Cassava Processing Wastes: Options and Potentials for Resource Recovery in Nigeria

C.G. Achi, A.O. Coker, and M.K.C. Sridhar

Abstract Agro-food processing industries are major contributors of wastes in most developing countries. With Nigeria leading in cassava food production, little attention has been paid to provide a sustainable and profit-oriented solution to the problem of solid waste resulting from cassava processing industries.

Considering the global effort to promote sustainability in the areas of food production, processing and waste management and also the need for resource recovery and utilisation to enhance cassava food value chain, this study assessed the quality and amount of waste in selected cassava industries with regard to cassava production rates and current waste management practices (from six randomly selected cassava industries) in Ibadan Nigeria. The potentials and various options for cassava waste utilisation were explored.

Six cassava production sites were randomly selected for the purpose of this study. Information gathered through personal field observations and key informant interviews showed that between 1.5 and 3 tons of solid (peels and pulp) waste and between 3 and 6 m^3 of liquid wastes were generated daily during cassava processing from a daily supply of between 6 and 8 tons of cassava tubers. Between 25 and 37% of solid wastes usually result from production of cassava tubers with only 25% of the total available waste being utilised as livestock feed.

The recovery of this huge amount of waste resource in terms of animal feed, biomass for energy production and biosolids from spent slurry has the potential to increase the cassava food value chain significantly.

Keywords Cassava food value • Resource recovery • Waste management • Biosolids • Clean energy

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1 Introduction

In recent times, there has been a global movement towards adopting sustainable practices in the use of natural resources and management of waste materials in many commercial and industrial sectors. The eleventh goal of the Sustainable Development Goals (SDGs) "sustainable cities and communities" clearly emphasises the importance of this global movement. The sustainability of a practice depends on the amount of resource that can be recovered and reused from the raw waste materials and also the sustained availability of the waste material stream. These resources recovered from waste can be translated to a substantial amount of fiscal savings resulting from the conservation of fresh material resources and utilisation of recovered resources.

The need to adopt sustainable best practices has been extended to agro-food processing industries. Agro-food processing industries constitute a significant part of every nation's economy. A typical example of an agro-food processing industry is cassava processing industry.

Cassava, a starchy staple food crop, is regarded as a primary food crop in Africa; this is due to its resistance to drought and diseases and its capacity to provide a reliable and an inexpensive source of carbohydrate for human consumption. Cassava tuber is processed into myriads of food items which vary sometimes based on cultural and customary differences and preferences (FAO 2006). Most cassava processing activities in Nigeria are predominantly done by subsistence farmers (Sangodoyin and Amori 2013). During cassava production and processing, large amounts of wastes (solid and wastewater) are generated. Most of these waste materials are discharged indiscriminately around the processing environment, and this usually leads to environmental pollution and sometimes obstruction of waterways and drains.

The perennial problem of food processing waste such as cassava can never be overemphasised in sub-Saharan Africa, especially in Nigeria, where cassava productions rank highest globally. With the growing production of cassava in Nigeria came the emergence of waste materials waiting to be utilised. These waste materials are currently not being utilised optimally. About 25% of peels are recovered through sun-drying during dry season and less than 20% during wet season. This is due to constraints associated with drying and concerns about safety of use, particularly hydrocyanide- and mycotoxin-related food poisoning. Drying peels in the open—practically impossible during the rainy season—takes 2–3 days. Consequently, peels are left to rot in heaps or set on fire—polluting the nearby air, soil and groundwater and wasting a potential feed resource.

The dried peels are used as livestock feed, leaving a significant amount of unutilised solid residues to go to waste. All of the waste effluents are currently being discharged indiscriminately into nearby streams and rivers thereby polluting them.

