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Mechanization of wet-sieving processing of fermented cassava pulp for akpu food

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DISCOVERY
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ABSTRACT

The sieving of fermented cassava pulp largely remains a traditionally manual process in most consumption areas, with inefficient time and energy utilization coupled with its unhygienic, contaminating and smelling effects. The circumstance, therefore, necessitates the need for the development of a fermented cassava pulp sieving machine. The machine is made of a specially designed screw conveyor with a digester section along its length. The conveyor is placed inside a close-fitting cylindrical sieve which is in turn placed inside a larger enclosing outer cylinder. The machine has a hopper for fermented cassava pulp inlet, the sieved fine pulp outlet and the chaff outlet, all externalized through the outer cylinder. The machine achieves its sieving operation by a combined action of the screw conveyor fitted with beaters and the perforated inner cylinder mesh on an intermitently wetted cassava pulp. The machine produces about 3 kg of fine wet pulp within a minute. By comparing the fine pulp content of the un-sieved pulp and that of the chaff, the sieving efficiency of the machine was evaluated to be 85% such that the chaff may be recycled for complete sieving. The machine is simple and affordable, it holds a great potential to take fermented cassava wet sieving to the next level.

Keywords: wet sieving; fermented cassava; screw conveyor; unhygienic; sieving machine

1. INTRODUCTION

The production and processing of cassava for both human and animal use are gaining momentum by the day as the strive for food security grows across the globe. Cassava (Manihot esculenta) when processed into pounded fufu (utara-akpu) is a major staple food consumed in Southeast Nigeria and currently extending to both their immediate neighbours and beyond. It forms the closest replacement to the expensive traditional pounded yam. It is derived from cassava tubers. The tubers are harvested from farms. The peels of the tubers are removed and the tubers cut into about 15cm lengths. They are then steeped in water using containers or by a secured corner in a bank of a flowing stream. It is left to ferment for about four days thereby removing the cyanide content and softening the pulp. The flowing stream reduces the smell, hence, making some processors replace the water from time to time in pot steeped ones. The softened fermented cassava is then wet sieved manually by mashing and stirring it with fingers inside a small circular palm fond made basket or aluminium perforated sieve. The sieved pulp is then put in bags or allowed to sediment in a container to enable excess water to drain off or be decanted. The wet pulp sediment is then cooked and pounded sequentially in two stages and then ready to be eaten with egusi (melon) soup, onugbu (beater leaf) soup, fluted pumpkin leave (ugu) soup, ugbogoro soup, oha soup, okazi soup, uchakuru soup, ukpo opoto soup, draw soups like ogbono soup and okra soup, amongst others (Agbo, 2021).

Unfortunately, though, there is currently no existing integrated modern technology for the complete processing of cassava tuber into any of its palatable forms (Okorji et al., 2003). Akpu production still relies majorly on traditional techniques in its processing. The fermented pulp sieving process is one of the tiring, tedious and demeaning jobs in the preparation of akpu. The manual stirring wears down the hand and also painful to the shoulder. The fermented cassava has a characteristic smell and the processor tends to smell cassava long after the sieving process. This is demeaning to the processor and offensive to passers-by. Because the kitchen place is the primary responsibility of women, they and their female offspring mainly are saddled with this part of the cassava processing job (Davies et al., 2008; Onyemauwa, 2012; Nwaobiala et al., 2019). Yidana et al. (2013) stated that even though cassava processing is profitable and contributes significantly to the standards of living of women, the challenges encountered drastically reduce productivity and economic returns. Many young girls have also lost appropriate suitors based on the fermented cassava smell which follows them after the sieving activity. According to Owolarafe et al. (2018) most fufu processing centres were owned by individuals and the unit operations were carried out manually usually by women with low education levels. Nonetheless, Hahn (1997) advocated to improve or modify the presently used simple mostly manual processing equipment or systems that are labour intensive with very low productivity, rather than changing to entirely new, sophisticated and expensive equipment. The aforementioned reasons make the fermented cassava pulp wet-sieving a candidate for immediate mechanization.

