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Energy Analysis For Production Of Local Alcohol (*Burukutu*) In Benue State, Nigeria

Ibrahim J. Sunday[1], Alex O. Edeoja[1], Ierve I. Aondover[2]
[1]*Department of Mechanical Engineering, University of Agriculture, P.M.B. 2373, Makurdi, Nigeria.*
[2]*Works and Housing Department, Buruku Local Government Council, Buruku, Benue, Nigeria.*

***Abstract:* -** Energy study in the production of local alcohol (Burukutu) was carried out in six (6) Local Government Councils, representative of the three senatorial districts of Benue State, Nigeria. Eighteen cases were randomly investigated within the locations. Types of energy utilization (manual, liquid fuel and wood fuel energy) in addition to unit operations were identified. Energy, time, and number of persons and mass/material data were collected and computed. The energy consumption pattern of the unit operations were evaluated for production of 642kg of finished product. The analysis revealed that seven unit operations were required for the production of Burukutu. Results showed no significant difference at 95% confidence level of the energy requirements for the 18 cases studied with respect to the identified unit process of production and the mean values of the total energy of consumption was found to be 3122.90MJ. The most intensive operation was boiling, which accounts for 97.76% of the total energy for the production of Burukutu. Optimization of the boiling process is suggested to make the system more energy efficient.

***Keywords:* -** *Analysis, unit processes, burukutu, energy utilization, optimization energy efficiency, central region, local.*

I. INTRODUCTION

Energy is said to be the engine of growth and development in all economies of the world. In all parts of the world today, the demand for energy is increasing on a daily basis. In Nigeria, energy and in particular, oil, has continued to contribute over 70% of federated revenue [1]**.** It is also true that all activities for the production of goods and services in the Nation's major sector of the economy (Industries, transport, agriculture, health, politics, education and so on, have energy as an indispensable input.

Energy produced by crude oil has over the past five years contributed average of 13.5% of Nigeria's Gross Domestic Product (GDP), representing the highest contributor after crop production [1]. Consequently, energy in Nigeria stands unique as an input to the production of all goods and services as well as an instrument for politics, security and diplomacy. However, it is now universally accepted that fossil fuels which is the major source f energy in Nigeria are finite and it is only a matter of time before their reserves become exhausted. Extended use of these reserves, worldwide, in the current manner will continue for no more than some decades to come [2]. The increasing energy demand coupled with the finite energy resources, the rising cost of fossil fuel, deforestation and its attendant environmental impacts necessitate an understanding into the mechanisms, which degrade the quality of energy and energy systems. The processes that degrade the quality of the energy resource can only be identified through a detailed analysis of the whole system [3]. Quantifying the energy requirements will go a long way in determining the most efficient and effective way to use energy in *Burukutu* production.

Burukutu production relies on energy and mass (material input/output) to carry out the desired operations and obtain high processing efficiencies. Energy is primarily invested in various forms such as mechanical (human-labour), chemical (fossil fuel) and thermal (heat). The amount of energy used in *Burukutu* production is significantly high in order to meet the demand for the expanding population that consume the alcohol. The raw materials used in manufacturing the drink are produced in the tropical regions of Africa particularly in the Northern Guinea savanna areas of Nigeria [4, 5]. The beverage is very rich in calories, vitamin B and essential amino-acids such as Lysin [6].

In Nigeria, *Burukutu* is consumed in various festivals and Nigerian ceremonies (marriage, birth, dowry and so on) and constitute a source of economic return for the women manufacturers. Currently the production of this beer is increasing because of the high cost of factory beer as one bottle of the least factory beer is N130.00 but a similar bottle of *Burukutu* is N40.00 yet it gives the same effect. According to [7], this *Burukutu* has come to provide a lot of women with Jobs, especially those living in rural and semi-urban areas. The annual growth rate in women employment in this enterprise is about 8 percent, while young girls and older women are keen on learning the trade. Many young girls learn it when helping their mothers in the local enterprise. Most women in the business confirmed that the business is lucrative.

Research works in the area of assessment of energy requirements generally and particularly in local cottage industries in Nigeria have been neglected; there is need to audit the energy consumption in these industries in order to salvage them from economic loses and environmental effects. A limited number of studies has been reported on energy analysis in process industries. [8] analyzed the 5 year energy consumption data for 25 tea factories in South India. The variation in energy consumption in kilowatt hour per kg of tea made in factories based on factors such as type of tea produced, production capacity of factories climate etc, were analyzed. They also studied the specific energy consumption for the different processes. The consumption of direct energy from major sources in tea industries in Assam India was studied by [9]. They submitted that a tea garden required an estimated 18, 408MJ/ha of human energy in the first year.

