Trends at Mechanizing Cassava Postharvest Processing Operations

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ABSTRACT

The recent transfiguration of cassava from a low profile into an industrial raw material, coupled with the new cassava revolutionary policies of the Federal Government of Nigeria have resulted in a serious surge in the demand for cassava and cassava-based products locally and the world over. 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 in the processing operations. This has made the review of the current processing technologies imperative in order to address the areas requiring technical improvement and further research efforts towards the evolution of cost effective technologies with improved efficiencies which would enhance the capacity to exploit the cassava market potential the world over. Therefore, this paper reviews the presents status of knowledge as regards cassava processing technology and a critical appraisal of the existing cassava processing technologies available to cassava processors and highlights the research need towards the evolution of better and improved cassava processing equipment.

Keywords: Cassava, processing, engineering properties, tuber age, postharvest

1. INTRODUCTION

Cassava, (Manihot esculenta, crantz) is a tuberous starchy root crop of the family Euphorbiaceae (Kochlar, 1981). It is a popular crop worldwide. It is known for drought tolerance and for thriving well on marginal soils, a cheap source of calories intake in human diet and a source of carbohydrate in animal feed (Kordylas, 2002). It is believed to be originally native of South America. It grows well in areas with annual rainfall of 500-5000mm and full sun, but it is susceptible to cold weather and frost (Agodzo and Owusu, 2002). Thus, it is commonly grown in all the tropical countries of the world, mostly in Brazil, Indonesia, Nigeria, Zaire, Congo, Uganda, Ghana, and the Democratic Republic of Congo etc. A very wide range of cassava varieties are grown worldwide depending on the locality, but they are broadly classified into the sweet and the bitter varieties based on the level of the poisonous hydrogen cyanide (HCN) present in the tuber. They are also classified based on time to maturity. Most of the traditional varieties mature in eighteen months and beyond but, some new improved cassava varieties have been developed by the International Institute for Tropical Agriculture which matures as early as six months after planting. They are high yielding, more resistant to pest and diseases, with cyanide contents as low as 3.1mg/100g, (Ikuomenisan, 2001).

Nigeria is by far the highest producer of the crop in the world with production level estimated at 49 million tons per year (Uthman, 2011). This is a third more than the production in Brazil (The world’s second largest cassava producer). And almost double the production of Indonesia and Thailand.

Until recently, cassava was primarily produced for food as it is consumed on daily basis in different forms and often times more than once a day. Its importance as a major cheap source of calorie intake for both human and livestock in many tropical countries has been widely acknowledged. It is mostly processed, traditionally, into gari, lafun, fufu, abacha and akpu in Nigeria, and, kokonte and agbelima in Ghana (Quaye et al., 2009) while the sweet varieties are boiled and pounded into dough and consumed with vegetable soup.

It is presently the most important food crop in Nigeria from the point of view of both the area under cultivation and the tonnage produced due to the fact that it 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 (Adetunji and Quadri, 2011). The world import demand for cassava in 2004 stood at 25 million tons while the local demand by poultry farmers alone was 400,000 tons. The 180 million litres yearly domestic demand for ethanol in Nigeria was met through importation in 2005 (Nigeriafirst, 2011). The Federal Government recent directive that flour millers must substitute 10% of the wheat flour with cassava flour (Olukunle, 2005), has also led to a surge in demand to the tune of 600,000 tons of processed cassava per day, apart from orders from abroad for semi-finished cassava products in the form of chips and pellets. All these facts are pointers to the fact that opportunities abound in the area of cassava processing, but, these opportunities cannot be fully exploited using the traditional processing methods currently in use in the country which is generally adjudged as arduous in nature, labour intensive, time consuming and unsuitable for large scale production (Adetan et al., 2003; Quaye et al., 2009; Agbetoye, 2005). The present situation in the country whereby limited quantities of cassava-based product 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 existing technologies for processing cassava into its various semi and finished products is pertinent. Therefore the objective of this paper is to review the efforts made, and currently being made towards an efficient and cost effective mechanization of cassava postharvest processing operations so as to address the challenges being faced in the quest to fully exploit the numerous benefits of cassava crop.