The available machines for cassava production are product/process dependent. Cassava can be processed into gari, dry fufu (alibo), wet fufu (utara akpu), tapioca, etc. Hitherto, most of the sieving machines developed were for processing dewatered grated cassava for gari production (Ikechukwu and Agu, 2018; Ikejiofor and Oti, 2012; Kolawole et al., 2010; Kudabo et al., 2012) and dried cassava pulp for flour and fufu (alibo) production (Nwaigwe et al., 2012). Odigbo (1978) developed a series of cassava production and processing machines including cassava planters, weeders, harvesters, peelers, graters, gari-mash pulverisers/sifter and gari frying machines. Olayanju (2019) developed a cassava peeling and washing machine while Esteves et al. (2019) and Ndaliman (2006) developed a cassava grating machine for gari production as well. In wet fufu (akpu) production, fermented wet cassava pulp sieving entails the separation of fine pulp particles from the coarse fibres using meshed or perforated container partly immersed in or supplied with water. Fayose (2008) developed a motorized starch extracting machine, based on the shaking mechanism of a sieve for wet cassava starch and other crops while Saengchana et al. (2015) achieved the same through the application of centrifugation and filtration mechanisms to separate free starch granules from the cassava pulp. It is observed from the literature review that the aspect of mechanizing fermented wet cassava sieving process has not received adequate attention from researchers. This paper hence focused on the mechanization of fermented cassava pulp sieving machine to reduce the negative effects on the processors.

2. METHODOLOGY

Design and design considerations

In the design of the wet sieving machine, the physio-chemical properties of the fermented cassava were considered along with the component materials. Economically viable component materials that can function in a moisturized and acidic environment without badly contaminating the product were selected. The desired functionality and quality of the machine was considered in conjunction with manufacturability, taking into cognizance the available manufacturing tools. The operating conditions and maintenance of the machine were considered with respect to the operators, who are mostly women with low education.

The computer rendering design of the fermented cassava pulp sieving machine is shown in Fig. 1.

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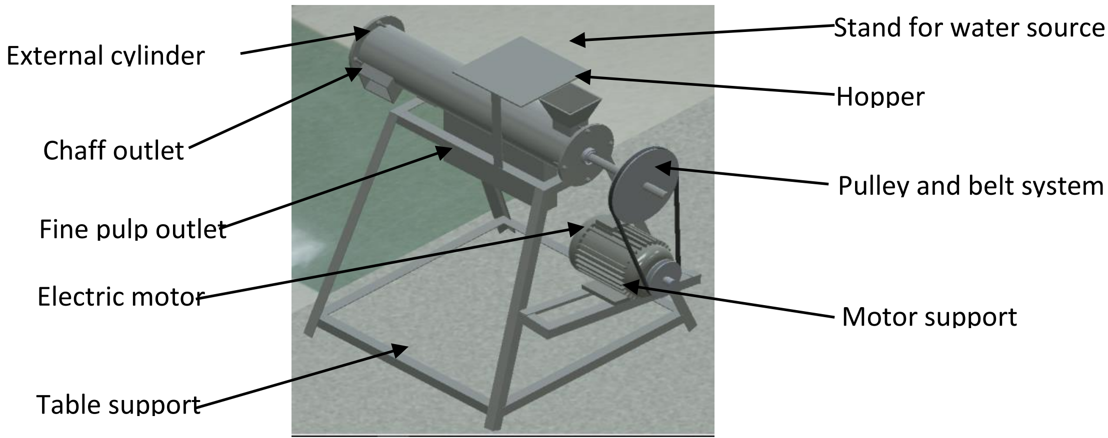

Fig.1: Cassava pulp sieving machine

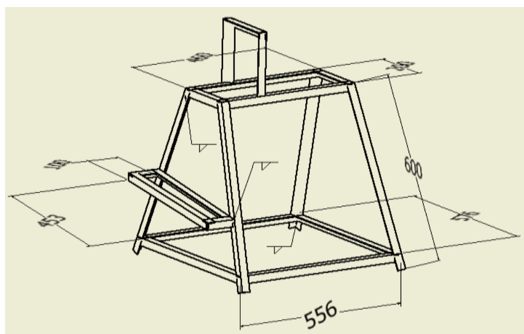

Fig. 2 Table support (dimensions in mm)

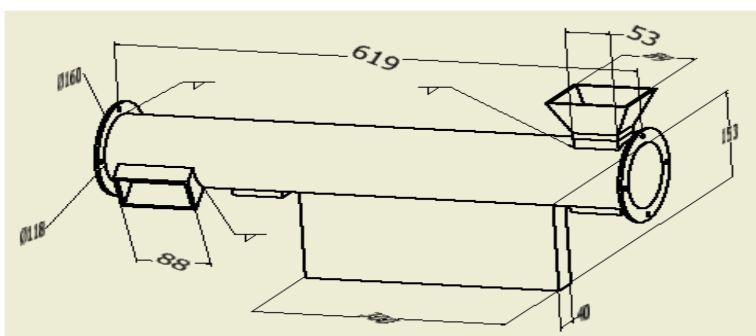

Fig. 3 External cylinder, inlets and outlets (dimensions in mm)