The waste effluents from cassava industries have been reported by many researchers to be toxic, containing cyanide (Siller and Winter 1998; Kaewkannetra et al. 2009), low in pH and high in BOD and COD (Hien et al. 1999; Luo et al. 2010; Sun

Table 1 Physico-chemical composition of cassava bagasse/pulp (g/100 g dry weight)

Composition	Soccol (1994)	Cereda (1994)	Sterz (1997)	Vandenberghe et al. (1998)
Moisture	5.02	9.52	10.70	11.20
Protein	1.57	0.32	1.60	1.61
Lipids	1.06	0.83	0.53	0.54
Fibres	50.55	14.88	22.20	21.10
Ash	1.10	0.66	1.50	1.44
Carbohydrates	40.50	63.85	63.40	63.00

Source: Pandey et al. (2000)

et al. 2012; Intanoo et al. 2014) and hence if not properly treated would have a negative impact on the environment and water resources (Oparaku et al. 2013).

The solid component of cassava wastes (peels and bagasse), due to their physico-chemical composition (see Table 1), has potentials to be utilised as feedstock for livestock (Ubalua 2007), as compost material (Sangodoyin and Amori 2013) and substrate for methane (energy) recovery (Cuzin et al. 1992; Ubalua 2007; Adelekan and Bamgboye 2009; Eze 2010; Panichnumsin et al. 2010; Oparaku et al. 2013) and biosolids (Ghimire et al. 2015). Studies are still being conducted in major cassava-producing regions in Africa and Asia focusing on exploring the resource recovery potential of cassava processing wastes and other potentials for value addition.

Beyond the problem of pollution identified in Nigeria due to poor management of cassava processing residues is the need to provide an alternative energy source for the rural cassava processors who are usually exposed to smoke and soot from burning firewood. Most of these farmers, mostly women, have limited resources to embark on large-scale production using modern heating technologies.

Considering these challenges, and the need to add value to the cassava food processing chain through waste utilisation and resource recovery, this study assessed the rate of cassava production and amount of unutilised waste, current waste management practices and options available for resource recovery in the Nigerian context.

2 Methodology

2.1 Selection of Study Locations

Six cassava processing industries were randomly selected for the purpose of this study. All the industries are located within Ibadan, southwestern Nigeria. The cassava industries were visited with the aim of assessing the current practices in terms of cassava processing operations, products and wastes management measures in place. The cassava industries are located in the following areas of Ibadan: Moniya, Eleyele 1, Eleyele 2, Ojoo, Agbowo and Egbeda.

3 Study Design

In order to achieve the aim and objectives of this study, the following methods were adopted:

- Extensive literature review on the subject matter
- Field visits in Ibadan for collecting primary and secondary data from small- and medium-sized cassava industries
- Face-to-face meetings (in-depth interviews) with cassava farmers and processors and assessment of current practices
- Assessment of daily cassava delivery and production rates
- Characterisation of cassava processing wastes

Investigations on the current practices at the selected cassava industries were carried out using the methods of key informant interview and direct personal observation.

The following data were collected and used to make comparison as regards management and waste disposal practices.

1. Name/location of the cassava processing site
2. Operations and major cassava products
3. Number of the workers and scale of the processing system
4. Cassava processing rate
5. The volume of cassava wastewater effluent produced per unit Kg of cassava
6. The weight of solid waste produced per unit Kg of cassava
7. The amount and volume of solid and liquid waste produced, respectively, in a cassava processing site
8. Solid waste disposal method employed

Based on the observations made at the cassava industries, the food products predominantly processed from cassava processing at the selected site are garri (Yoruba and Igbo customary types), fufu and lafun.

4 Cassava Processing Steps

Various steps involved during the processing of cassava tubers into the desired food product are as represented below (Figs. 1, 2 and 3):

In order to quantify the amount of waste that can be generated from a unit weight of cassava tuber processed, a basket full of cassava tubers was weighted before and after peeling and the amount of waste (peels, bagasse and effluent) recorded. This was used to estimate the total amount of waste generated daily based on amount of cassava tubers supplied daily.

