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Short Communication

Energy Expended in Processing *Gari* (Cassava Flakes) *Manihot esculenta* Crantz, Using Three Levels of Mechanization

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Abstract. The effect of using mechanical equipment for the unit operations involved in *gari* (cassava flakes) processing on individual and total energy demands were studied. The data used to estimate energy demand were the quantity of cassava processed, time taken for each operation, number and gender of labour, method of processing, quantity, and source of energy. Of the seven unit operations for *gari* production, one, three and five operations were mechanized in low, medium and high-level, respectively. Garification (simultaneous cooking and dehydrating operation of *gari*) accounted for 97.38, 97.70 and 47.39% of total energy consumption in low, medium and high levels of mechanization, respectively. Total energy requirements for processing 100 kg of cassava root into *gari* were found to be 771.0 ± 83.71 MJ for low-level mechanized factory, 684.53 ± 26.98 MJ and 73.97 ± 1.84 MJ for medium and high-level mechanized factories, respectively. Energy demand by all unit operations significantly differed ($p<0.05$) between low and high levels of mechanization.

Keywords: cassava, *gari* processing, unit operation, mechanization, energy demand

It is imperative that energy development, management, improvement, utilization and conservation must have predetermined plans and strategies that are capable of driving the economy towards a sure path of sustainable development (Aderemi *et al*., 2009).

Knowledge of energy consumption for each product in a food-processing factory is useful for budgeting, evaluation of energy consumption for a given product, predicting energy requirement in a plant, and for planning plant expansion. Available literature on the estimation of energy input in food processing include sugar-beet production (Mrini *et al*., 2002); cashew nut processing operations (Jekayinfa and Bamgboye, 2006); palm-kernel oil processing operations (Jekayinfa and Bamgboye, 2007); bread making processes (Le-bail *et al*., 2010); sugar production factory (Abubakar *et al*., 2010) and cashew nut processing mills (Atul *et al*., 2010).

Cassava (*Manihot esculenta* Crantz) is a perennial vegetative propagated shrub commonly cultivated within the lowland tropics and *gari* (cassava flakes) is a staple food widely consumed in Nigeria and other West African countries (FIIRO, 2003). Different methods are used for processing cassava in several parts of the world and these methods have resulted in the production of a wide variety of food products (Oladunmoye *et al*., 2010) including *gari*, industrial starch and flour. Labour requirements for traditional processing of cassava into *gari*, *fufu*, *lafun* and other products are huge (Odebode, 2008).

This research examines the effect of using mechanical equipment for the unit operations involved in *gari* (cassava flakes) processing on individual and total energy demands.

Three categories of *gari* producing factories in Ogun State, Nigeria were selected based on the mechanical equipment used for cassava processing. Data for three categories was gathered by direct measurement during normal operation periods (8.00 am to 5.00 pm) of the randomly selected mills production. Four factories were examined for each level of mechanization. The random selection done from the pool of those were up to date in data taking and management practices and are less than 3 years old. Freshly harvested cassava roots (TMS 55752) were used for the production of *gari* and parameters (source of energy, quantity of cassava processed, quantity of fuel consumed, time and number of persons in each unit operation) for evaluating energy inputs were recorded.

At each stage of the unit operations of cassava processing, energy input is required in the form of either thermal energy or manual energy (Samuel *et al*., 2010). The type and magnitude of the energy input is a function of the technology employed and the quantity of cassava

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processed. For all operations, utilizing manual energy as source, energy input estimated based on 0.75 MJ/h for an adult male worker (Abubakar *et al*., 2010) and 0.68 MJ/h for an adult female worker was assumed. The energy input for the female worker is 10% less than that of her male counterpart. All other factors affecting manual energy were assumed to have no significant effect (Jekayinfa and Bamgboye, 2007). To determine the energy input of a worker, the time spent by the worker on each operation including intermittent resting periods were recorded. Equations 1 and 2 were used to estimate energy input using male and female labour, respectively. The procedure for each factory was repeated thrice; mean values were recorded as obtained data. Data collected were analyzed using SPSS software. Level of significance was 5%.

$$E = C_r W + 0.75T \quad (1)$$

$$E = C_r W + 0.68T \quad (2)$$

Where, E is the energy input (MJ), T is the useful time spent by a worker (h) and W is the quantity of fuel used (L).