2. THE PROBLEM STATEMENT

Freshly harvested cassava roots starts deteriorating almost immediately after harvest and can only last for three days. This is due to its high moisture content of about seventy percent (Ngoddy, 1989). The best form of preservation and reduction of post harvest losses is therefore immediate processing into various shelf stable products such as gari, chips, pellets etc. Alternatively, farmers prefer to delay harvest of the tubers until it is actually needed, thereby leaving it in the ground for up to two years and beyond since it stores well in-ground and effort at developing modern storage technologies to store cassava tubers beyond few days is still on-going. Processing cassava into finished or semi-finished products often involves all or some of the following operations, depending on the desired end-products; peeling, washing, grating/chipping, dewatering/fermentation, pulverizing, sieving, pelletizing, and drying/frying. Up till now, most of these operations are still being done manually, and they are generally labour intensive, arduous in nature, time consuming and unsuitable for large scale production (Adetan et al., 2003; Quaye et al., 2009), due to their low output capacity among other negative attributes, although some levels of success have been recorded in the areas of grating and dewatering (Davies et al., 2008; Adetunji and Quadri, 2011).

Mechanization of cassava processing operations will no doubt play a pivotal role in removing the negative attributes of the traditional processing techniques and promote timely large scale processing of the tubers in hygienic environment. Mechanizing cassava processing operations requires the design and development of equipment such as cassava peelers, graters, chippers, dewatering machines, pelletizers, dryer etc. Several attempts have been made at solving these problems which resulted in the development of various types of cassava peeling machines (Odigboh, 1976; Ezekwesili, 1976, 1979; Nwokedi, 1984; Ejovo et al., 1988; Ito, 1999; Sheriff et al., 1995; Ariavie and Ejovo, 2002; Olukunle et al., 2005; and Olukunle and Ademosun 2006); various types of cassava grating machines (Akinjumobi and Akinlua, 1999; Akande et al., 2005); various types of cassava chipping machines (Raji and Igbeke, 1994; Bamgboye and Adebayo, 2009) etc. However, most of these machines have been widely acknowledged as being inefficient (Adetan et al., 2006; Davies et al., 2008; Kolawole et al., 2010). A major constraint is the poor quality of the products from these machines and poor efficiencies of the technologies. Some of the problems with these machines include peeling off of unacceptable percentage of useful flesh during mechanical peeling, reduction in peeling efficiency with increased time of operation, production of grated cassava mash or cassava chips with uneven (particle) sizes resulting in varying and low product qualities between processors and even from the same processor. The dewatering mechanism (hydraulic jack) only increases the processing (dewatering) capacity per batch but still takes the usual longer time to dewater to acceptable moisture content thereby allowing fermentation. Imported dryers as an alternative to sun-drying is too costly while locally fabricated flash dryers are yet to be efficient (IITA, 2006).

3. PRESENT STATUS OF CASSAVA POSTHARVEST TECHNOLOGIES

Cassava processing operations are often preceded by peeling which makes a very important operation. However, no efficient cassava peeler is presently in the market (Ejovo et al., 1988; Adetan et al., 2003; Agbetoye, 2005). Attempts at mechanizing the peeling operation was acknowledged not to be fully developed yet (Kolawole et al., 2010) and this is attributed to the irregularity in the shape of the tubers as well as the wide variations in the thickness of the peel, tuber size and weight across the different varieties of the crop (Adetan et al., 2006; Kamal and Oyelade, 2010). Odigboh (1976) also listed the period of the year that the tuber is harvested and the time that lapsed before peeling is carried out after harvesting as some of the factors causing wide variations in the peel characteristics of the tubers.

Most of the research efforts at developing a suitable peeler have concentrated on the use of abrasive drum to achieve the peeling (Ezekwe, 1979; ; Nwokedi, 1984; Odigboh, 1988). However, a common problem with these set of machines is the fact that a tuber may be reduced to a uniform cylinder with considerable wastage of useful flesh before satisfactory peeling could be achieved. Nwokedi (1984) even reported a peeling efficiency as low as 45% but was able to achieve a better performance with sized root lots.