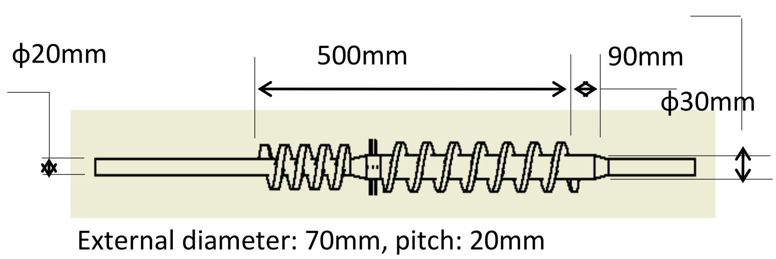

Fig. 4 Screw conveyor

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Figure 2 shows the table support which carries the components of the machine and the feed material. The support is expected to carry only a load of up to 60 kg or 590 N under the worst-case scenario, however, to maintain stability and withstand vibrations during operation, a trapezoidal frame arrangement was designed. Figure 3 shows the external cylindrical barrel. The barrel houses the sieve and the screw conveyor. It carries the hopper which opens into the inner part of the sieve. The sieved cassava slurry passes through the sieve into the outer cylinder where it is discharged through the fine pulp outlet. Another opening that runs through to the inside of the sieve provides for the chaff discharge. Figure 4 shows the screw conveyor, which forms the base for the sizing of other components of the machine. The fermented cassava is poured into the hopper and is conveyed to the digestion section by the screw conveyor. The screw conveyor has beaters attached to the central region for digestion and sieving operations. The sieving goes on through the predetermined length of the sieve till the end where the chaff is then discharged. The specified motor, pulley and belt in combination with the conveyor screw lead makes for optimized linear speed of the cassava for efficient sieve surface contact, prolonged sieve surface exposure and good mixing and churning of the pulp. The screw conveyor is rotated through a pulley system by an electric motor at a predetermined speed reduction ratio of 1:0.4 to enable enough resident time for the completion of the sieving operation before the chaff discharged. The speed is indirectly proportional to the pulley diameter, hence for the choice 1.0 hp motor speed of 700 rpm and standard pulley diameter of 62.5 mm the machine speed was obtained as 280 rpm using a standard pulley of 156 mm. The length of the screw conveyor's functional (sieving) part was taken as 590mm and the major diameter as 70mm making the shaft relatively long for longer exposure of about 5 seconds between the inlet to chaff outlet and thus more efficient sieving.

A quasi-order of magnitude analysis of the loads and torques to which the screw conveyor is subjected gave an idea as to whether the shaft is subjected to adverse loading and stress. The shaft is loaded with two downward forces (its weight and the belt tension) and they act in such a way that their bending moments about the first bearing support, counterbalance or nearly counterbalance each other. The resisting torque is minimal compared to the motor torque, and also, at every point of operation of the machine when the conveyor is full with cassava pulp, the pulp pressure is evenly distributed around the shaft. From the choice of materials and element sizing, there is neither adverse stress nor adverse loading of the shaft.

The screw conveyor takes the form of a spiral blade coiled around a shaft and rotates inside a close-fitting perforated sieve tube. For a screw conveyor shown in Fig. 4, the rate of volume transfer is directly proportional to the area of the annulus tangential cross-section between the shaft and the sieve and the linear velocity of the cassava mash. The linear velocity is however directly proportional to the rotation rate of the shaft. For every one complete revolution of the conveyor, the materials would have moved a distance equal to the pitch of the conveyor screw.

Materials

Material selection and cost analysis were done to ensure functionality, ruggedness and cost-effectiveness. Given that the machine's parts and components will be manufactured in-country using available tools and also subjected to contact with water and acidic environment during operation, cheap and locally available materials that are resistant to corrosion were of utmost importance. Galvanized steel sheet was chosen as the material for the hopper, sieve, external cylinder casing, sieved cassava mash outlet and the chaff outlet since these parts of the machine have direct contact with water while the machine works. The conveyor shaft was cut from a medium carbon steel rod. Other components used in the machine include electric motor, 2 bearings, 2 pulleys and a v-belt, bucket, water hose and 2 control taps.

