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REVIEW ON CASSAVA MASH SIF TING METHODS AND MECHANISMS

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ABSTRACT

Cassava is presently the most important food crop in Nigeria from the point of view of both the area cultivated and the tonnage produced.Cassava has transformed greatly into high yielding cash crop, a foreign exchange earner as well as a crop for world food security and industrialization. As a result of this, there has been an unprecedented rise in the demand for cassava and its numerous products worldwide for both domestic and industrial applications. However, cassava processors are currently finding it extremely difficult to respond positively to this increase in demand due to the prevalence of the traditional processing methods employed the sifting operation inclusive. This has made the appraisal of the current sifting technologies pertinent in order to address the areas that need technical improvement and further research efforts towards the evolution of cost effective sifting technologies with improved efficiencies which would enhance the capacity to exploit the cassava market potential. Therefore, this paper reviews the efforts made, and currently being made towards an efficient and cost effective mechanization of cassava mash sifting operation so as to overcome the challenges being faced using traditional method of sieving cassava mash.

Keywords: Cassava mash, Sifting methods, Sifting mechanism, Sifter.

INTRODUCTION

There has been an unprecedented rise in the demand for cassava and its numerous products worldwide for both domestic and industrial applications. In Nigeria, cassava is presently the most important food crop from the point of view of both the area under cultivation and the tonnage produced. Therefore,cassava has transformed greatly into high yielding cash crop, a foreign exchange earner as well as a crop for world food security and industrialization. (Adetunji and Quadri, 2011).

Utilization of cassava is numerous, but the utilization of cassava root in food and other industrial applications is limited by the rapid post-harvest physiological deterioration (PPD), which reduces the shelf life and degrades its quality attributes (Sánchez *et al*., 2006). This physiological deterioration is attributed to its high moisture level (60 to 75 %, wet basis) (Salcedo *et al*., 2010). The metabolic process continues after harvest, resulting in softening and decay of the root and, thus, rendering it unwholesome for human consumption (Salcedo *et al*., 2010). Other factors which can cause deterioration of cassava root include pests, diseases and mechanical damage such as cuts and bruises which occur during harvesting, post-harvest handling and processing (Iyer *et al*., 2010). The cut area exposes the root to vascular streaking and microbial attack, thereby accelerating deterioration and decay (Opara, 1999, 2009; Buschmann *et al*., 2000). Studies have shown that physiological changes start within 24 hours after harvest with a blue black discolouration commonly appearing on the root after 72 hours, at ambient storage temperature (Iyer *et al*., 2010; Zidenga *et al*., 2012). The colour change of the root is accompanied by fermentation and, thereafter, an offensive odour indicating complete rotting (Reilly *et al*., 2004). This rapid degradation of quality in fresh cassava roots is a major reason for the poor utilization, poor market quality, short root storage life and low processing yield (Reilly *et al*., 2004; Sánchez *et al*., 2006). Converting cassava root to other food forms creates products with longer shelf life, adds value to the root and reduces postharvest losses (Falade and Akingbala, 2010).

The application of novel post-harvest handling, processing and packaging and storage techniques is of critical importance for successful large-scale production and utilization of cassava roots and products. Successful application of these post-harvest technologies will contribute towards maintaining product quality and safety as well as reducing incidence of postharvest losses and, thereby, improve food security (Opara, 2013). For this reason, cassava is usually sold as a processed product in form of gari, farinha, fufu, and flour (Ahiakwo *et al*., 2015). The traditional processing of cassava is a labour demanding operation while women and children are the major producers (Agbetoye, 2003). The processing method comprises the combination of the following activities: peeling, boiling, steaming, slicing, grating, soaking, fermenting, pounding, frying, pressing, sifting and drying.

A sifter (also called a ***screener***) is a unique and often misunderstood machine compared with other equipment in the powder and bulk solids handling industries: Only one material goes into a sifter, but two or more materials come out. Any dry free-flowing material can be handled in a sifter for food products such as wheat flour, sugar, and baking soda; plastics and rubber (Ricklefs, 2017).