Ejovo et al., (1988) developed a rotary batched cassava peeler that worked based on a novel peeling concept involving compression of the unpeeled tuber against a sharp-edged rig and rolling off the peels without disturbing the tuber flesh (peel-flesh separation through compression). Although, a peeling efficiency of 92% was reported with zero flesh loss, the tubers had to be sliced into straight segments before being fed into the machine. They, however, pointed out that the stage of maturity of the roots greatly affected the performance of the machine. Adetan et al. (2005) also designed and fabricated an experimental mechanical cassava peeler using this concept following the characterization of some properties of the root which they earlier reported (Adetan et al., 2003). In 2006, the authors developed and validated a model with data from the peeling machine. The model was able to predict the peel removal efficiency of the machine with a certainty level of 95.46%.

Odigboh (1976) had however earlier attempted the development of a continuous flow peeler consisting of a solid cylinder mounted parallel to another ‘cylinder’ of knives which peeled the tubers as they traverse the length of the cylinders in-between a 20mm space. The results showed that much of the useful flesh of the large roots
was designed such that the tubers were soaked in water prior to the peeling operation. During the peeling operation the tubers were held in-between two rotating drums with abrasive surfaces. Peeling was achieved when the two drums were rotated in opposite directions. They reported a peeling efficiency of 83.0% and an average percentage flesh loss of 5.4% but the peeling efficiency of the machine reduced with increase in the speed of rotation of the drums while the percentage flesh loss increased with the speed of drums as well as peeling time, hence, the machine had to be operated at a slow speed which consequently affected its throughput capacity adversely (as low as 35kg/hr). The poor performance of the machine may due to the force required to bring about peeling which was not actually used in the design calculation instead the report appear to have based the calculation on the torque needed to peel cassava and an arbitrary values seemed to have been used.

A collaborative work between IITA and FUTA in 2005 was reported by Agbetoye (2005) to have resulted in the development of a single and double gang hand-fed peeling machine which peels by using a rotary brush. It gave an efficiency that was less than 80% and useful flesh waste of more than 8% with unsatisfactory output capacity which the authors describe as unacceptable. The machines’ output per day was reported to be dependent, among other things, on the variety and stage of maturity (age) of the tubers (Olukunle et al., 2010). This also underscores the need for an in-depth study of the properties of the tubers with emphasis on the influence of age and variety. A self-fed version of the machine reported by Olukunle et al. (2010) also required that the tubers were trimmed into slices longer than 10cm otherwise they were poorly handled. A peel retention as high as 16% was also reported for the self-fed peeler which makes it unsuitable for end products like gari and high quality cassava flour.

Apart from the peelers, various types of cassava grating machines have been developed (Akinyemi and Akinlua, 1999; Akande et al., 2005), likewise cassava chippers (Kodylas, 1990; Ajibola et al. 1991; Balasubramanian et al., 1993; Kurup et al., 1995; Bamgboye and Adebayo, 2009; Igbudu, 2009). While a modest success have been recorded in the development of cassava graters and chippers, including (pressers) other postharvest operations such as washing, slicing, drying and frying are still predominantly undertaken manually (Davies et al., 2008). One of the shortcomings of the existing graters is that the grating mechanism gets blunt easily and does not give smooth products (Quaye et al., 2009). The modest success may not be unconnected with the fact that almost all the publications on the design and fabrication of cassava processing equipment rely solely on previously published data on the engineering properties of the root which may have been haphazardly determined while trying to develop the machine since data from in-depth studies are scarce. For instance, Bamgboye and Adebayo (2009), while designing their cassava chipper used a value of 0.68 for the coefficient of friction of cassava on mild steel as previously used by Ashaolu (1989) in the design of a cassava chiping machine. This value is almost double the 0.363 value reported by Ejovo et al. (1988) for cassava flesh on mild steel. They also used a shear strength value from the work of Igbeka (1985) which has been found to be in wide variation from all other values published on the same subject matter. The influence of tuber moisture content was also not considered during the design and performance evaluation. This probably accounted for the 60% efficiency of the machine so designed using these data. Worst still, Akande et al. (2008) did not even use any mechanical property data in the design of their manually operated cassava chipping machine. They only design for the size of the shaft carrying the chiping plate. Even, most of the existing machines were merely fabricated without adequate engineering research (Kolawole et al., 2010). This manifest in the frequent need to replace the bearings, belts and grating mesh, which is compounded by serious vibration, as revealed by Davies et al. (2008) while presenting the results of a survey on the availability and level of adoption of cassava processing machines in Osun State. Another major problem is the different particle sizes obtained from the various types of graters (Igbeka et al., 1992; Onyekwere et al., 2006), and constant breakage and damage of the roots during these operations which sometimes exceed 10% (Odigboh and Ahmed 1982; Ajibola et al., 1991). Fish and Trim (1993) have also identified wide variation of cassava chips’ size, perhaps from various cassava chipping machines, as a major problem encountered with cassava chips’ production and drying.