An energy study was conducted by [10] in an organic fertilizer plant in Ibadan, Nigeria, to determine the energy requirement for the production of both powdered and pelletized organic fertilizer. In their study they evaluated the energy consumption pattern of the unit operations for production of 9000kg of the finished products. Their analysis revealed that eight and nine defined unit operations were required for the production of powder and pellet, respectively. The electrical and manual energy required for the production of powdered fertilizer were 94.45 and 5.5% of the total energy, respectively, with corresponding 93.9 and 5.07% for the production of pelletized fertilizer. The respective average energy intensities were estimated to be 0.28 and 0.35 MJ/kg for powdered and pellets. The most energy intensities were estimated to be 0.28 and 0.35 MJ/kg for powder and pellets and the most energy intensive proportion of 33.4 and 27.0% of the total energy for production of powder and pellets. Optimization of the production system was suggested to make the system energy efficient. Analysis of energy usage in the production for three selected cassava – based foods in Nigeria was done by 11 . They used some energy accounting symbols. The computation of energy use was done using Microsoft Excel spreadsheet. In 12 , study on the energy consumption pattern in palm kernel oil processing operations, data on PKO production, quality of fossil fuels used, the electrical power used from state grid, and captive power generated were obtained for each of the seven readily defined unit operations. 13 studied the energy use pattern in medium- and small-scale rice parboiling outfits. Five set of par-boilers in the upper Benue River basin in Adamawa State, Nigeria were selected for the study: three small rural par-boilers and two medium-scale suburban par-boilers. The study reveals the need for optimized energy use for rice parboiling and it shows that in order for rural rice processing to be sustainable, energy sources must be carefully considered and the concept of recycling of fuel biomass should be integrated into the process. 14 Studied various types of energy pattern used in rice milling industries viz., thermal energy, mechanical energy, electrical energy and human energy. They noticed that though, wide variety of technologies have been evolved for efficient use of energy for various equipments of rice mills, so far, only a few have improved their energy efficiency levels. Most of the rice mills use old and locally available technologies and are also completely dependent on locally available technical personnel. They concluded that energy conservation in the rice industry would lead to reduction in the use of fuels and electricity.

There is therefore no known report of any work in the literature on the energy requirement in *Burukutu* production in Nigeria or elsewhere in the world. A similar procedure for the breakdown of the *Burukutu* production process into unit operations and determination of energy requirement in each was used. The objectives of this work can be summarized into:

(i) to determine by mass, material and energy balance, the process and unit operations of *Burukutu* production in Benue State;
(ii) to determine the energy requirements of each and the entire process; and
(iii) to identify the energy use pattern in the production system as a step towards optimization of the system.

II. MATERIALS AND METHODS

Processing data was obtained randomly from six commercially viable *Burukutu* producing Local Governments Councils in Benue State, Nigeria, namely Buruku, Gboko, Makurdi, Oju, Katsina–Ala and Vandeikya. The trend observed for Benue State is conveniently representative of other locations in the Middle Belt and some parts of the Northern Region of the country. Each local government was made up of three randomly selected case areas (sites) of *Burukutu* processing industries. A total of eighteen sites were used for the study. The flow chart of the production system is shown in Fig. 1.

The primary energy resources utilized in the plant were identified to be manual (obtained from human labour), liquid fuel energy (obtained from fossil fuel), and wood fuel energy (obtained from wood fuel). Seven unit operations were defined for *Burukutu* production process: steeping, washing, grinding, filtering, mashing, boiling and re-filtering. The weight of sample input was measured from a weighing balance. An inventory of number of persons involved time required for production (h), quantity of fuel used (L), quantity of wood fuel used (kg) and material flow for the seven readily defined unit operations was made. The energy analysis was based on process analysis in which the direct energy consumption in every successive production step was estimated and the materials in put to each operation also indicated. These raw data were then converted to energy equivalents using (1), (2), and (3).

2.1 Estimation of Energy Input into each Unit Operation.

The energy components (manual, liquid fuel and wood fuel) for the production of for each of the unit operation were calculated for the production of 160.53kg of finished *Burukutu*. The following procedure was used:

2.1.1 Manual energy input

Manual energy estimation was based on the values recommended by 14 . They affirmed that at the maximum continuous energy consumption rate 0.30KW and conversion efficiency of 25% the physical power output of a normal human labour in the tropical climates is approximately 0.075KW sustained for an 8 – 10 hour workday; all other factors affecting manual energy expenditure were found insignificantly and therefore neglected.

