

Energy Consumption in Processing and Production of Pap (Ogi) in Nigeria

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ARTICLE INFO

Received: January, 2021

Accepted: April, 2021

Published: April, 2021

Keywords:

Standardization
Life Cycle Assessment
Ogi
Food Processing
Food Production

ABSTRACT

The energy consumption for production and processing of ogi was investigated using pre-emergence (land preparation to planting), post emergence (maintenance to harvesting) and post-harvest phase (drying to ogi flour). Proximate analysis was also determined using standard methods. The highest thermal energy consumption was recorded in the milling unit. The post-harvest phase consumed the highest energy with 44,017.499MJ after pre-emergence phase which consumed 1,433.251MJ and post-emergence stage which accounted for the least energy with 2.10kJ. Total energy required to produce dry Ogi powder from 1 kg of maize was estimated as 10.01 MJ and the proportion of the manual, electrical and thermal energy consumption were 5.6, 19.3 and 75.2% respectively. The moisture content, dry matter content, fat content, ash content, crude fibre, crude protein and carbohydrate composition of the locally made ogi were 24.67, 75.33, 6.71, 0.84, 0.21, 10.82 and 56.75% while the powdered ogi gave 6.89, 93.11, 11.81, 2.16, 1.13, 16.86, 61.15 respectively. The energy consumption in production and processing of ogi is minimal and in tandem with similar biomaterials.

1. INTRODUCTION

Agricultural processing firms are among the largest sectors that consume large amount of energy. All agricultural activities take input or releases output to the environment which might have several impacts thus, it is important to study these effects on the immediate environment. Agricultural practices consume and produce energy directly and indirectly in the form of diesel, fertilizer for plant protection, chemicals, irrigation water and machinery (Ogunlade *et al.*, 2020). A reduction in production cost and rise in profit margin is inevitable when there is proper utilization of energy in agricultural production and processing (Singh *et al.*, 2002). The life cycle analysis (or eco-balance) is a technique to assess each impact associated with all the stages of a process or production system from raw material processing, manufacture, distribution, uses, repair, maintenance and disposal or recycling (Jekayinfa *et al.*, 2013). The need for a more efficient and economic processing and production system can therefore be effectively answered through the analysis of the energy inputs and utilization (Karakus *et al.*, 2002; Adeleke *et al.*, 2020).

Maize is one of the significant grains in Nigeria due to its economic and nutritional value. It is an important cereal in the world after wheat and rice (Osagie and Eka, 1998) and the third most important cereal crop

after sorghum and millet in Nigeria (Ojo, 2000). The demand for maize as a result of various uses shows that the domestic demand outstrips supply production (Zalkuwi *et al.*, 2010). It is processed industrially for flour, animal feeds, biscuits, beverages and beer and consumed widely across Nigeria. Olaniyan (2015) posited maize as a panacea for hunger as it has been maximally utilized over the years through various local processing techniques to produce food, livestock feed and raw material for industries (Abdulrahman and Kolawole, 2006).

Ogi is a staple cereal fermentation product found predominantly in Southern Nigeria and it's usually the first native food given to babies at weaning. It is produced generally by soaking maize grains in warm water for 2-3 days followed by wet milling and sieving through a screen mesh. Nnanyelugo and Onofiok (2004) reported the use of *ogi* as a weaning food in western Nigeria to supplement breastfeeding between ages of 3-6 months. It has also been shown that *ogi* liquor has both anti-bacterial (Adebolu *et al.*, 2007) and antifungal (Adebayo and Aderiye, 2010) properties. It is often eaten along with meat, stew, vegetable soup, steamed bean cake ('moin-moin') or fried bean cake (Akara) (Igbedioh *et al.*, 1996). Maize is still currently being processed locally in Nigeria to *ogi* and one of the issues in ensuring food security is to promote optimum utilization of available food supply through recipe standardization. The energy involved in maize production line and its processing to *ogi* is scanty in the literature. Information on this will aid the upgrade of the traditional technologies and promote modernization. Thus, the main aim of this study was to assess the energy associated with the *ogi* processing and production line.

