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Original Research Article

Characteristics and Waste Management Practices of Cassava-Based Processing Clusters in Ibadan Oyo State, Nigeria

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ABSTRACT

This study is aimed at investigating indigenous cassava processing systems and waste management practices in five selected Local Government Areas (Akinyele, Ido, Ona-Ara, Ibadan North and Egbeda) within Ibadan, Oyo State, Nigeria. The selection was based on dominance and spatial distribution of cassava processing clusters. Data on social parameters, processing operations, and wastewater information were obtained from 50 processing clusters scattered across the study areas. Collated results were presented using statistical package for social science (SPSS). The results showed that dominant products include: gari (30%), fufu (28%) and lafun (30%). Unit operations were manually done by middle-aged (40-49 years) women with low education level. About 68% of the processing units were owned by individual processors while 32% are jointly owned. Plastic drums were mostly used for soaking cassava mesh for 3-5 days. Freshwater is largely sourced from nearby deep wells and borehole with half of the processors generating wastewater in the range of 400 - 500 litres/day. Due to the lack of wastewater treatment facilities, the manually drained wastewater is left to flow freely or discharged on proximate land surface. The study, therefore, recommends the development of low-cost technologies for efficient production and proper wastewater management to minimize the negative impact of cassava processing clusters.
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1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is adjudged as the most important staple root crop in the world and ranked as one of the most important food crops grown in tropical countries (Droppelmann, *et al.,* 2018;

Olutosin, and Barbara, 2019). Nigeria occupies a significant global position in cassava production, with 57.13 million tons produced in 2016, followed by Thailand, which produced 31.16 million tons, and Brazil, which produced 21.08 million tons (FAO, 2018). Despite Nigeria's leading role in cassava cultivation, Thailand occupies the leading role in dried cassava exportation globally. Apart from playing an important role in food security, it is the cheapest source of industrial starch globally (Zainuddin *et al.,* 2018; Oyeyinka *et al.,* 2019). Cassava is known to be highly perishable which necessitates timely processing to avoid deterioration. Processing is also necessary to detoxify the roots from its high cyanide content [120-1945 mg HCN equivalent/kg] (Cock and E1-Sharkawy, 1988; Uchechukwu-agua *et al.,* 2015; Djabou *et al.,* 2017). Limited processing technologies and the subsistence level of cassava cultivation and processing in Nigeria largely account for this setback (Falade and Akingbala 2010; FAO, 2017). Corroborating this position, Idowu and Akindele (1994) reported that a substantial amount of the harvested tubers is processed for consumption rather than industrial use.

In Nigeria, cassava is fast becoming significant as alternative feedstock in many industrial applications (such as ethanol production, drug manufacturing, industrial baking flour, etc.) due to its low comparative cost and availability (Anyanwu *et al.,* 2015). Cassava processing techniques vary in different parts of the world and unit operations are mostly influenced by available technology and product utilization (Lawal *et al.,* 2019). In Nigeria, fresh cassava root is locally processed into various indigenous products such as *fufu*, *lafun*, *tapioca*, *gari* and cassava flour. Cassava processing has metamorphosed over time, evolving from completely manual and crude operations to partially mechanized systems with innovations largely influenced by social, economic and process needs (Adebayo *et al.,* 2002; Adebayo, 2009). The growing demand for local cassava products has resulted in the establishment of indigenous processing centres in urban and peri-urban areas resulting in the generation of huge solid and liquid waste that is poorly managed by processors (Ekop *et al.,* 2019). Major processing wastes generated during cassava processing includes cassava peels, fibrous by-products resulting from crushing and sieving, settling starch residues and wastewater effluents (Ubalua, 2007; Zhang et al., 2016). Despite contributing to processors' economic upliftment, the siting and operations of indigenous processing clusters are seldom regulated leading to varying degrees of environmental degradation (Lawal *et al.,* 2019). Several environmental problems have been linked with indiscriminate discharge of cassava processing effluent; prominent among these are eutrophication of slow-moving water bodies resulting in oxygen depletion and death of aquatic life, withering of plants and unpleasant odours due to poor waste disposal practices (Olorunfemi *et al.,* 2008; Lawal *et al.,* 2019). Furthermore, processors are predisposed to various health risks such as exposure to high levels of hydrogen cyanide (HCN), redness of the eyes and skin irritation (Howeler *et al.,* 2000; Arimoro *et al.,* 2008, Lawal *et al.,* 2019). These environmental and health risks are poised to increase with increasing interest in cassava processing activities.