Other unit operations involved in cassava processing include dewatering of cassava pulp (mash), drying (of chips, lafun, mash for flour production, etc) and frying (for gari production) which are still majorly carried out manually with the attendant negative attributes (Ajibola, 1987; Igbeka, et al.1992; Nweke 1994; Kolawole et al. 2007a). Traditionally, grated cassava mash is dewatered by filling it into sacks and placing it under heavy materials like big stone, iron etc. This operation has, however, been improved upon by the hydraulic and the screw jack mechanism whereby piles of bagged cassava mash are slowly compressed with the jacks. The failure of the machine by frequent worn out of the screw (Davies et al., 2008; Quaye et al., 2009) or the deformation or complete breakage of the cross bar as a result of the high pressure experienced daily by the hydraulic press is an indication that necessary engineering properties of the crop, such as cassava cake resistance in the form of reaction to the action of the jack, was not factored into the design. This problem may not be unconnected with the fact that most of these machines were developed using engineering property data that were reported by others which may either be unsuitable or haphazardly determined and insufficient to form a reliable data-base for the scientific design and development of these machines (Adeyan et al., 2003). Research publications are scanty on the study of relevant engineering parameters for the dewatering of cassava pulp.

Ajibola (1987) studied the important parameters in the dewatering of grated cassava mash by applying heavy weights on the grated
Adzimah and Gbadam (2009) also modified existing grater and press into a single automated unit using two side crank mechanisms in combination with chain drives, gears and springs. The tubers were pressed against a rotating perforated plate by the side crank mechanism and caused the tubers to grate. The centrifugal force developed by the grating plate throws the grated mash into the pressing unit where it was pressed against a spring-loaded gate. When a set pressure level is attained in the pressing chamber the side crank mechanism in the forces the spring-loaded gate open to push out the pressed cake. The machine seems good but complex for the a typical local setting for prompt repair and maintenance in times of breakdown and this could adversely affect its adoption by the rural processors who are, according to Quaye et al. (2009) very sensitive to issues relating to repair and maintenance when taking decisions on the adoption of any new technologies.

Some moisture-dependent engineering properties of cassava mash during drying for lafun production were also studied by Faborode et al. (1992) and he reported a general non-linear decrease in bulk density, coefficient of friction and emptying angle of repose as drying progressed. Also, Igbeaka (1980) studied the relationship between moisture content, temperature and diffusion coefficient of cassava during drying and he concluded that moisture diffusion followed an Arrhenius relationship with respect to temperature. He further developed an equation relating the diffusion coefficient to the moisture content and temperature of the chips and to the relative humidity of the drying air coupled with a model to describe the moisture gradient within the thickness of a cassava slab drying from only one surface, using a finite difference approach. It was however noted that most of the above results reported by Igbeaka were experimented with the sweet variety of cassava, which may or may not be applicable to the bitter or the improved varieties since wide variation in features (or behaviour) have been widely reported across varieties divides.

