal feed producers. In addition, during transportation, loading and unloading of chips, dust generation causes serious air pollution, placing pressure on the importers in Europe to improve the nature of Cassava pellets handled by the ports (Anon, 2003).

Cassava pellets can be produced by using two methods. The first is production of Cassava pellets from Cassava root. Cassava pellet produced by this method is an unfermented dried Cassava product obtained by compressing raw Cassava root under appropriate processing conditions resulting in the formation of dried, bulky produce suitable for the animal feed industry and for exportation with an average length of 3cm. The essential operations of this method are as follows:

- Sorting and weighing: The raw Cassava is sorted out to remove unwholesome roots and foreign materials before weighing
- Washing and peeling: The Cassava roots are washed in potable water and manually peeled with knives
- Grating: The peeled roots are milled into mash using grating machine.
- Dewatering: The wet mash is dewatered to suitable moisture content usually 12% mist, using hydraulic press.
- Pelleting: The dewatered mash is then feed into a pelleting machine to form pellets of predetermined shape and size.
- Cooling: The pellet are allowed to cool to ambient temperature prior to packaging
- Packaging: The pellets are packaged in light density polyethylene bags or double lined polyethylene bags and it is read for sale or for exportation.

These essential operations can be achieved by simple machines which can be fabricated locally. The process flow-chart is shown in Figure 1.

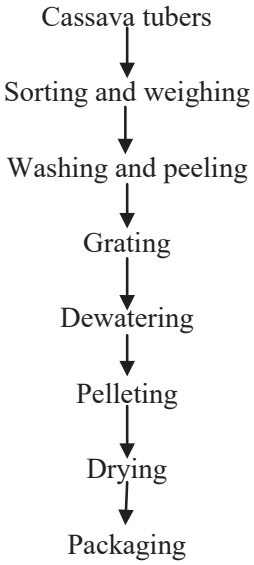

Figure 1. Flowchart production of cassava pellet form raw cassava root. (Miller, 1999)

The second method is through chips. It is also an unfermented dried Cassava pellet production obtained by compressing raw Cassava root under appropriate processing conditions resulting into pellets for the animal feed industry or export. Here the crops are first treated to get the required preconditioned form.

The essential operations of this method are listed below.

- Sorting and weighing: The Cassava chips are sorted to remove damaged chips and foreign material before weighing.
- Grinding: The chips after sorting and weighing are now grinded to reduce the particle size of the chips into powered form. Pelleting need finely ground materials. This reduces the energy cost of pelleting and reduces machine wear because material flow better in the pelleting machine barrel with less friction
- Conditioning: The product from the grinder is in powdered form and has to be conditioned to attain an appropriate moisture content level.
- Pelleting: The conditioned mash is then fed into a pelleting machine to form pellets of predetermined shape and size
- Cooling: After pelleting the pellets are cooled with a cooler to bring the temperature of the pellets down to ambient temperature
- Packaging: The pellets are package in light density polyethylene bag or double line polyethylene and ready for sale or for exportation.

The process flow chart for the production of Cassava pellet from Cassava chips is shown in Figure 2.

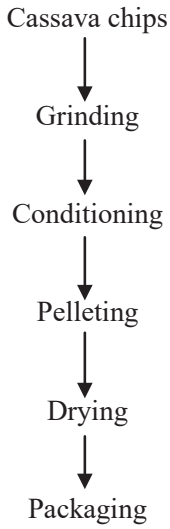

Figure 2. Flowchart Productions of Cassava pellets form Cassava chips (Miller, 1999).

Whichever method of production that is used requires pelleting. The objective of this study is to develop a pelleting machine using local materials.

2. MATERIALS AND METHOD

2.1 Design Considerations

The following design considerations form the basis of this design:

(i) The machine should be simple but rugged, and comparatively inexpensive
(ii) The dewatered Cassava must be feed constantly so that there is a consistent and uniform operation of the pelleting machine.
(iii) The speed of the shaft must be reduced by using a v-belt.

(iv) The pitch of the screw conveyor is larger in the inlet compared throughout the screw so as to maximize transportation, in the barrel of the machine.
(v) There should be increase in pressure and temperature in the barrel of the pelleting machine so as to push the pellet out of the die or extrusion plate and also cook the Cassava pellets.
(vi) The assembly of the machine is made simple for easier maintenance
(vii) The parts of the machine are locally, sourced and inexpensive.