Pulverization and sifting are necessary operations in gari processing. They do not only reduce the lump into fine particles (undersize) which pass through the sieve, they separate the coarse unwanted particles (oversize) which are discarded after each batch of sieving. Sifting produces a quality gari free from fibrous contaminants and having similar sized granules. The quality of gari produced and ultimately the texture of the end product depend on two prime factors namely, the sieve aperture size used and the garifying process, which include heat input regulation and the manipulation skill of the operator (Ahiakwo *et al*., 2015). Pulverizing and sifting operations cause great challenge in gari production. Large percentage of cassava mash lumps is still been pulverized and sifted manually by rubbing hands on local sieve called 'raffia sieve' (Ajav and Akogun, 2015). The raffia has high product loss (due to spillage or breakage in the sieve), is time consuming, demands an unfriendly sitting posture resulting in back aches and pains and hazardous. Jackson and Oladipupo (2013) reported that it takes about three men one hour to sift 1 kg of dewatered cassava mash using the traditional method compare with an operation that will be efficiently carried out in one minute using a mechanical sifter. Though cheap, the raffia sieve needs frequently replaced.

Sifting of cassava mash is important before frying to ensure that particles have uniform size. The uniform size of particles will ensure uniform roasting during garification. Final product must be uniform in size to attract good market value. Cassava mash is first sifted after dewatering in order to remove the fibre (ungrated cassava pieces). In the final re-sieving, the product is separated into chaffy, fine, coarse and medium size fractions. This is done after the frying operation. It has been identified that one of the ways to achieve better quality of gari as well as to reduce time duration for processing gari, is to have proper and quicker means of sifting cassava mash (Agbetoye and Oyedele, 2007). FAO (1998) explained that after pressing, the de-watered cassava mash has to be broken up and sieved to remove the large lumps and fibre, in order to obtain a homogenous product.

The present situation in the country whereby limited quantities of cassava-based products are exported is due largely to the inability of such products to meet the international standards for healthy foods (Adetunji and Quadri, 2011), which could be attributed to the unwholesome and unhygienic features of the traditional processing methods being used. Thus, a review of the existing technologies for sifting cassava mash for gari production is germane. Therefore, this paper aims at reviewing the efforts made, and currently being made towards an efficient and cost effective mechanization of cassava mash sifting operation so as to overcome the challenges being faced using traditional method of sieving cassava mash.

METHODS OF SIFTING CASSAVA MASH

There are two broad methods of sifting cassava mash namely traditional sifting and mechanized sifting methods.

Traditional Sifting Method

Sifting of cassava mash is achieved traditionallyin batches by loading 1.5 kg of the mash on a handwoven raffia sieve (approximately 450 × 450 mm in dimension) and applying slight pressure with both hands to rub the cake against the sieve for some time. This causes constant breakage of its strands and eventually,only coarse-grained particles are retained on top of the woven raffia sieve (Sanni *et al*, 2008). Although very popular, the use of the raffia sieve is a very slow, unhygienic, tedious and hazardous process (PHTRG , 1998). Sieving operation using traditional method involves a receptacle, a raffia sieve or screen, dewatered cassava mash and human power (Ahiakwo *et al*, 2015).

The Receptacle is the container that receives the fine particles (undersize) that pass through the sieve as the dewatered cassava mash is crushed against it.The Sieveusually square or rectangular in shape. It is made of cane, raffia palm or palm frond material. This is cut out into several pieces of flat rectangular flexible strip measuring about 0.5 × 60 cm, with thickness of about 1 mm. Whereas, 0.5 cm represent the width of a single sieve strip, 60 cm which represent the length of the sieve can vary depending on the length of the sieve. These are weaved by the native specialist craftsmen in such a way that an aperture (square hole) of about 2 to 3 mm^2 is revealed at alternate position throughout the sieve. The woven strip is secured over framework of thick material. The alternating arrangement of the woven material provides a rough surface for crushing the lumps of cassava mash (Ahiakwo *et al*, 2015). The siever is the source of power –the two human palms. These serve two purposes; that of lifting the lumps of the mash onto the sieve and that of compressing and shearing the lumps against the sieve. This results in fine particle drifting down through the sieve apertures to the receptacle while retaining the coarse unwanted particle which will be discarded after each batch of sieving ((Ahiakwo *et al*, 2015). Fig. 1 shows the picture of a typical traditional sifter.