This study is, therefore, part of an on-going research which seeks to develop a sustainable and holistic approach to solving the dominant challenges faced by indigenous cassava processors and their host communities. The study outcome will be used to develop an integrated optimized processing system that will improve processing mechanization and equipment utilization, reduce freshwater consumption, reduce processing time and ultimately minimize generated wastes. It is firstly aimed at accessing and characterizing cassava processing clusters and adopted waste management practices in selected local government areas within Ibadan, Oyo State, Nigeria.

2. MATERIALS AND METHODS

2.1. Study Area

This study was conducted in Ibadan, the capital city of Oyo State, Nigeria. The State is adjudged as one of the dominant producers of cassava tubers in Nigeria (HarvestPlus, 2015). There are eleven (11) Local

Government Areas (LGAs) in Ibadan metropolitan area. Five are in urban settlements while six are in semi-urban area of the city. The five (5) local government areas (Akinyele, Ido, Ona-Ara, Ibadan North and Egbeda) selected for this study was because of the dominant presence of cassava processing clusters.

2.2. Methods, Sample Sizes, and Sampling Technique

Ten (10) indigenous processing clusters were randomly selected from a pool of urban and semi-urban processing clusters purposely compiled for this study (Table 1). Agricultural extension elucidators were engaged to interact with the processors and administer equal number of questionnaires in the purposively determined LGAs as described by Hanafie *et al.* (2016). A total of 50 questionnaires were administered in the processing clusters. Focus group discussions were also held in all the selected locations to characterize the processing clusters. Information was obtained from key aspects namely background information, production/processing information, unit operations, processing technology and amount of waste generated.

Table 1: Characterization of the local government areas within the study area

S/No.	Local Government Area	Latitude	Longitude	Urban/Semi-Urban
1	Akinyele	7° 33' 41.47" N	3° 54' 21.92" E	Urban
2	Ido	7° 51' 9.25" N	3° 55' 52.50" E	Urban
3	Ona-Ara	7° 16' 59.99" N	4° 01' 59.99" E	Semi-Urban
4	Ibadan North	7° 24' 33.19" N	3° 53' 24.40" E	Urban
5	Egbeda	7° 22' 46.55" N	3° 58' 2.88" E	Semi-Urban

The unit operations (peeling, washing, soaking, water replacement, decanting of effluence/wastewater, pulverization/pulping/mashing, dewatering the mash, drying dewatered mash, cooking and packaging) involved in cassava processing were investigated to determine the processing techniques and level of mechanization. Figure 1 (A-F) shows the different activities investigated during cassava processing. The data obtained from the questionnaires were descriptively analyzed using the Statistical Package for Social Sciences (SPSS) version 10.0 (Hanafie *et al.,* 2016).

Figure 1: Raw cassava tubers (A); peeling of raw cassava tubers (B); processing containers (plastic drums) used for soaking and retting soft cassava tissue (C); unpaved drainage channel where cassava processing effluent is discharged and left to flow freely (D); manual grating of soft tubers (E); frying of *gari* by a young male (F)

3. RESULTS AND DISCUSSION

3.1. Cassava Processing as a Livelihood Activity

Cassava processing activity contributes immensely to household food security and incomes in all the selected study areas. It was observed that the importance of cassava processing activities to household incomes and the levels of commercialisation of the processing clusters were not different in all the study areas. This clearly shows the commercial intents of all the processing clusters visited. Contrary to this report, Adebayo *et al.* (2003), observed that commercialisation of *fufu* processing enterprises was quite different and higher when cassava is processed into *fufu* for commercial purpose rather than subsistence processors. It was further observed that cassava processing activities were mostly done in peri-urban and semi-urban areas with increasing popularity. Though individual ownership is dominant (68%), about 32% of the processors are micro-enterprises that can adequately employ more than 20 casual labour at a time, but they are relatively few (Figures 2A and B). The processing clusters can be characterized as small (employing 3-4 workers), medium (employing 5-6 workers) and large scale (employing above 20 workers) [Figure 2B]. The low literacy level of the processors may largely account for why processing activity constitutes a full-time job in the study area. About 60% possess senior secondary school certificate while about 32% primary school certificate holders (Figure 2C).