2.2 Description of the Machine

The Cassava peeling machine is as shown in Figures 3 and 4. The machine is to be powered by an electric motor through a belt and pulley arrangement. The connection to power supply can be modified to use gasoline engine in local areas or places where there are no electricity supply. The design here is however based on the use of electric motor for power supply. A 4hp 1500 rpm single phase electric motor is recommended for this machine. The motor shaft is connected in linked to a v-belt, which reduces the speed to which is they operational speed of the screw conveyor.

Especially, the machine consists of a shaft carrying the screw conveyor of varying pitch mounted in the barrel of the pelleting machine. A spherical plate with little openings in it called the die or extrusion plate is screwed on the end part of the barrel. The shaft with the screw conveyor is mounted on the machines frame with a roller bearing at the feed end and self aligning similar bearings at the beginning of the shaft for better support.

The barrel is a cylindrical vessel with opening in the bearing where the hopper is being welded upon it is from this opening that the feedstock enters the barrel of the machine. The pitch of the screw conveyor at the inlet (i.e. directly below the opening where the hopper is mounted) is larger maximize transportation of feedstock as it enters the barrel. The pitch of the conveyor at the middle and end (i.e. kneading and final cooking zone) is decrease and the pressure is also increased for uniform pellets of pellets in the die or extrusion plate.

There is knife arrangement at the face of the die that can be adjusted to cut pellets of different lengths as they are coming out of the machine. The electric motor is mounted on a sit that is welded vertically below the shaft. The type of belt used is A-belt of length 54 cm. The entire machine is sitting on a frame that is made up of mild steel having four legs. The extrusion plate or die is attached to the end of the barrel by a circular flange joint held in place of four (4) bolt, so that the plate can be change with other plates having different holes diameter for producing different sizes of pellet and for maintenance and cleaning of the machine.

2.3 Operation of the Machine

When the machine is on and running, the preconditioned cassava is fed in through the hopper from the hoper there is transportation of the feedstock by means of a screw conveyor. The conveyor pushes the feedstock through the various cooking zone in the barrel and an increased temperature and pressure forces it out through the die thereby the pellets taking the size of the hole on the die. The knife arrangement at the face of the die cuts the pellets as it comes out from the machine to the required length that has been preset. The pellet is then dried and cooled, and its ready for packaging and storage.

2.4 General Design Considerations

Engineering design involves the activities that lead to proper decisions on effective development of machines and engineering processes. In the design of cassava pelleting machine, the physical properties of cassava are considered. Some factors such as the machine noise, vibration, arrangement of the components, placement of controls and the total physical efforts required to arrive at the through put

capacity are considered. The comfort and operator's safety as well as higher efficiency and reliability of the machine are all taken into consideration.

2.5 Experiments to Determine Design Parameters

Relevant parameters for estimation of power requirement of the machine were determined as ready information about them could not be obtained otherwise, the experiment include the determination of relevant parameters for the design of a Cassava pelleting machine for Cassava pellet production preconditioned Cassava is used.

The first experiment was to determine the optimal speed of the pelting machine. The apparatus used in conducting this experiment included the following, weighing balance, stop watch, recording equipment, preconditioned Cassava. Preconditioned Cassava which I prepared was used in this experiment. The preconditioned Cassava weighing 25 kg was fed into the Cassava pelleting machine rotating at an initial speed of 220 rpm. The time for pelting the cassava was recorded by the use of a stop watch. The experiment was repeated with different speeds of 230 rpm, 240 rpm, 250 rpm, 260 rpm, 270 rpm respectively and the corresponding pelting time was recorded. Table 1 shows the result of the experiment.

The second experiment was to determine the Cassava pelleting machine efficiency, capacity and percentage of Cassava pellets formed. The equipment used in conducting the experiment included weighing balance, pre-conditioned Cassava, recording equipment and stop watch. Preconditioned Cassava with an initial weight of 30 kg was fed into the hopper of the pelleting machine rotating at an optimal speed of 250 rpm. After pellets were formed, the pelleting time was taken by means of a stop watch and recorded. The experiment was repeated with different weights of 35 kg, 40 kg, 45 kg, 50 kg, 55 kg, 60 kg and 65 kg respectively.

Figure 3. Plan View of the Cassava Pelleting Machine

Figure 4. Front view of the machine

Figures 5: End view of the Machine

Figure 6: Dried cassava pellets

3. RESULTS AND DISCUSSION

Experiments were conducted on the pelting machine to evaluate its performance. The results obtained during the experiments are shown in Table 1 and the graphs showing the relationship between pelleting time and speed of the machine is shown in Figure 6.