Figure 1 Picture of a typical traditional sifting operation
Source: Ahiakwo *et al* (2015)

Mechanical Sifter
Mechanical sifter separates the material according to particle size by moving the material in relation to a screen.Typical applications of mechanical sifter include removing fines from dried herbs, spices, sugar, and granular pharmaceuticals (Ricklefs, 2017).Sifter can be used in a quality assurance program to scalp material, remove fines, or grade material. You can also use a sifter to grade material in a manufacturing process.For *scalping, which is* the sifter's most common quality assurance application, the sifter removes oversize or foreign materials. These can be agglomerates and lumps in materials such as flour mixes, as well as foreign materials such as insects, bin wall scale and flakes, moldy material, or tramp metal.

For *removing fines,* the sifter removes undersize and dedusts the material to meet final product specs. This is useful for friable materials that give off fines or other materials that release fines in response to excessive or rough handling. For *grading,* the sifter controls both oversize and undersize in your material. A common example for quality assurance is grading sugar to simultaneously remove the lumps and fines. In manufacturing for quality assurance applications, especially for sanitary, in addition to removing coarse oversize and fines, grading can produce multiple intermediate particle sizes in materials such as wood particles or polystyrene beads.In each of these uses, sifting provides another benefit: Passing through the screen aerates the material, which gives it a more uniform bulk density for subsequent processing and handling steps (Ricklefs, 2017).

The most common location of sifter for quality assurance is immediately after raw materials are received. When materials are received in bulk, the sifter can be inserted into a pneumatic unloading system to sift the materials before they reach bulk storage. Sifting at this point allows you to monitor the supplier's and transport company's quality control and sanitation practices while allowing you to remove contaminants before they can enter your bulk storage vessels. When raw materials are received in small bags, the bags are emptied directly into the sifter before the materials are moved to storage or processing. The sifter not only breaks up and removes lumps but separates any torn bag pieces, strings, or other contaminants from the raw materials. For a manufacturing application such as grading, a common sifter location is just prior to packaging and shipping. This allows you to package different grades of material for shipment to specific customers (Ricklefs, 2017).

SIFTER CLASSIFICATION

Sifters are broadly classified based on application or screening motion.

Classification based on Application

When classified by their application, sifters are either gravity-flow or in-line units.In a *gravity-flow sifter,* shown in Figure 2a, material flows at atmospheric pressure through the sifter by gravity. The material can be fed to and carried away from the sifter by a pneumatic conveying system (shown in the figure) or by mechanical conveyors. With a pneumatic conveying system, two blowers are typically required, one for conveying material to the sifter and one for conveying material away from it. However, the machine is designed to sift material without the influence of positive or negative airflow on the sifting motion.Using the gravity-flow sifter requires auxiliary equipment such as a cyclone or filter receiver, airlocks, a blower package, and associated dust control equipment. The gravity-flow sifter itself costs less and is less likely to leak than an in-line sifter. If the flexible connections linking the sifter's inlet and outlet to the conveying equipment fail, less spillage will result because of the sifter's operation at atmospheric pressure. The gravity-flow sifter also allows you to separate your material into multiple fractions and more easily use metal detectors (Ricklefs, 2017).

In an *in-line sifter,* shown in Figure 2b, which is installed directly in a pressure or vacuum pneumatic conveying system, the material flows with the conveying air at the conveying line pressure into and then away from the sifter. But because the pressure is equalized above and below each screen in the sifter, no force other than gravity causes the material to pass through the screen. Only one blower (that for the conveying system) is required, thus simplifying the operation and reducing the system's cost by eliminating the need for auxiliary equipment. This limited amount of equipment also reduces the system's installation costs, including those for electrical controls, and reduces maintenance and power costs over the system's life.