2. METHODOLOGY

Data Collection

The survey on production line was obtained at the Teaching and Research Farm of Adeleke University, Ede, Osun State, Nigeria. The University is at Latitude 7.7612 and Longitude 4.4656. DMS Lat7° 43' 53.668" N, UTM Easting 658,353.05, UTM Northing 854,890.16 and UTM Zone 31N. The primary data for energy input resources in maize production was collected by field survey and personal interview. The various input and output of raw materials from each unit operation including first ploughing, second ploughing, herbicide application, fertilizer application, pesticide application, harvesting and dehulling were obtained and recorded. The energy consumption, fuel consumption and duration of each operation were determined based on the machine power ratings, hours of operation and diesel fuel used for each operation in litres.

Energy Inputs

Both direct and indirect energy inputs were considered as energy in farm operations except sequestered energy of mechanical power sources and implements. However, for the purpose of computation and analysis, three groups of energy resources were considered namely physical, chemical and biological energy inputs. The chemical and biological energy inputs were considered as indirect energy inputs while physical energy inputs were considered as both indirect and direct energy inputs (Singh *et al.*, 1994). Physical energy include human labour and mechanical power, while biological energy input include seedlings, and chemical energy inputs include fertilizers, herbicides and pesticides. The direct energy input is the energy consumption of physical energy resources for physical work during field operations.

Energy Evaluation

The production line of *ogi* from maize plants is categorised into pre-emergence phase (land preparation to planting), post-emergence phase (maintenance to harvesting) and postharvest phase (drying to *ogi* flour) as presented in Figure 1. The three most common energy sources in agricultural processing and production systems (electrical energy, manual energy and thermal energy) were calculated using equations 1 - 3. The

energy equivalent values of fuel (45.3 MJ/L for gasoline fuel and 45.5MJ/L for diesel) were used for calculation.

- i. **Electrical Energy:** The uses of electrical energy in most of the processing and production systems are in many cases achieved by the use of electric motors. Mathematically, electrical energy expended was obtained using equation 1 (Waheed *et al.*, 2008)

$$E_p = \eta Pt \quad (1)$$

Where: E_p is the electrical energy consumed in kWh, P is the rated power of the motor in kW
 t is the hours of operations in hours and η is the efficiency of power factor of the motors.

- ii. **Manual Energy:** This was obtained at maximum continuous energy consumption rate of 0.3 kW and conversion efficiency of 25%, the physical power output of a normal human labourer in tropical climates is approximately 0.075 kW sustained for 8-10 hours working day (Singh and Singh, 1992; Jekayinfa *et al.*, 2018). Equation 2 was used to obtain the manual energy consumed.

$$E_m = 0.075Nt \text{ (kWh)} \quad (2)$$

Where: 0.075 is a constant denoting the average power of a normal human labour, N is the number of persons involved in an operation and t is the useful time spent to accomplish a given task in hours.

- iii. **Thermal Energy:** the thermal energy value was obtained using methods demonstrated by Waheed *et al.*, 2008 as given in equation 3:

$$E_t = C_f W \quad (3)$$

Where: E_t is the thermal energy consumed in Joule (J), C_f is the calorific value of the fuel used in joule per litre (J/l) or kilo-joule per kilogram (kJ/kg) and W is the quantity of the fuel used in litre (l) or kilogram (kg) (Waheed *et al.*, 2008).