Table 1: Speed of machine and time of pelleting for 25kg

S/No	Speed (rpm)	Weight of conditioned Cassava (Kg)	Time of Pelleting (min)
1	230	25	21.5
2	240	25	20.8
3	250	25	19.4
4	260	25	19.2
5	270	25	19.0

From Table 1, it is seen that the optimal speed is 250rpm because from the speed of 250rpm upwards, the pelleting time is approximately the same.

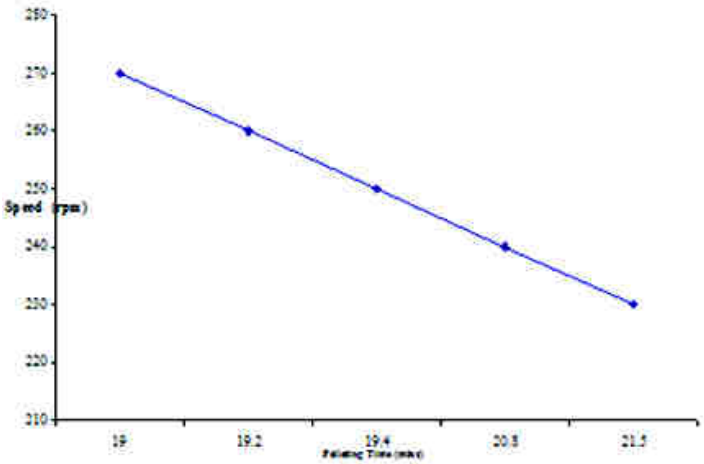

Figure 6. Pelleting time (min) against speed of the machine (rpm)

Table 2. Amount of pellets formed at speed of 250rpm

S/N	Speed (rpm)	Weight of preconditioned cassava (kg)	Amount of pellets formed (kg)	Pelleting time (min)
1.	250	30	29.5	23.65
2.	250	35	34.5	27.55
3.	250	40	19.2	31.26
4.	250	45	44.3	35.10
5.	250	50	49.7	38.48
6.	250	55	44.2	41.34
7.	250	60	59.0	44.47
8.	250	65	64.2	48.47
		380	374.9	290.55