Whether used for a gravity-flow or in-line application, the sifter typically provides one of several types of screening motion. Each type of motion results from the differential movement between the screen and particles at a given amplitude and speed. Usually, the particles are moved in relation to the screen, but in the case centrifugal sifter, the particles move while the screen remains static. For best sifting results, the material must be metered uniformly to the sifter and be well distributed over the full screen surface with minimal agitation. The particles naturally stratify, with fine particles migrating to the material bed's bottom and thus having maximum exposure to the screen surface.

Classification of Sifter According to Screening Motion

The most common types of screening motion are centrifugal, vibratory, gyratory-reciprocal and gyratory. Each motion typically is suitable for sifting any dry free-flowing material, but has advantages and disadvantages which must be considered before selecting a sifter for your application.

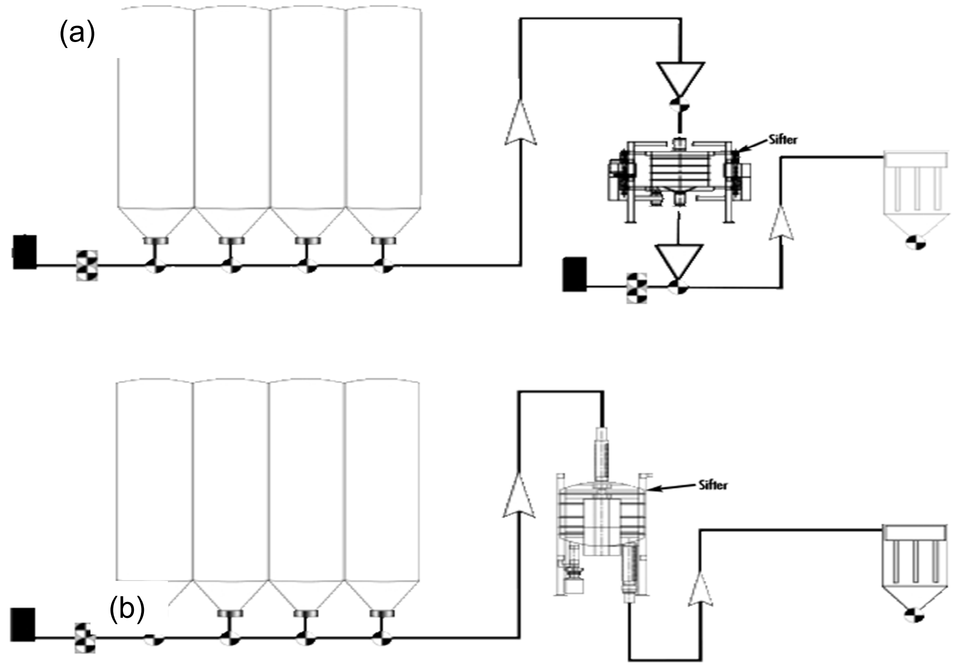

Figure 2: (a) Gravity-flow sifter (in pneumatic conveying system); (b) In- line sifter
(Source: Ricklefs, 2017)