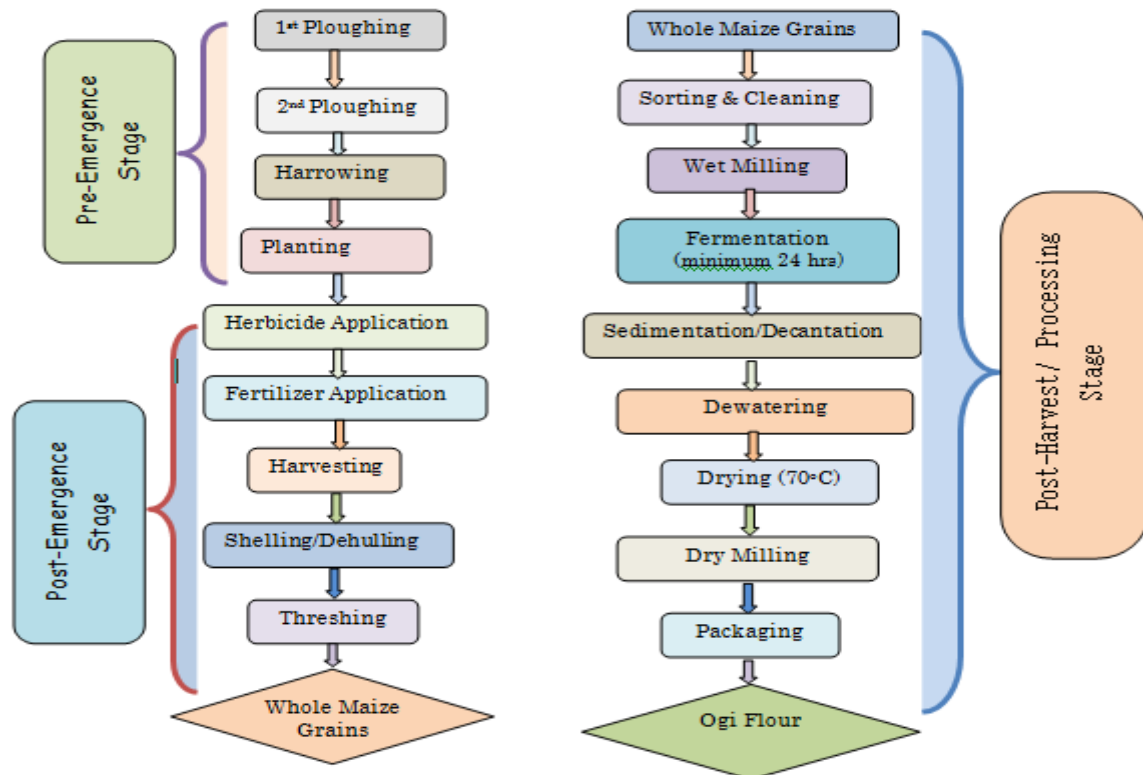


Figure 1: Dried Ogi Production and Processing Line

Ogi Processing Procedure

Dried *ogi* was prepared by steeping the maize in water for three days (72hrs) after which it was wet milled with a burr and sieved using finely porous cloth in order to remove parts of the hull. The sievate was allowed to sediment and ferment for 2-3 days to yield wet *ogi* and the supernatant is decanted. The sievate was made into *ogi* slurry which is a sour, starchy sediment. After fermentation, products were dewatered with a muslin cloth and dewatered fermented products was placed on a foil paper, arranged on the drying trays and dried at 70°C for 7 hours 10 minutes.

Proximate Analysis Test

Moisture content, dry matter content, fat content, ash content, crude fibre, crude protein and carbohydrate were determined in accordance with AOAC standard methods of evaluation.

3. RESULTS AND DISCUSSION

Energy Consumption at the Pre-Emergence Phase

The energy used up during the Pre-Emergence Phase (Land Preparation to Planting) is presented in Table 1. It was observed that the highest energy in the pre-emergence stage was 477.75×10^{-3} kJ for first ploughing while the least energy was obtained for planting. The declining order of energy consumption in the pre-emergence is first ploughing, second ploughing, harrowing, herbicide application and planting.

Table 1: Energy Used For Pre-Emergence Phase

Operation	Energy requirements	Time spent	Total Energy (KJ)
1 st Ploughing	10.5 lit of diesel	1hr	477.75×10^3
2 nd Ploughing	8 lit of diesel	45mins	364.00×10^3
Harrowing	6.5lit of diesel	30mins	295.75×10^3
Herbicides Application	6.5lit of diesel	30mins	295.75×10^3
Planting	2persons/ha	7hrs	1.05×10^2

Energy Consumption at the Post-Emergence Phase

The energy used during Post-Emergence Phase (Fertilizer Application to Harvesting and Dehusking) is presented in Table 2. The declining order of energy requirement in the post-emergence stage is harvesting and dehulling, pesticide, fertilizer and urea applications.

Table 2: Energy Used For Post-Emergence Phase

Operation	Energy requirement	Time spent	Total Energy (KJ)
Fertilizer Application	2persons/ha	2hrs	0.3
Pesticides Application	2persons/ha	3hrs	0.375
Urea Application	2persons/ha	2.5hrs	0.3
Harvesting & Dehulling	5 persons	3hrs	1.125

Energy Consumption at Post Harvest Phase

The energy used at the postharvest phase is presented in Table 3. It was observed that wet milling consumed the highest energy in the post-harvest stage followed by drying, threshing, wet sieving and dry milling as shown in Table 3. The total energy consumption for the wet milling operation was estimated as 43,563.95 MJ into 720 kg dry *ogi* powder which shows the highest energy consumption after ploughing. The total energy required to produce dry *ogi* powder from 4500 kg of maize was estimated as 45,450.75 MJ and the

proportion of the manual, electric and thermal energy consumption was 1.91×10^{-4} , 1.06×10^{-3} and 99.9% respectively. The post harvesting phase consumed the highest energy with 44,017.499 MJ after pre emergence phase which consumed 1,433.251 MJ and post emergence stage which accounted for the least energy with 2.1kJ. A total of 45,450.75 MJ is required to process 4.5 tonnes of maize into 720 kg dry *ogi* powder, this implies that the total energy inputted for 1 hectare of land preparation to processing of dry *ogi* from cradle to grave to produce 1 kg of dry *ogi* from cradle to grave is 10.1 kJ.