Okpala et al. (2003) also studied the drying characteristics of cassava slices and concluded that the drying characteristics of cassava generally had no constant rate period, but two falling rate periods, the second being slower that the first and that drying is controlled by liquid diffusion. In a survey conducted by Davies et al. (2008) to assess the level of acceptability of cassava processing technologies in Iwo Local Government of Osun State, Nigeria, in terms of availability of the machines, cost of acquisition and cost of maintenance revealed that operations such as peeling, washing, chipping, slicing, drying and frying were still being done predominantly by manual methods. High cost of acquisition and cost of maintenance were cited as some of the reasons for the low level of adoption of the technologies. Rusting, tearing and wearing of the grating mesh as well as serious vibration and frequent need to change the bearings were also cited as common problems of the garters even though the spare parts were readily available with most of them adulterated. Thread of the screw type cassava dewatering presses easily got worn-out while the hydraulic jack type often spills it oil through the plunger casing. The few sifting machine found during the survey had low efficiencies as the sieves got clogged and rusty easily thereby requiring frequent replacement.

A similar survey conducted by Quaye et al. (2009) in Ghana reported similar problems with the machines. The survey which set out to determine the adoption requirements for some cassava processing technologies vis a viz cassava graters, pressers, improved stoves for gari and High Quality cassava flour (HQCF) production, revealed the factors that end-users consider before...
adopting new technologies as affordability of the technologies in term 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 a new cassava processing technology 
which most of the existing machines currently lack.

4. RESEARCH NEEDS

4.1 Engineering Properties of Cassava Roots

The need to design and develop efficient and cost effective 
machines and equipment for cassava postharvest processing and 
handling operations cannot be over emphasized, given the present 
global status of the crop as a foreign exchange earner, crop for 
food security and an important industrial raw material. However, 
the design and development of equipment and processes for these 
purposes solely depends on thorough understanding of the 
engineering properties of the root, but cassava-based researches 
have focused more on its production than processing (Kolawole et al., 2010). This, perhaps, accounts for the reason why advances in 
cassava processing technologies lag behind its production. A good 
knowledge of the engineering properties of the root is, however, 
germane to a successful mechanization of its postharvest handling 
and processing operations (Adetan et al., 2003). This is pertinent 
as earlier reports by Odigboh (1976) revealed that over 200 
different varieties of the crop are planted in all the cassava 
planting areas of the world, each with its unique features. More 
clones of cassava have recently been added by the IITA, Ibadan 
and the NRCRI, Umudike, which are high yielding, resistant to 
diseases and pests, and early maturing, among other positive traits. 
These desirable traits are being exploited by the farmers which 
probably accounted for the present position of Nigeria as the 
world leading cassava producing nation (Kolawole et al., 2010). 
This, consequently, demands an expansion of the frontier of 
knowledge on the engineering properties of the tubers since no 
two varieties exhibit similar properties (Odigboh, 1976), hence a 
follow up study of the engineering properties of these new 
varieties is imperative for a successful effort at mechanizing 
cassava postharvest operations.

Several researchers have made attempts on the engineering 
properties of cassava while trying to develop cassava handling and 
processing equipment. Odigboh (1976) determined some physical 
properties of some cassava varieties whose particular identities 
were not declared while trying to develop a continuous flow 
cassava peeler. Properties such as the roundness, shape and tuber 
weight were determined. He reported that many varieties (over 
200) are grown in the tropics with each of them yielding roots 
with wide variations in their physical properties including the 
shape, with cross sections having a mean roundness ranging from 
0.65-1.00. The tuber weight reported ranged from 25g to 4,000g 
with conical shaped tubers predominating. All these properties 
were reportedly dependent on the age of the tubers at the time of 
harvest as well as the time of the year when the roots were 
harvested. This was only an observation because the experiment 
was actually carried without conscious effort at studying the 
effects of age on these properties.