Centrifugal Sifter

A typical centrifugal sifter is shown in Figure 3a. In operation, an integral screw feeder meters material into the sifter's stationary screening chamber, which is formed by a cylindrical screen. Rotating beaters or paddles in the chamber impact the material and accelerate its movement through the screen, shown in Figure 3b. This high velocity presents the particles to the screen surface many times, providing many chances for the particles to pass through the screen. Moving material so quickly requires high energy. Containing this energy causes the screen to deflect and flex, which helps prevent screen blinding without requiring screen cleaners. Although all screens eventually fail, the centrifugal sifting motion's flexing severity reduces the screen life more than other sifting motions (Manivelprabhu *et al*., 2017). The centrifugal sifter is compact and typically easy to disassemble and maintain. It doesn't have flexible connections at the inlet and outlet, eliminating this common source of leaks. According to most centrifugal sifter manufacturers, the sifter can break up soft agglomerates in sticky materials or materials that contain fat, which can be an advantage in some applications. However, the centrifugal sifter has relatively high power requirements, applies high stresses to the screen, and isn't typically suited for precise separations of near-sized particles. Current Baking Industry Sanitation Standards Committee guidelines suggest using sifters that "employ no rubbing or physical pressure to facilitate" flow through the screen; the centrifugal sifter's rotating beaters do apply rubbing or pressure, which can be a concern for food products because the beaters can fracture particles and force them through the screen (Ricklefs, 2017),

Vibratory Sifter

A vibratory sifter, shown in Figure 4a, has horizontal screens. Each screen is typically mounted in a round frame; each screen and frame together forms a *screen deck.* (Each screen deck also includes a large-opening wire mesh, called a *back wire,* that's mounted below the screen vertical motion to each screen, shown in Figure 4b. The vibratory sifter's benefits include its simple to hold a set of screen cleaners, such as rubber or plastic balls or cubes. The cleaners bounce against the screen's bottom surface during sifter operation to prevent screen blinding). Material is fed into the sifter as a drive mechanism applies both short, back-and-forth linear motion and le drive mechanism, which makes the sifter inexpensive, and its simple design. This device is used for separate products like grains, turmeric powder, chilly powder, rice powders and chemicals used in pharmaceutical industries (Manivelprabhu et al., 2017). However, the vertical motion tends to disturb the particles' natural stratification on the screen surface, so that material tends to be airborne much of the time rather than in contact with the screen; this, coupled with the sifter's short linear stroke, reduces the sifter's efficiency. Because the sifting motion is relatively small, relatively little energy is imparted to the sifter's screen cleaners, which can lead to screen blinding (Dong *et al*., 2013).

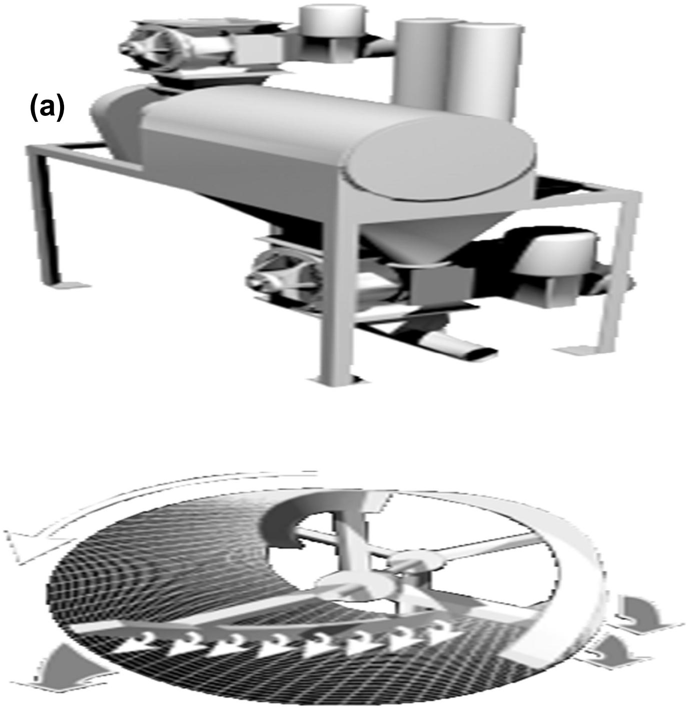

Figure 3: (a) Centrifugal sifter (b) Centrifugal sifting motion
(Source: Ricklefs, 2017)