Unit operations in *gari* processing were peeling, washing, grating, dewatering, sifting, garifying and sieving. Based on number of mechanical equipments used, *gari* factory mechanization was classified as low, medium, and high levels of mechanization. Of the seven unit operations for *gari* production, one, three and five operations were mechanized in low, medium and high-level, respectively (Table 1). Peeling and washing operations were manual for all levels of mechanization because inefficient mechanical means of peeling cassava probably influenced the choice of hand peeling using knife (FIIRO, 2003) and cheap and available labour encouraged the use of manual method for washing. Diesel powered cassava-grating machine was generally adopted for grating. The application of this machine was found to be cheap and effective (Odebode, 2008). In addition, the technology of its design, fabrication and maintenance is locally available. The major difference between medium and high levels of *gari* factory mechanization was the use of mechanical means for garification (simultaneous cooking and drying of *gari*) and sieving by high-level mechanization.

Using low, medium and high levels of mechanization, 100 kg of cassava produced 28, 27 and 27 kg of *gari* respectively; and the production outputs were in line with what was reported by Karim and Fasasi (2009). The quantity of *gari* obtained from the three categories of factories were not significantly different ($p< 0.05$). Furthermore, peeling and grating which had earlier been reported to affect cassava product yield (Davies *et al*., 2008) were carefully carried out in the factories examined. The factories also ensured the removal of moisture of cassava tubers; and regardless of the method and time, the moisture content of cassava was reduced from 58% to an acceptable level of 12% w.b (FIIRO, 2003).

The total energy requirement for processing 100 kg of cassava roots into *gari* were 771.00 MJ for low, 684.53 MJ, for medium and 73.97 MJ for high factories, respectively.

Low energy requirements (73.97 MJ) in the high level of mechanization processing may be attributed to the use of mechanical equipment that reduced the time involved and quantity of fuel used for garification (Table 2) unlike other methods where much time was expended and huge quantity of firewood was used. The time consumed and quantities of firewood were found to be the major variables that determined the energy used for *gari* production in this study. Garification accounted for 97.02, 97.40 and 70.98% of the total energy consumption in low, medium, and high levels of mechanization, respectively. The time and efficiency of garification depend on source heat and design of fryer (Samuel *et al*., 2010). Thus, garification is the major factor in determining energy requirements in *gari* processing. In addition, level of mechanization of *gari* processing conserved energy utilization.

Table 1. Level of mechanization of each *gari* factory

Factory	Unit operations						
classification	Peeling	Washing	Grating	Dewatering	Sifting	Garification	Sieving
Low	×	×	√	×	×	×	×
Medium	×	×	√	√	√	×	×
High	×	×	√	√	√	√	√

Where √ is for mechanical equipment and × represents manual operation.

Table 2. Mean energy (MJ) estimated in *gari* processing factories

	Factory classification		
Unit operation	Low	Medium	High
Peeling	2.71 ± 0.11[a]	1.91 ± 1.09[b]	0.82 ± 0.02[c]
Washing	0.12 ± 0.03[a]	0.13 ± 0.02[a]	0.16 ± 0.01[b]
Grating	12.56 ± 0.76[a]	9.77 ± 1.95[b]	9.65 ± 0.90[b]
Dewatering	4.26 ± 0.32[a]	0.91 ± 0.63[b]	1.31 ± 0.28[c]
Sifting	0.27 ± 0.16[a]	2.76 ± 0.97[b]	27.01 ± 0.47[b]
Garification	750.87 ± 84.21[a]	668.83 ± 29.17[a]	35.06 ± 1.55[b]
Sieving	0.21 ± 0.01[a]	0.23 ± 0.09[a]	0.14 ± 0.00[b]
Total	771.00 ± 83.71[a]	684.53 ± 26.98[a]	73.97 ± 1.84[b]

Note: values with the same superscript on same row are not significantly different at $p < 0.05$.

The mean energy consumed by each level of the factory showed that there were significant differences ($p<0.05$) in energy demand by the unit operations between low and high levels *gari* factory mechanization (Table 2). Different levels of mechanization reduced the processing time and this is in agreement with the findings that the duration of processing is a major parameter in estimating energy utilization (Wang, 2009). However, between low and medium levels of mechanization, unit operations including peeling, washing, garification and sieving were not significantly different ($p>0.05$) while grating, de-watering and sifting were significantly different ($p<0.05$). These differences could be attributed to the fact that peeling, washing, garification and sieving were not mechanized unit operations at low and medium levels of *gari* factory mechanization.

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