In 1981, Asoegwu determined the stress relaxation modulus and 
creep compliance of cassava tubers he thought necessary in the 
design of cassava harvesting technologies, and these parameters 
may not be completely relevant in the design of processing 
equipment. Ejovo et al. (1988) also determined some physical and 
mechanical properties of cassava such as the tuber length, weight 
diameter, peel thickness, Poisson ratio and, coefficients of friction 
and rolling resistance. Others were shear stress, peeling stress, 
cutting force and rupture stress. They reported that the coefficient 
of friction of cassava on wood ranged from 0.404-0.663, the 
values of this property on mild steel ranged from 0.364-0.577 
while the values ranged from 0.213-0.404 on aluminum surface. 
They also reported some values of coefficient rolling resistance of 
cassava root on wood, mild steel and aluminum surfaces as 5.57-
8.73; 5.27-9.38 and 4.71-7.80 respectively. However, like the 
elier researchers, limited number of specimens was used to study 
most of these parameters. For instance, these authors used only 
three specimens each to determine the five mechanical properties 
studied. Also, the study did not take into account the influence of 
moisture contents, tuber age and cassava specie, but they later 
concluded that their results might have been influenced by the 
stage of maturity of the tubers used in testing the machine 
produced with the data so generated. In addition to age (as pointed 
out by the authors) the influence of moisture content may be very 
significant. The authors, while comparing results, reported that 
their values of shear stress (3.22N/mm² and 0.28 N/mm² for 
unpeeled and peeled tubers respectively) were closer to the 0.676 -
9.6N/mm² reported by Asoegwu (1981) but in wide variation to the 
21.8 – 87N/mm² reported by Igbeka (1984) which they claimed 
were yet to be corroborated by any research results. It is however, 
noteworthy that the frictional properties reported by Ejovo et al., 
(1988), though limited as they were in terms of number of samples 
used and scope, they are yet to be refuted or corroborated by any 
other research publications.

Adetan et al. (2003) also published an extensive work on the 
physical properties of cassava where they reported that the 
percentage by weight of peel ranged from 10.6-21.5%, peel 
thickness ranged from 1.20-4.15mm, root diameter ranged from 
18.8-88.5mm while the peel penetration force per unit length 
ranged from 0.54- 2.30N/mm. The values of the peel proportion 
by weight were reported to be in reasonable agreement with, but 
slightly higher than the range of 0.085-0.17 reported by Ezekwe 
(1979). However, an improvised tool (tool penetrometer) which 
was manually loaded was used to measure the peel penetration 
force of the tubers. This casts aspersion on the reliability of the 
reported values. Better and more reliable results could be obtained 
with more sensitive equipment.

Furthermore, Kolawole et al. (2007b) studied some strength 
and elastic properties of cassava root using TMS 4(2) 1425 cassava 
cloned and reported that the tubers were stronger under tension than 
compression at higher moisture contents than at lower ones. The 
values ranged from 0.235 to 0.116N/mm² and 0.065 to 
0.095N/mm² for tensile stress and strain respectively in the 
moisture content range of 50-70% (wb) while values ranging from
0.080 to 0.0472N/mm² and 0.032 to 0.0932N/mm² were reported for compressive stress and strain respectively. Values ranging from 0.187 to 0.112 and 0.140N/mm² to 0.048N/mm² were also reported for shear stress and strain respectively. They observed a positive relationship between the strength properties (tensile and compressive) of cassava and its moisture contents, whereas, Nwagugu and Okonkwo (2009), after determining the compressive strength of a sweet type of cassava reported a negative relationship between compressive strength and moisture content. Maximum compressive force values of 499N and 274N were reported for compression along and across the cassava fibre directions respectively. In both separate studies, only one cassava variety was used and they were not the same.

Njie et al. (1998) studied the thermal properties of cassava, yam, and plantain as a function of moisture content at temperatures near 30°C and moisture contents between 18 and 70% wet basis. They reported thermal conductivity values ranging from 0.16 to 0.57 Wm⁻¹°C and a positive relationship between thermal conductivity and moisture content of samples of cassava. A similar trend was observed for specific heat capacity and moisture content with values ranging between 1.636 and 3.275kJ Kg⁻¹°C⁻¹. The specific heat also increased with increase in temperature. The thermal diffusivity of cassava, however, initially increased but later decreased with decrease in moisture content. The average values ranged from 0.79 to 1.66 x 10⁻³m²s⁻¹.