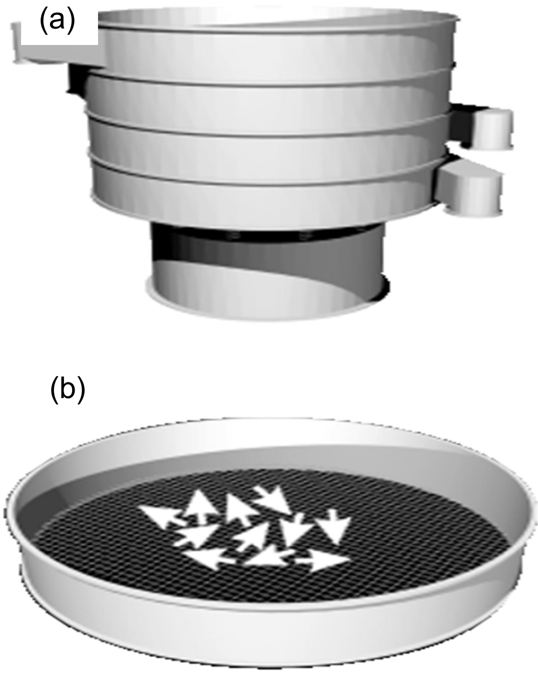

Figure 4: (a) Vibratory sifter; (b) Vibratory sifting motion
(Source: Ricklefs, 2017)

The machine also won't break up lumps or agglomerates, but this may not matter for some applications. The sifter has an additional disadvantage for grading applications: its inefficient use of screen area. This is because most vibratory sifters have only one screen per size grade, providing the same screen surface area for each grade, regardless of the quantity of material in each grade. So, for instance, if the sifter separates a material into four grades (greater than 10 mesh, between 10 and 20 mesh, between 20 and 40 mesh, and less than 40 mesh), the sifter's capacity would, for most applications, be limited by the 40-mesh screen area. As a result, excess screen area would be provided for the 10- and 20-mesh screens (Ricklefs, 2017)

Gyratory-reciprocal Sifter

A gyratory-reciprocal sifter, shown in Figure 5a, has a rectangular, relatively steeply inclined screen and a drive mechanism that imparts a gyratory motion at the sifter inlet end and a reciprocating, linear motion at the outlet. Together, these movements produce a gentle elliptical motion, shown in Figure 5b, that both conveys the material and promotes particle flow through the screen. The sifter's benefits include its simple design and gentle sifting motion. The sifter also requires little headroom because, for each mesh size required, only one screen deck is used to provide the application's required screen area. The screen's incline and linear motion at the discharge also help it convey bulky material or high volumes of material from the inlet to the outlet. However, the sifter's conveying action can limit the particles' maximum exposure to the screen openings, reducing the sifting efficiency. The screen's large area results in other disadvantages, including increasing the sifter's required floor space and making the screen unwieldy and awkward to handle for service or replacement. Like a vibratory sifter, the gyratory-reciprocal machine isn't usually configured to accurately allocate the screen area required for the application.

Gyratory Sifter

A gyratory sifter consists of a stack of multiple square, rectangular (Figure 6a), or round (Figure 6b) screen decks. Multiple screens in the stack can have the same mesh size to provide the required screen area for the application. A drive mechanism imparts a circular motion in a horizontal plane to the screens, shown in Figure 6b. The horizontal screens and lack of vertical motion produce the sifter's gentle sifting motion and maintain the material's natural stratification -- with fine particles adjacent to the screen and coarse particles at the material bed's top. In an application producing only two fractions, multiple screens arranged in a series provide the required screen area. The oversize pass from one screen to the next and each screen removes a portion of the particles that pass through it while the oversize continues to pass from one screen to the next. In an application producing more than two separations, the gyratory sifter provides a major benefit: Because it uses smaller stacked screen frames, the screens can be accurately allocated to each separation's requirements. For instance, to handle the grading application previously discussed for the 10-, 20-, and 40-mesh screens, the gyratory sifter's screen area would be allocated appropriately. Typically, the 10-mesh separation would require a smaller screen area and thus fewer screens than the 20-mesh, and the 20-mesh would require less than the 40-mesh. The result is that no excess screen material, cleaners, or maintenance would be required for underused screens and screen frames (Ricklefs, 2017).