To determine the manual energy for a given operation, the time spent by the worker on each operation was recorded. These include the intermittent resting periods. This was done mathematically as:

$$E_{m=}\ 0.075N.T_a\ \ (kW) \qquad (1)$$

where 0.075 = the average power of a normal human labour in kW, N = number of person involved in the operation; and T_a = useful time spent to accomplish a given task in hours.

2.1.2 Wood Fuel Energy Input

The wood fuel energy was estimated by measuring the amount of log that was consumed by the process, The wood fuel energy consumption Et is estimated from *W*, the amount of firewood used and *Ck*, the heating value of using the following relationship: $E \propto W$, 15

$$E = C_f W \quad \text{(MJ)} \qquad (2)$$

where, C_f, is the constant of proportionality which represents the calorific value (heating value) of fuel used.

2.1.3 Fossil fuel energy input

The total quantity of energy consumed from fossil fuel (diesel and petrol) was estimated by multiplying the quantity of fuel consumed by its lower heating value, thus,

$$E_{FLD} = 47.8D, (MJ) \quad 16 \qquad (3)$$

where E_{FLD} = liquid fuel energy input for diesel (MJ), 47.8 = Unit energy value of diesel (MJL^{-1}), D = Amount of diesel fuel consumed per unit operation, (liter). For Petrol, $E_{LLP=}\ 42.3p\ (MJ)$, E_{LLP} = liquid fuel energy input for petrol (MJ), 42.3 = corresponding Unit value of petrol, and p = Amount of petrol consumed per unit operation (liters).