In all the reported works on the engineering properties of cassava to date it is observed that in most cases, the studies were not conducted with respect to the influence of moisture and age on the studied properties while in some, only one cassava specie was used. More importantly, most of the reported data were unsuitable and insufficient to form a data base for the engineering properties of cassava as exemplified in the work of Igbudu (2009) where only one sample was used to determine the force required to make chips from cassava tubers. This may evidently be part of the reasons for the modest breakthroughs recorded so far in the development of appropriate technologies for the postharvest handling, processing, and transporting of cassava.

4.2. Effects of Age on Engineering Properties of Cassava Tubers

Cassava roots are considered ripe as from the age of 12 months after planting, but are often left in the ground beyond a year (Odigboh, 1976; Ngendahayo and Dixon, 1998; Sriroth et al., 1999). At times they are left in the ground up to two years because it can continue to grow for years due to its perennial nature. The main reason for this practice is the problem of poor storability of cassava roots after harvesting, (Ngwe, 1995) whereas, its quality is sustained when left in-ground up to 24 months and beyond. Even though this common practice among cassava farmers has some advantages such as easy and flexible harvesting time, year round availability of the crop etc., one of its greatest shortcomings is that the roots become more fibrous and woody with time. Besides, many previous studies have reported the influence of age on tuber yield, dry matter and starch accumulation, culinary quality of cooked roots, as well as the quality and physico-chemical properties of the starch and flour produced from them (Moorthy and Ramanujam 1986; Nwawuhunga et al., 1995; Ngwe, 1995; Ngendahayo and Dixon 1998; Defloor et al., 1998; Sriroth et al., 1999; Chatakanonda et al., 2003; Chotineeranat et al., 2006; Apea-Bah et al., 2011).

In a study conducted by Obiweskan and Agboola (1973) it was reported that root size continued to increase with age even when left in the soil beyond 24 months. Kolawole et al., (2007a) actually studied the influence of tuber age on the dewatering parameters of grated cassava mash and concluded that the 15 months old samples compressed more than the 12 and 9 months old samples. However, other researchers (Odigboh, 1976; Ejovjo et al., 1988; Adetan et al., 2005) only observed that the tuber age might have influenced their results but they never made conscious efforts at studying the effects that the age could actually have on the engineering properties of the tubers.

Also, in their study, Sriroth et al., 1999 reported that the age of root considerably influenced the starch granule size, granule structure, granule size distribution and hydration properties. The granule size distribution changed from normal to bimodal distribution with increase in tuber age, implying that the structural and functional properties of cassava tubers could be influenced by the age of the root.

Apea-Bar et al., (2011) also reported a significant influence of tuber age on cassava flour yield, crude protein and ash content of the resulting flour reducing with time while Chotineeranat et al., (2006) reported that roots with different ages exhibited different levels of chemical compositions and cyanide content and thus resulted in the production of flour exhibiting different levels of cyanide contents depending on the age of the tuber used.

Ngwe (1995) while presenting the results of the investigation into the cooking properties/quality of some cassava clones in Cameroon reported that all the clones investigated would cook well harvested at the age of 8 months after planting beyond which some of them, classified as ‘non-cookable’, would not cook while the cooking time of the ‘cookable’ clones increased with increase in age of the roots. This corroborated the findings of Moorthy and Ramanujam, (1986) who had earlier reported a similar observation.

5. CONCLUSION

From the foregoing, a serious death of research publications on the influence of age on the engineering properties of cassava tuber is apparent even though a lot has been reported on the effects of age on many of the properties of the starch and other by-products produced from its roots and in spite of the acknowledgement of some of the earlier researchers of a possible influence of tuber age on the engineering properties of the root. This implies that little is presently known about cassava in relation to the influence of tuber age on its engineering properties. Most of the earlier works on the engineering properties of cassava were either conducted using one cassava variety most of which were not of the same clone, or they were determined using crude methods or insufficient number of samples that cannot be said to be representative of the characteristics of the crop, hence the need for
an in-depth study of the influence of age and variety in addition to the engineering properties of the roots.

REFERENCES