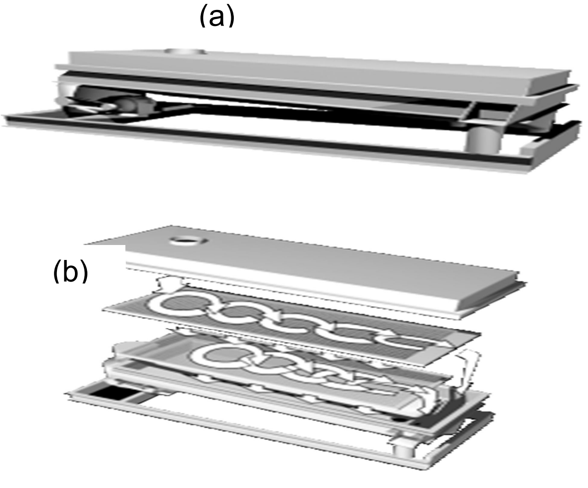

Figure 5 (a) Gyratory reciprocal sifter; (b) Gyratory reciprocal sifting motion
(Source: Ricklefs, 2017)

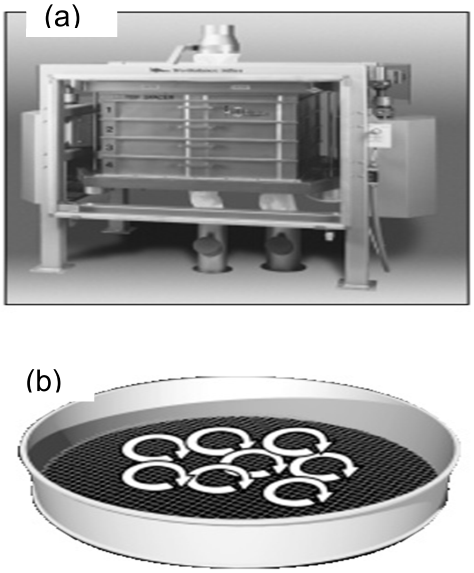

Figure 6 (a) Gyratory sifter; (b) Gyratory sifting motion
(Source: Ricklefs, 2017)

TRENDS IN CASSAVA MASH SIFTING TECHNOLOGIES IN NIGERIA

Shortcomings of traditional method of sifting was identified as problem of rubbing one's hand against palm fibre which can cause injury to operator's hand; problem of the operator having backache because of time of sitting down for the operation, hygiene issues and energy consumption. IITA (1990) suggested that sieving raw cassava particles is better done by feeding the cassava cake back into the grater after dewatering. But graters cannot sieve the cassava mash to the required particle size for frying, since graters do not have screen that can separate the mash into fine particles.

Mechanical sieves have been developed in Nigeria by researchers to mimic the traditional process of sifting cassava mash. Odigboh and Ahmed (1984) developed a prototype machine for pulverizing and sifting gari mash with a sifting capacity of 125 kg/hr. However, it was reported that the machine was complex; it might not be technically suitable for peasant family unit processors.

Igoni (2000) constructed a continuous flow rotary sieve for dewatered cassava mash. It sieves gari at moisture content of 47.6%. The machine has sifting efficiency of 48.6%, which is not enough for effective operation. Jimoh and Oladipo (2000) also developed an electrically operated reciprocating sifter. The machine has a sifting capacity and operating efficiency of 8.0 kg/hr and 61 % respectively. However, the machine could not be used in rural areas where there is no electricity supply.

Agbetoye and Oyedele (2007) developed a mash sifter using reciprocating action to shake the cassava cake lumps and pulverize it to allow smaller particles to pass through the apertures of the sieve. Although, this concept is better than the traditional method, some of the limitations are that the trays are uncovered and the quality of the final product is contaminated by foreign particles. In addition, the primary beneficiaries most of whom are small scale processors are unable to effectively utilize and maintain the machines.