Methods

The fabrication was commenced by cutting and turning an 850 mm shaft length from a medium carbon steel rod on a lathe machine to get the required length stepped diameters of 30 mm and 20 mm with the tapers (see Fig. 4). A single spiral thread formed from galvanized steel sheet of 4 mm thickness was welded unto the predetermined sections of the shaft to make the thread of the screw conveyor with a 25 mm pitch. A 0.6 mm thick galvanized steel sheet of 600 mm length by 240 mm width was cut, perforated into a mesh of 3mm holes, 13 holes per square inch, using the tip of a 3-inch concrete nail, folded, welded and trimmed to obtain the sieve. The sieve mesh size was adapted from the manually operated sieve which hitherto gave acceptable cassava mash texture. A 1.0 mm thick galvanized steel sheet was cut, rolled and welded to obtain the external cylinder. Openings were cut on both the sieve and the external cylinder for fermented cassava inlet, sieved mash outlet and the chaff outlet accordingly. The table frame with motor support was produced from 42 by 42 by 3 mm angle steel bars. The table also has provisional support for the water supply system overhead tank.

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3. RESULTS AND DISCUSSION

Figure 5 shows the completely assembled machine for fermented cassava sieving with the overhead water tank installed to sprinkle water on the mashed cassava to aid its passage through the sieve during operation. The overall dimension of the machine is given as follows: length equals 850 mm by width equals 470 mm and by height equals 1450 mm. The total weight is below 70 kg. Most of the parts in contact with the fermented cassava were made of galvanized steel sheet to avoid corrosion and contamination of the product. The sieved cassava outlet is located below the outer cylinder where the product is collected and decanted for further processing and/or marketing.