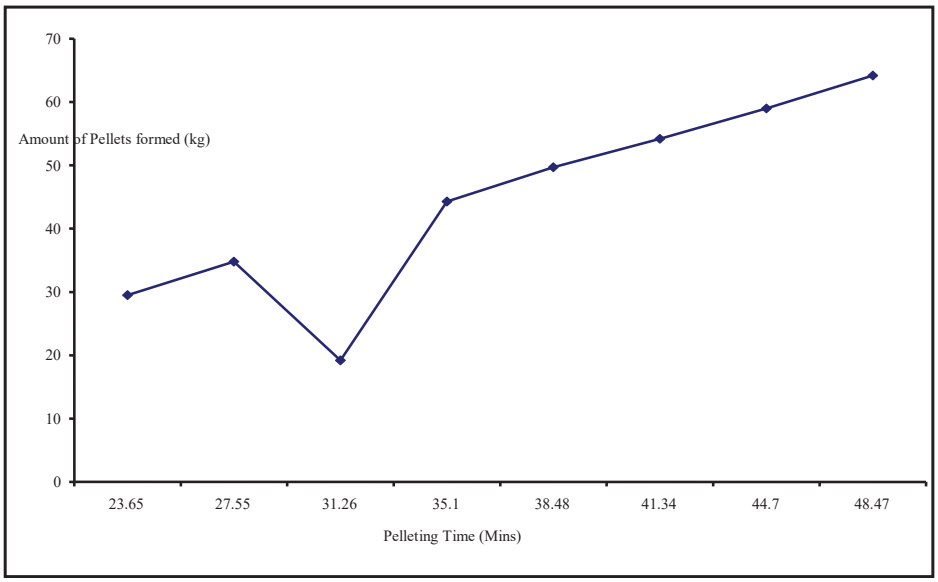

Figure 7. Graph of pelleting time against amount of pellets formed

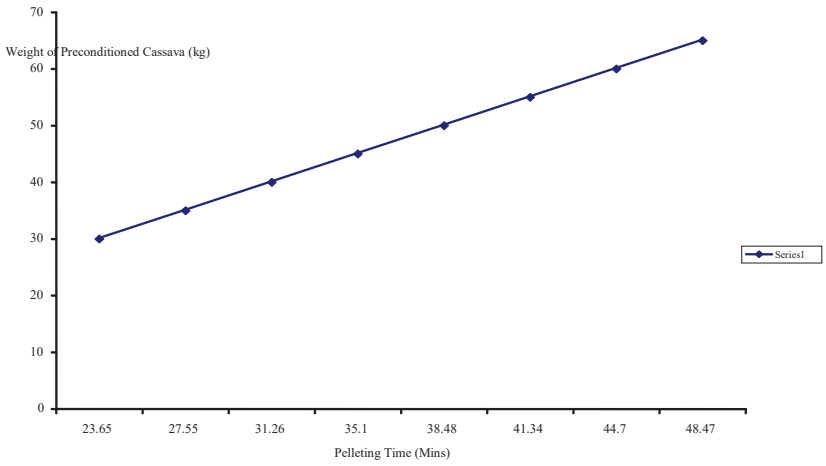

Figure 8. Graph of pelleting time against weight of preconditioned cassava

From Figure 8, the graph of the time of pelleting against the weight of preconditioned Cassava shows that an increase in the weight of preconditioned cassava increase the time of pelleting at a constant speed.

Preliminary Test Factor

Capacity of machine = $\frac{\text{Total amount of preconditioned cassava}}{\text{Total time (in hr)}}$

Pelleting efficiency = $\frac{\text{Total amount of cassava pellet formed x 100}}{\text{Total weight of preconditioned cassava}}$

From equation above

Capacity of the machine = $\frac{\text{Total amount of preconditioned cassava (kg)}}{\text{Total time (hrs)}}$

From Table 2.
Total amount of preconditioned cassava = 380kg
Total pelleting time = 290.55min = 290.55/60 = 4.82hrs
Therefore, the capacity of the machine = 380/4.82 = 78.84kg/hr

Pelleting efficiency = $\frac{\text{Total amount of pellets formed x 100}}{\text{Total weight of preconditioned cassava}}$

= (374.9 x 100) / 380 = 98.66%

4. CONCLUSION

This paper presents the development of a cassava pelleting machine for producing cassava pellets. The feed material (preconditioned cassava) is forced along by a varying pitch screw conveyor against a restricted opening known as the extrusion plate or die. The screw conveyor pitches at the discharge outlet have been sized properly to achieve the desired compression ratio. Pains are taken to properly size all the machine components that will be subjected to tangible forces to ensure that this robust and reliable machine is produced.

The machine capacity is purposely made small in order to achieve the desired objective, a suitable machine that is highly efficient and affordable by an average Nigerian and usable in rural areas, where there is no electricity since the machine can be operated by the use of gasoline engines.

REFERENCES

Anon 2003. Commodity fact sheet 10th edition *Bureau of Agricultural Statistics*. (BAS). Accessed on www.google.com on January 14, 2010.

Coombs J and Vlitos A. J. 1978. An assessment of the potential for biological solar energy utilization using carbohydrates produced by higher plant photosynthesis as chemical feedstock. Vol. 2. *Proceedings of International Solar Energy Society Congress*.

Devendra C. And Raghavan, G. V. 1978. Agricultural by-products in South Asia, availability, utilization and potential value. *World Rev. Anim Prod*. 14(4):11-27

El Sharkawy M. A. and Cock J. H. 1987. Response of Cassava to water stress. *Plant and Soil* 100: 345-360.

Growley, P. R. 1979. Transferring LEC Technology to developing countries from concept to application and beyond. *International Workshop proceedings* (Tanzania). p 11-14

Harper, J. M. 1981. Extrusion of Food, Vol. 1 and 11 Bola Raton, Florida CRC Press Inc.

Harper J. M. 1978. Extrusion processing of food, food Technology 32(7): 67-72

Hartwell J. L. 1967. Plants used against cancer. A survey, pp 30-34

Hillocks R. J. 2002. Cassava in Africa in Cassava; biology production and utilization eds R. J. Hillocks, J. M. Thresh and A. C. Bellolli pp 41-54 CAB international walling ford.

IITA 1997. Cassava in Africa, past, present and future international Institute of Tropical Agriculture, Ibadan, Nigeria. Journal Vol. 3 pg. 3.

Janssen, L. P. B. 1978. Twin screw extrusion New York Elsevier Applied Science 2nd edition

Khurmi R. S. and Gupta J. K. 2006. A textbook of machine designing Eurasia Publishing House (PVT) Ltd Ram Nagar New Delhi pp: 224-260

Miller, R. C. 1990. Unit operations and equipment. *American Association of Cereal Chemist Publications*. St. Paul, MN, PP 135-193.

Rehm S. and Espig G. 1991. The cultivated plants of the tropics and subtropics verlag Josef. Margrave Germany, pp, 243-247 Second ed.

Strahm, B. 1999. New generation extruders in proceedings of focus on extrusion of pet food industry. Mt Morris IL: Watt publishing co. 24-28

www.google.com. A search on cassava pelleting Accessed 14th October, 2009.