Sanni *et al*. (2008) developed a rotary pulverizer for cassava cake in gari production.Two different sieve sizes (5 mm and 7 mm) were considered. The efficiencies were 81.2 % for 5-mm sieve and 69.0 % for 7-mm sieve. The throughput capacity got for 5-mm sieve was 350 kg/hr while 227.71 kg/hr was obtained for 7-mm sieve. The uniformity coefficient of the sifted mash using the 5-mm sieve (1.72) gave a product that compared favourably with that of raffia sieve.

Ikejiofor and Oti (2012) evaluated the performance of acombined cassava mash pulverizer/sifter developed by National Root Crops Research Institute (NRCRI). The sifter has a sifting capacity and efficiency of 167.52 kg/hr and 91.2 %, which are high, but effect of sieve aperture on the performance of the machine was considered, since only one sieve aperture (4 mm) was used.

Kudabo *et al*. (2012) developed a motorized cassava mash sifter, which was powered by an electric motor with an output capacity of 136.2 kg/hr and 93.3 % sifting efficiency at a sifting speed of 410 rpm. The results obtained from evaluating the machine was silent about the size of the sieve aperture used. Moreover, it was recommended that the receiving outlets should be folded to help gather the sifted materials effectively.

Adetunji *et al.* (2013) developed an improved gari sifting machine with a sifting efficiency of 92.5 %. Jackson and Oladipo (2013) evaluated the sifting efficiency of a dewatered cassava mash at different operating speeds developed at National Centre for Agricultural Mechanization (NCAM). The efficiency got was 86.5 % at an operating speed of 650 rpm. Ajav and Akogun (2015) developed a combined dewatered cassava mash lump pulverizing and sifting machine to studied the effect of moisture content, operating speed, and mash quantity on the performance of the machine. The results of the analysis revealed that sifting efficiency for 5 mm aperture sieve ranged from 78.8% to 89.0%, sifting efficiency for 3 mm aperture sieve ranged from 62.8% to 79.9%, input capacity ranged from 232.29 to 405.25 kg/hr, output capacity for 5 mm aperture sieve ranged from 56.2 to 97.4 kg/hr, while output capacity for 3 mm aperture sieve ranged from 45.10 to 87.8 kg/hr.

Sanni, *et al*. (2016) developed a motorized rotary sifter to pulverize pressed cassava cake and sift out fibre-free cassava meal for gari and cassava flour production. The material recovery efficiency of the machine ranged from 4.79 to 41.30%. The optimum throughput capacity and material recovery efficiency of the machine were 231.79 kg/h and 92.98 % respectively compared to 56.29 kg/h and 100 % for the manual method. The results show that the motorized rotary sifter performs better than the popular manual method in terms of throughput even though there was a slight decrease in material recovery efficiency.

A survey conducted by Quaye *et al.* (2009), which was set out to determine the adoption requirements of some cassava processing technologies revealed the factors that end users consider before adopting new technologies as affordability of the technologies in term of of cost implication on the profit margin of the user, efficiency of the machine, number of labour required to operate the machine as well as simplicity or otherwise of the machine to enhance or impair local capacity for repair and maintenance of such technologies.were listed as some of the considerations often made for adopting a new cassava processing technology which most of the existing machines currently lack, especially the sifting machines which are not readily available in the market due to the aforementioned reasons. In view of this, there is need to develop mechanical sifters that would be affordable and meet the requirements of the rural processors.

CONCLUSIONS

Mechanical sieving of cassava mash is faster, more hygienic and reduces the drudgery associated with traditional sifting of cassava mash to a very great extent. It definitely has several advantages over the traditional sieving and several mechanical sifters are already developed within Nigeria but the traditional sieving is still widely used in many rural communities in Nigeria and many countries in West Africa, where gari is largely processed and consumed as staple food. It is now very essential to harness the merits of the already developed sifters and develop a more efficient commercial prototype that is upgraded for manufacturing and utilization by our local processors, who are the end beneficiaries at affordable price.

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