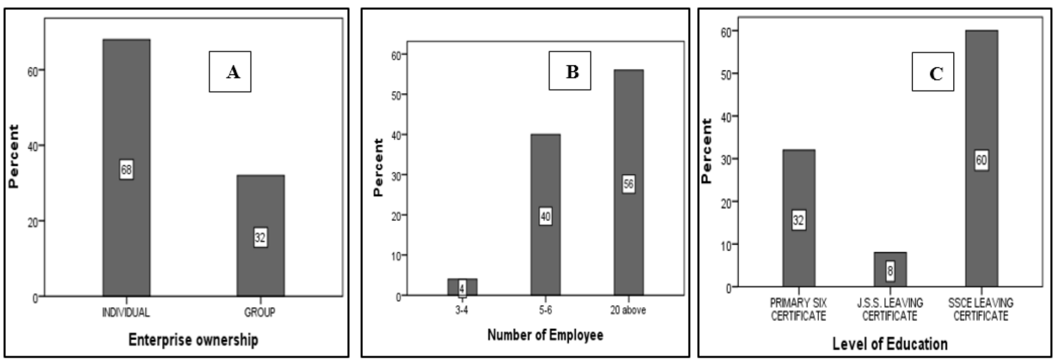

Figure 2: Ownership and employee of cassava-based processing clusters

3.2. Impact of Social Economic Background on Cassava Processing Activities

It was observed that 86.7% of the processors were female while 13.3% are male. As shown in Figure 3A, most clusters visited are predominantly operated by middle-aged native women between 40 to 49 years old. A slightly similar age group was also reported to be involved in *gari* frying in Ifo local government area of Ogun State by Adetifa and Samuel, (2012). This age bracket should be adequately considered to design an effective processing system to ease the processors' burden. Figure 3B shows that out of 50 processing centres visited, 30% produce gari, 28% produce fufu, 30% produce lafun and 12% produce other products like starch, tapioca, etc. in small quantities. Since these products are often by-products, their production is inevitable and are sometimes produced on demand. As shown in Figure 1E and 1F, younger and more active women and young boys specialize in cassava grating and frying while the much older women help in peeling the tubers. This finding was also reported by Adebayo *et al.* (2003) and negates a previous study that adjudged cassava processing as an exclusive female enterprise where men's involvement is only limited to milling and equipment hiring (Afolami and Ajani, 1995). A similar study partly conducted at Ode Remo in Ogun State, Nigeria reported several examples of men involved in running their own large-scale processing sites (Adebayo *et al.,* 2003). This growing involvement of men greatly reflect the potential of cassava processing as a profitable commercial enterprise, however, their absence in some unit operations (e.g. peeling and washing) may negatively influence the possibility of investing in more capital-intensive unit operations and techniques (Adebayo *et al.,* 2003). The low literacy level and huge individual ownership status of most processing outfit may be responsible for the low mechanization level resulting in inefficient processing and poor waste management practices observed in all the processing clusters visited. However, these findings show that improved and efficient production options that can scale-up production output will be most welcomed by cassava processing communities.

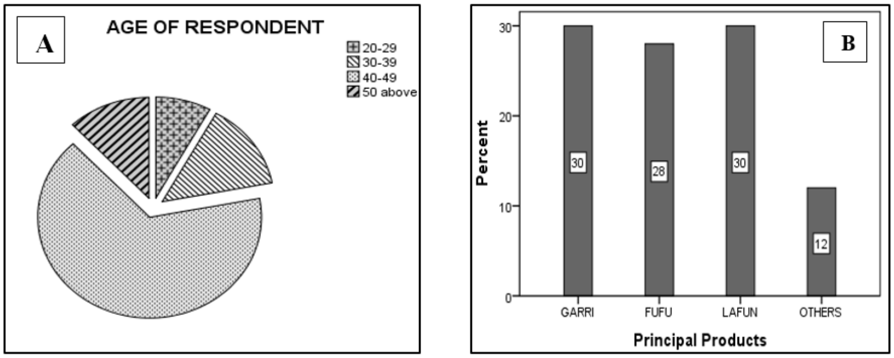

Figure 3: Age of respondents and principal products

3.3. Cassava Processing Unit Operations

Contrary to the report by Adebayo *et al.* (2003) and Owolarafe *et al.* (2018) who reported varied processing operations in wet *fufu* production across their study locations; the unit operations were observed to be similar in all the processing clusters across the five selected LGAs. This similarity largely accounts for the uniformity observed in the processing techniques and equipment. Table 2 shows the level of mechanization adopted by local processors for the various unit operations.

Table 2: Characterization of cassava processing unit operations

S/No.	Unit operations	Level of mechanization
1	Peeling	Manual
2	Washing	Manual
3	Soaking/Fermentation	Manual
4	Decanting/Water replacement	Manual
5	Meshing/Milling	Semi-mechanized
6	Dewatering	Semi-manual
7	Drying/Cooling/Frying	Manual
8	Sieving	Manual

Most processing clusters visited are mostly operated by women who operate at a micro-scale household level basically operated with the aim of improving household incomes (Figure 2A-C). The unit operations are listed in Table 2. Almost all the unit operations are executed as domestic chores, where equipment are available, they are mostly simple and locally developed by local fabricators. Examples of commonly used equipment include screw press, cassava graters, steel frying pots and frying stands constructed from mud and concrete. A similar trend in equipment utilization was also reported by Adebayo, (2009). This suggests that despite huge efforts by the various agencies of government and researchers, much has not been achieved in fully mechanizing cassava processing operations. Previous researchers have linked this low adaptation with social, economic and innovation related factors (Collinson, 2001; Adebayo *et al.,* 2002).