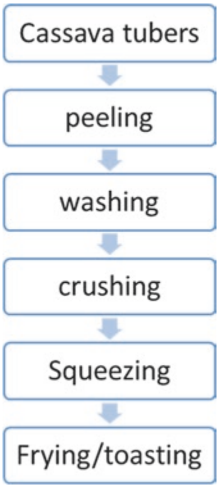


Fig. 1 Garri processing

Fig. 2 Fufu processing

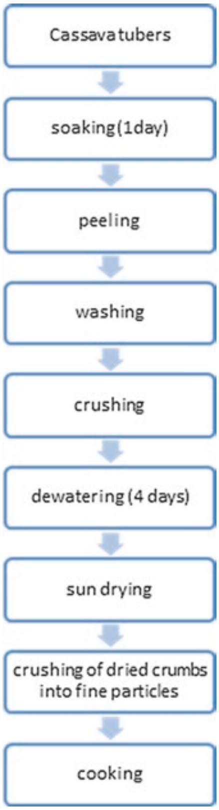
5 Results and Discussion

The information collected from each industry is summarised in Table 2:

These common features were recorded in all the sites visited.

1. All the sites were located close to a stream or flowing river which served as a final disposal point for the waste effluents (Plates 1, 2, 3 and 4).

Fig. 3 Lafun processing



2. No strict measures have been put in place for the management of solid and waste effluent and as such are disposed indiscriminately or dumped without check; the vast majority of cassava peels resulting from the processing of this root is either abandoned nearby the processing sites, used as landfill or burnt. Between 20 and 25% of cassava peels and fibrous waste (spent pulp) are sun-dried (after having being washed, to remove dirt, and drained) and fed to pigs and goats as can be seen in Plate 5.
3. The only energy source available for cassava processing is firewood for cooking and roasting cassava products (Plate 6)

With regard to the current energy option for cooking and frying cassava into finished products, it was observed that firewood is the only energy option available to the processors. Certain challenges have been reported and observed in the use of firewood. During frying operations, there is a challenge of maintaining a uniform heating using firewood. Smouldering of firewood exposes workers (mostly women) to toxic fumes besides exposure to cyanide during peeling and fermentation processes (Plate 7).

Table 2 Cassava processing and waste disposal practices in six different sites in Ibadan

Parameters/locations	Eleyele 1 (Temidire)	Eleyele 2 (Ologuneru road)	Ojoo Barracks	Moniya	Agbowo	Egbeda
Daily cassava root supply (tonnes)	6–8	1–2	4–5	3–5	4–5	7–9
No. of workers	200–250	20–30	70–80	40–50	80–100	500–550
Final product	Garri, fufu and starch	Garri and fufu	Garri and fufu	Garri, fufu, starch and lafun	Fufu only	Garri, fufu, lafun and starch
Solid waste (peels) disposal practice	10–25% of peels are used as livestock feed	Utilised as livestock feed	Utilised as livestock feed	Sun-dried and used as livestock feed	Utilised as livestock feed	10–25% of peels are used as livestock feed
Fibrous waste (bagasse) disposal practice	Disposed of in a nearby bush	Disposed in a nearby bush	10–25 used as pig feed, the rest disposed off	10–25 used as pig feed, the rest disposed off	10–25 used as pig feed, the rest dumped alongside other municipal wastes	Thrown away in the bushes
Cassava effluent disposal practice	Discharged in nearby drains leading to nearby water body	Discharged indiscriminately	Discharged into nearby water body	Discharged in nearby drains leading to nearby water body	Discharged into nearby water body	Discharges into nearby river
Distance to nearest water body (metres)	Approximately 200	100	150	200	50	100
Weight of peels produced daily (kg)	1464–2049	244–512	976–1281	732–1281	976–1281	1708–2305
Volume of effluent produced daily (litres)	>5712	>1428	>3570	>3570	>3570	>6426

Plate 1 Women peeling cassava in a typical cassava processing industry

Plate 2 Heap of unutilised cassava bagasse/pulp

Beyond the health of the processors, there is also the environmental impact with regard to the current practice of using firewood. There is a major concern with the pressure put on forest trees amidst the growing cassava production rates, due to sole dependence on forest woods and also the emission of greenhouse gases from rotting cassava wastes in waste dumps leading to ozone layer depletion. Hence the need to embrace a resource-oriented approach towards addressing these challenges.