Table 3: Post Harvest Phase – Drying to Ogi Flour

Operation	Energy Requirement	Time Spent	Total Energy (KJ)
Threshing	10 lit	5hrs	453×10^3
Wet Milling	1 lit	14mins	43563.98×10^3
Wet Sieving	1 person	1hr 10min	84.02
Drying	700watts	7hours	459.81
Dry Milling	550watts	30mins	24.75

Proximate Analysis

The composition of the locally made *ogi* was 24.67, 75.33, 6.71, 0.84, 0.21, 10.82 and 56.75% while the powdered *ogi* showed a proximate composition of 6.89, 93.11, 11.81, 2.16, 1.13, 16.86, 61.15% moisture content, dry matter content, fat content, ash content, crude fibre, crude protein and carbohydrate respectively as presented in Table 4. The low moisture content of dried *ogi* indicate that they would have good storage ability as food spoiling micro flora will find it difficult to survive therein. The ash content shows that the food product contains meaningful amount mineral content. The dry matter content showed that the food crop contains lesser water content and will enrich the human body as solid food. The carbohydrate level shows that the food crop will give adequate energy to the human body when consumed.

Table 4: Proximate Analysis

Samples	Locally Made Ogi	Powdered Sample
Moisture Content (%)	24.67	6.89
Dry Matter Content (%)	75.33	93.11
Fat Content (%)	6.71	11.8
Ash Content (%)	0.84	2.16
Crude Fibre (%)	0.21	1.13
Crude Protein (%)	10.82	16.86
Carbohydrate (%)	56.75	61.15

Energy Source in Production and Processing Line of Ogi

It was obtained that the total energy to process 4.5 tonnes of maize into dry Ogi was 10.01 MJ/kg. However, thermal energy was the highest form of energy used up in the processing and production line while manual energy was the least form of energy used up as shown in Table 5.

Table 5: Form of Energy Used up in Production and Processing of Ogi

Energy form	Energy Rate (MJ)	Proportion (%)
Thermal	7.52	75.12
Electrical	1.93	19.3
Manual	0.56	5.6
TOTAL	10.01	100

4. CONCLUSIONS

The energy analysis of the dry *ogi* production and processing was investigated using pre-emergence, post-emergence and post-harvest stages for analysis. Diesel was mainly used as fuel or source of energy in the land preparation and threshers for the processing of the grains. The thermal energy is required in larger proportion in the production and processing line of dry *ogi*. The proximate composition falls within acceptable standard for normal living and body development.