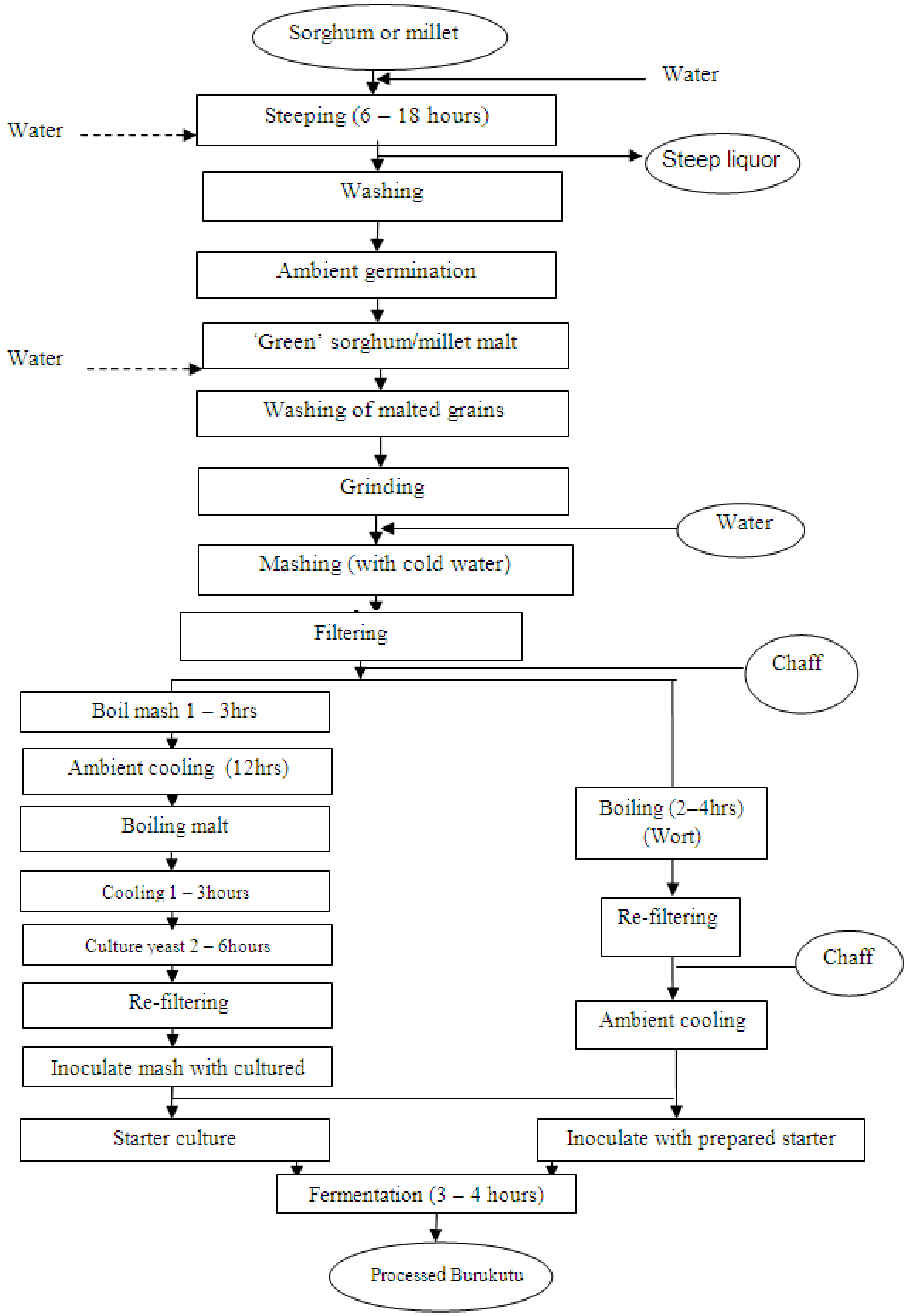

Figure 1: *buruktu* production process

2.2 Experimental Procedure

Before the commencement of grinding operation, known quantity of fuel was measured into the plastic tank. The tank was constructed from a white transparent plastic bucket. The capacity of the bucket was 4 liters. A 250ml measuring cylinder and water were used to calibrate the tank. After the completion of the batch, the quantity of fuel left in the tank was recorded. The difference in these readings represented the quantity of fuel used in (litres). The weight of fuel wood used was determined by similar difference. From this procedure, it was possible to assign, thermal energy, manual energy and liquid fuel energy, and a combination of two or all the forms of energies as the case may be, to each unit operation. The processing facilities of all the mills were very similar. All the mills selected were evaluated over the same period and seasons, and as a result the error of seasonal variation changes was eliminated. No prior experimental conditions were used as data collection in each locality was done as the mills were in operation. The following apparatus/materials were used for this study:

(i) Stop watch for measuring the production time;
(ii) 4 liters capacity constructed plastic tank used for measuring the quantity of fuel consumed during unit operation;
(iii) A measuring cylinder which was used to calibrate the constructed fuel tank; and
(iv) A weighing balance to measure the quantity of fuel

Using energy accounting symbols energy and mass flow diagrams were constructed Fig. 2 for typical *Burukutu* production mill.

III. RESULTS

3.1 Analysis of variance (ANOVA)

Analysis of variation (ANOVA) at 5% significant difference was conducted for the 18 cases which make up the locations of study for the energy requirement and the different unit operations for the production of the alcoholic local beverage as presented in Table 1.There was no significant difference in the energy requirements for all the 18 cases for at 95% confidence level implying that the system has been standardized. The mean values of the 18 cases were then considered for analysis.

Table 1: ANOVA for energy requirement for *burukutu* production

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F critical*
Rows	599483.5	17	35263.74	1.121219	0.344688	1.723833
Columns	1.43E+08	6	23753584	755.2512	3.96E-82	2.188761
Error	3208026	102	31451.24			
Total	1.46E+08	125				

Ho: F ≤ F Critical $\alpha = 0.05$

Ha: F > F Critical

3.2 Energy Requirement for Production of *Burukutu*.

The average energy input at different stages of *Burukutu* production process is presented in Table 2 and Figure 2. From table 2 and figure 2, the energy consumption data obtained provides useful information on the sources of energy requirement of each processing unit. The data revealed that wood fuel was extensively used for operation. 97.06% of the average total average in all the six locations was obtained from wood fuel source, followed by 2.1% and 0.85% from liquid fuel and manual energy sources respectively. This clearly indicates that most of the tedious operation involved in *Burukutu* production were performed by heating and use of liquid fuel, with over 90% of the energy consumption attributed to the use wood fuel combustion over 2% of the energy consumption attributed to the use of internal combustion engine powered grinding mill.