3.4. Fresh Water Utilization and Waste Generation

Boreholes (60%) and deep wells (40%) are the major sources of water used by processors. These sources are readily available within the processing clusters in all the clusters visited. This is comparable with a previous study conducted by Owolarafe *et al.* (2018) in two agricultural zones of Ogun State, Nigeria. The authors however, reported that processors are mostly located near major water sources which are at least 100 m from the processing centres. The urban and semi-urban locations of the processing clusters may be responsible for the siting and use of hygienic water sources observed in this study.

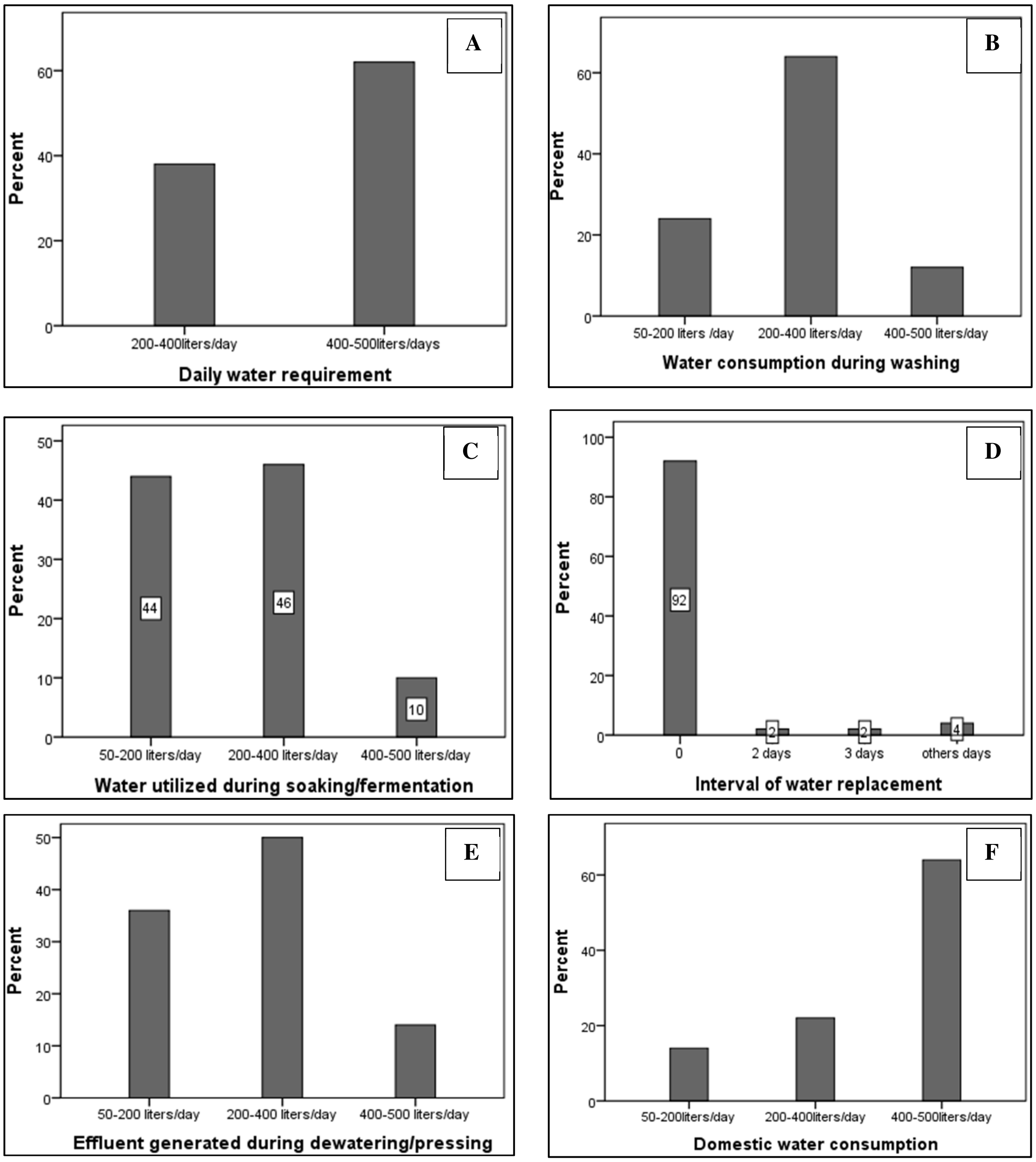

Figure 4: Freshwater consumption and effluent generation during cassava processing