References

- Abdurahaman, A. A., Kolawole, K. O. (2006). Traditional Preparation and Uses of Maize in Nigeria. *Ethnobotanical Leaflets*, 10: 219 – 277.
- Adeleke, K. M., Jekayinfa, S. O., Fadara, T. and Ogunlade, C. A. (2020). Life Cycle Assessment of Groundnut Production and Processing System. *Adeleke University Journal of Engineering and Technology*, 3(1): 1 – 8.
- Adeniji, A. O. and Potter, N. N. (1978). Properties of Ogi Powder made from Normal, Fortified and Opaque-2 Corn. *Journal of Food Science*, 43: 1571.
- Aderiye, B. L. and Laleye, A. S. (2003). Relevance of Fermented Food Products in Southwest Nigeria. *Plants Foods for Human Nutrition*, 58(3): 1-16.
- Afolabi, O. B., Oloyede, O. I., Olayide, I. I., Obafemi, T. O., Awe, J. O., Afolabi, B. A. and Onikani, S. A. (2015). Antioxidant Enhancing Ability of Different Solvents Extractable Components of Talinum Triangulare in some Selected Tissue Homogenates of Albino Rat-In Vitro. *Journal of Applied Pharmaceutical Science*, 5(9): 56-61.
- Afolayan, M. O. (2010). An Investigation into Sorghum Based Ogi (Ogi-Baba) Storage Characteristics. *Advanced Journal of Food Science and Technology*, 2 (1): 72-78.
- Aminigo, E. R. and Akingbala, J. O. (2004). Nutritive Composition of Ogi Fortified with Okra Seed Meal. *Journal of Applied Science and Environmental Management*, 8(2): 23-28.
- Bekele, A. J., Obeng-Ofori, D. and Hassanali, A. (1997). Evaluation of Ocimumkenyense (Ayobangira) as Source of Repellents, Toxicants and Protectants in Storage against Three Major Stored Product Insect Pests. *Journal of Applied Entomology*, 212: 169-173.
- Enwere, N. J. (1998). Foods of Plant Origin. Afro-Orbis publications Ltd, Nsukka.
- Hatirli, S. A. B., Ozkan, U. and Fert, C. (2005). An Econometric Analysis of Energy Input Output in Turkish Agriculture. *Renewable and Sustainable Energy Review*, 9:608- 623.
- IITA (International Institute of Tropical Agriculture) (2001). Annual Report on Maize Production. Publication of International Institute of Tropical Agriculture, Ibadan, Oyo State.
- IITA (International Institute of Tropical Agriculture) (2004). Annual Report. Publication of International Institute of Tropical Agriculture, Ibadan, Oyo State.
- IITA (International Institute of Tropical Agriculture) (2009). Annual Report. Publication of International Institute of Tropical Agriculture, Ibadan, Oyo State. www.iita.org/maize
- Iken, J. E. and Amusa, N. A. (2004). Maize Research and Production in Nigeria. *African Journal of Biotechnology*, 3(6): 302-307.
- Jekayinfa, S. O., Pecenka, R., Jaiyeoba, K. F., Ogunlade, C. A. and Oni, O. (2018). Life Cycle Assessment of Local Rice Production and Processing in Nigeria. The Proceedings 12th CIGR Section VI International Symposium 22 –25 October, 2018, 617 – 633.
- Nnanyelugo, D.O. and Onofiok, N. O. (2004). Weaning Foods in West Africa: Nutritional problems and possible solutions. Occasional Paper Department of Home Science and Nutrition, University of Nigeria, Nsukka.
- Odunfa, A. S. and Teniola, O. D. (2002). Microbial Assessment and Quality Evaluation of Ogi during Spoilage. *World Journal of Microbial Biotechnology*, 18(8): 731-737.

- Ogunlade, C. A., Jekayinfa, S. O., Olaniran, J. A. and Adebayo, A. O. (2020). Energy Life-Cycle Assessment and Economic Analysis of Sweet Orange Production in Nigeria. *Agricultural Engineering International: CIGR Journal*, 22(2): 123 – 132.
- Ojo, S. O. and Imoudu, P. B. (2000). Efficiency Measurement of Palm Oil Marketing in Ekiti State of Nigeria. *African Journal of Business and Economic Research*, 1(2):7-12
- Okoh, N. P. (1998). Cereal Grains: Nutritional Quality of Plant Foods. Post-Harvest Research Unit, University of Benin, Benin. 32 – 52.
- Okoruwa, A. (1995). Utilization and Processing of Maize. Ibadan IITA. Research guide No 35.
- Olaniyan, A. M., Sunmonu, M. O., Odewole, M. M., Ige, O. O. (2015). Process Conditions Governing the Drying Rate and Quality of Tomato Powder Obtained from Foam-Mat Dried Tomato Paste. *UFJ*. 4(3): 423-430.
- Osagie, A. U. and Eka, O. U. (1998). Nutritional Quality of Plant Foods. Post-Harvest Research Unit, University of Benin, Benin pp. 34 – 41.
- Purseglove, J. W. (1992). Tropical Crops: Monocotyledons. Longman Scientific and Technical, New. York. Pp. 300 – 305.
- Singh, H., Mishra, D. and Nahar, N. M. (2002). Energy Use Patter in Production Agriculture of Typical Village in Arid Zone, India- part-I. *Energy Conservation Management*. 43: 2275-86.
- Sulaiman, M. A., Kuye, S. I., Giwa, S. O. and Olowoyeye, O. A. (2018). Exergetic Analysis of Breakfast Cereal Production in Nigeria. *Nigerian Journal of Technology*, 37(1): 139 – 146