Plate 3 Cassava peels dumped beside a cassava industry in Ibadan

Plate 4 Effluent produced from *fufu* making

6 Current Trends and Future Perspective in Cassava Waste Utilisation

In view of the enormous amount of waste generated daily from cassava processing centres in Nigeria (>1 tonne) which is currently not being utilised fully, except for the little amount being utilised as livestock feed, there is an obvious need to channel these waste materials into a more profitable use. Although the International Livestock Research Institute (ILRI) with its CGIAR research partners has initiated an innovative technique of processing cassava peels into high-quality cassava peel

Plate 5 Traditional method of drying cassava peels in the sun

Plate 6 Piles of firewood for cooking and frying cassava products

(HQCP) mash for use as livestock feed, the feed produced from HQCP has the potential to replace 10–20% of maize in poultry diet and 30–40% diet for cattle, sheep, goat and pigs. Based on their assessment, approximately 40 million ton of cassava waste is generated in Africa and if harnessed properly can provide up to 150 million jobs, provide about 13 million tonne of feed per annum and result to about 3,900 million USD per annum.

There is still the need to provide alternative uses for these waste materials in the rural community, so as to meet other local needs—energy and organic fertiliser.

Plate 7 Women frying of garri using firewood and mud stove

Research is currently ongoing in the areas of energy recovery from cassava waste products co-digested with livestock wastes and other domestic wastes. Through these research efforts, sufficient energy would be generated to meet the local energy demand in cassava processing industries.

Furthermore, through composting, waste products and biosolids resulting from cassava processing are converted to useful organic manure for improving soil fertility. Stabilised digestates from aerobic digestion of cassava waste materials are also being explored for use in organic farming and growing of mushrooms.

7 Conclusion

In Nigeria, the problem of poor infrastructural facilities, including lack of sustainable energy options, has been identified among many other challenges currently facing subsistent cassava farmers. In order to prevent environmental impacts arising from the huge waste streams generated during cassava processing, various agricultural wastes should be gathered and converted to useful products.

Based on the current assessment of cassava production rate and waste generation in Ibadan City, there is a significant potential for utilising cassava waste as a sustainable energy source for meeting energy demands in rural cassava processing industries. The daily supply of cassava waste (>1 tonne) is sufficient to maintain a steady supply of substrates for biogas production to meet up with basic energy demands.

According to study carried out by Cuzin et al. (1992), 5 tons of cassava roots produced 1 ton of cassava meal and 1.5 tons of cassava peel; 1.5 tons of cassava peel is needed to produce 121 m^3 CH_4, 1200 kWh or 121 m^3 CH_4 (calorific value of methane, 9.95 kWh/m^3 CH,) which are required for drying 1 ton of cassava meal. Furthermore, use of cassava wastes as substrate for producing biogas would decrease the potential damages to forests as it reduces the overall amount of firewood employed to produce heat (for cooking or other purposes).

Apart from the already stated energy need for heating, the bioenergy recovered could also be used to power generators, which will be used to light up the processing environment during dark working hours. It would also provide a more convenient means of supplying water through pumping to the cassava processors from wells. Most cassava processing industries usually suffer from scarcity of water and energy supplies. In essence, this will reduce the stress of the women involved in cassava processing, who would have to go through the drudgery of drawing water from alternative sources and deep wells.

A sustainable utilisation of cassava wastes for various purposes mentioned above would go a long way in making life a lot easier for the rural farmers and ultimately adding significant financial value to cassava production business.

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