Cassava processing waste can generally be categorized into solid and liquid waste. Cassava peel, chaff, wash water and processing wastewater are reported as the major waste generated during cassava processing in Ghana (Sackey and Bani, 2007). The major solid waste generated in the processing clusters visited is cassava peels. The peels make up to 10% of the tissue wet weight and constitute an important potential resource for livestock farmers (Obadina *et al.,* 2006). It is usually sold as animal feed (Alinnor and Nwachukwu, 2012). Since the environmental impact of the solid waste is minimal compared to the huge impact of the liquid waste, this study is therefore focused on the effluent generated by the processing clusters. Cassava processing activities consume an enormous amount of freshwater generating a huge amount of toxic wastewater in the process.

Zhang et al. (2016) estimated that the processing of fresh cassava roots gives rise to between 8.85 and 10.62 metric tons of effluent and 1.12 metric tons of peels per ton of fresh cassava roots processed. In this study, daily water requirement by most (62%) processing clusters ranged between 200-400 litres/day while 36% require 400-500 litres/day (Figure 4A). Over 96% of the respondents confirmed the importance of immediate washing of the peeled tubers in large plastic drums before soaking to increase the market value of the final product. Contrary to this observation, Owolarafe *et al.* (2018) reported a relatively lower (53%) number of processors wash manually immediately after peeling the tubers. About 64% of the processors wash their tubers with 200-400 litres of water per day while 24% utilize 50-200 litres/day. Few (12%) processors use between 400-500 litres/day (Figure 4B). About 2% of the processors confirmed washing a few hours after peeling which compares well with the 1% reported by Owolarafe *et al.* (2018).

Freshwater consumption during soaking/fermentation ranged between 50-500 litres/day. About 46% of the processors use 200-400 litres/day while about 44% of the processors use between 50-200 litres/day. Furthermore, about 10% of the processors use 400-500 litres/day. (Figure 4C). These amounts are usually lower during the dry seasons as the water table is low and clean processing water is scarce. Generally, soaking/fermentation was observed to take between 3-5 days to aid the removal of cyanide as corroborated by Tivana, (2012). Most processors do not replace the water while very few (2-4%) replace the water during this period (Figure 4D). The water is usually changed once during soaking/fermentation to eliminate unpleasant smell and facilitate product quality. This is widely practiced in all the processing clusters across the study area. Soaking for longer periods has been reported to increase nutrient loss and growth of unwanted bacteria in the final product (Montagnac *et al.,* 2008). Effluent generation relatively commensurate with the amount of freshwater utilized during processing. Generally, the percentage and composition of the wastewater is a function of the final product (Coker et al., 2010). It was observed that 50% of the processing cluster visited generate effluent in the range of 200-400 litres/day while 36% generate between 50-200 litres/day (Figure 4E). Few (14%) large processing cluster generate 400-500 litres/day. Almost all the clusters discharge their raw effluent into available unpaved drainage and open field near processing clusters which results in obnoxious odour and environmental pollution (Lawal, et al., 2019). Quantity of water utilized for domestic activities ranged between 50-500 litres/day with about 22% of the cluster utilizing 200-400 litres/day while 14% utilize 50-200 litres/day and 64% of the respondents utilize 400-500 litres/day (Figure 4F).

4. CONCLUSION

The study presents the characteristics and waste management techniques of indigenous cassava-based processing clusters scattered cross five selected LGAs within Ibadan metropolitan. The processing clusters have been characterized based on the number of employees, processing capacity and waste output. Freshwater consumption and effluent generation ranged between 50-500 litres/day. The study observed that all the processing clusters visited lack waste treatment facilities. This accounts for why processors discharged their effluent directly on unlined floors, farm lands or unlined drainages. Despite having primitive knowledge of the hazards associated with cassava processing, paucity of funds and the fragmented nature of the processing clusters limits their capacity to afford appropriate waste management facilities. Furthermore,

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slack enforcement of relevant environmental laws is a major setback in promoting and implementing an optimized processing system. Resources can be combined to build well designed processing centres where generated wastes can be properly managed or converted to value added products (like animal feeds or used as feed-stock to generate energy for the centres) leveraging on the fact that processors operate in well-organized clusters.

5. ACKNOWLEDGMENT

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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