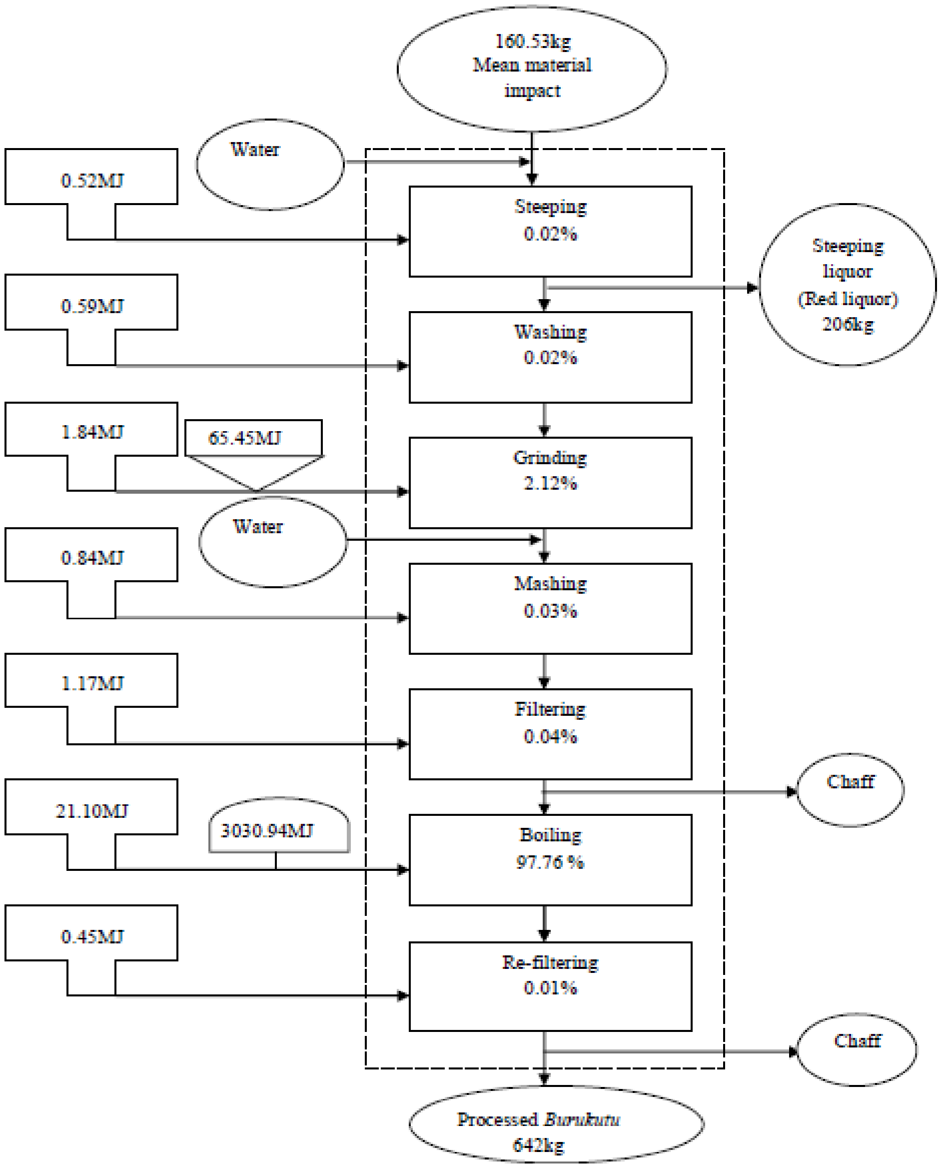

Figure 2: flow diagram for production of *buruktu* in the middle belt region of Nigeria

Table2: Mean Time and Energy Requirement for Production of *Burukutu* in the Middle Belt Region of Nigeria

S/No	Process	Time (hrs)	Manual Energy (MJ)	Wood Fuel Energy (MJ)	Liquid Fuel Energy (MJ)	Total Energy (MJ)	%Total Energy
1	Steeping	1.28	0.52	-	-	0.52	0.02
2	Washing	1.5	0.59	-	-	0.59	0.02
3	Grinding	1.55	1.84	-	65.45	67.3	2.12
4	Mashing	1.54	0.98	-	-	0.98	0.03
5	Filtering	1.77	1.17	-	-	1.17	0.04
6	Boiling	27.36	21.1	3030.93	-	3052.03	97.76
7	Re-filtering	0.72	0.45	-	-	0.45	0.01
	Total		26.51	3030.93	65.45	3122.9	100
	Mean Total%		0.85	97.06	2.1	100	

IV. CONCLUSIONS

The energy analysis for production of *Burukutu* in the middle belt region of Nigeria suggested that:

- Seven defined unit operations were required for the production of *Burukutu*.
- Wood fuel energy was the major energy input in the production of *Burukutu.*
- The most intensive operation was boiling, which accounts for 97.76% of the total energy for the production of *Burukutu*. Modification of the local stove to enhance more efficient utilization is hereby recommended and could be the subject of future work in this area.
- The use of waste biomass such as rice husks, combustible by-products from the production process as alternative fuel and modified stove may be key in ensuring sustainability of the boiling process.

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