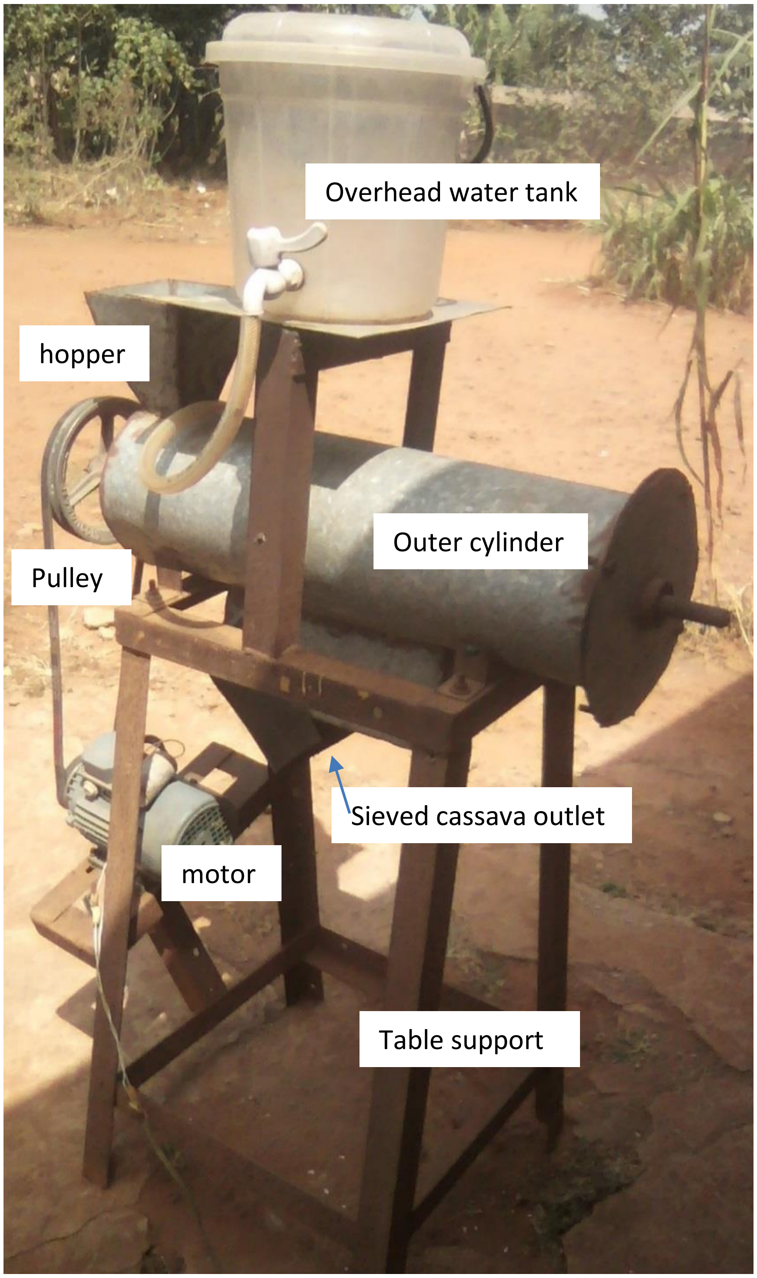

Fig. 5 Completely assembled fermented cassava wet sieving machine

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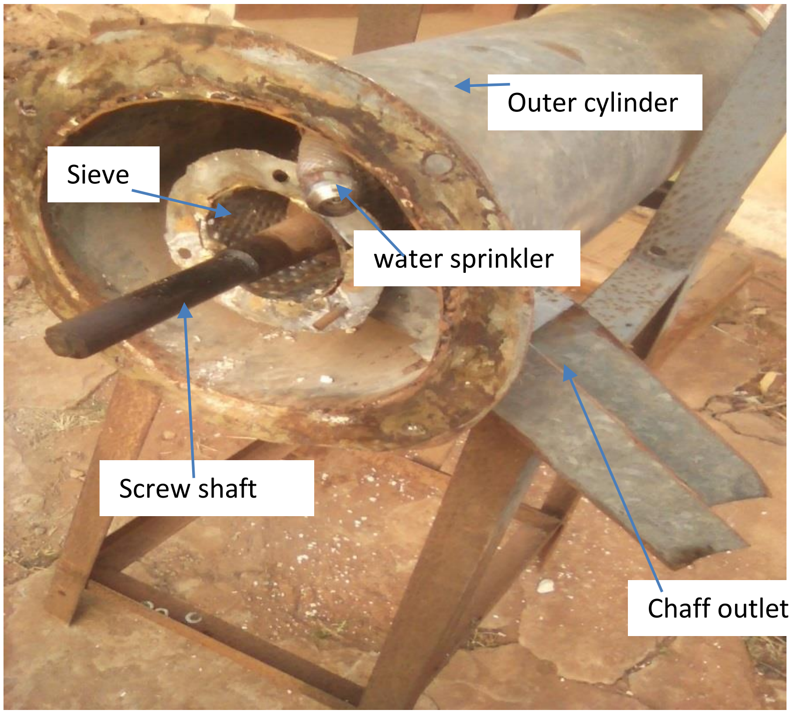

Fig. 6 The inner configuration of the fermented cassava wet sieving machine

Figure 6 shows the inner configuration of the sieving elements which included the outer cylinder where the sieved product is collated and discharged through the sieved mash outlet while the chaff is discharged through the chaff outlet. The sieve of the perforated galvanized steel sheet is centrally located within the outer cylinder with the water sprinkler ensuring that the cassava mash remains in slurry form for easy passage through the sieve. Figure 7 shows the conveyor screw shaft with three major segments which include the inlet side which starts from the hopper and transports the fermented cassava to the digester. The transported fermented cassava in the digester is disintegrated into particulates and passed down through the sieve into the bottom part of the outer cylinder for onward discharge at the outlet while the chaff is pushed into the outlet segment of the conveyor screw. At the outlet end, the remaining fine particles within the chaff is sieved out while the chaff is transported to the chaff outlet where it is discharged.

Fig. 7 The fermented cassava wet sieving screw conveyor shaft

The machine produces about 3 litres of 90% fine watery pulp in a minute. The sieving efficiency of the machine was obtained by comparing the fine pulp content of the un-sieved pulp and that of the chaff which shows that 85% of the pulp was converted into a fine sieved mash. However, a second recycle sieving gives complete sieving.

4. CONCLUSION AND RECOMMENDATION

A wet sieving machine has been developed for the fermented cassava sieving process which hitherto has been carried out by a tedious traditional manual operation. The machine limits the bodily contact with the fermented cassava, the injury to the fingers and body pains, and other unhygienic activities associated with the hand processing including the demeaning characteristic odour that follows the processor. The machine was fabricated using locally available and cheap raw materials thereby making it affordable even by the low economic strata of the society. The machine is highly functional, rugged and suitable for use and to operate by

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lowly skilled and lowly educated persons who constitute the majority of cassava farmers and processors. The machine's sieved cassava mash output of 3 kg per minute far outweighs the maximum capacity achievable through hand processing. The machine processing is therefore a suitable replacement to the awkward traditional method of fermented cassava sieving. The machine is therefore recommended to fermented cassava processors just as Agric Extension Officers must disseminate the information about this latest development.

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Conflict of Interest:

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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