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EnergyUsage and Conservation Approaches in Production of Condiment *(ogiri)* from Melon seeds (*Citrullus vulgaris*)

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Abstract*:*The production of condiment (ogiri) from melon seeds has attracted interest of researchers and industrialists, as the production involves series of unit operations which are energy dependent. Studies on energy usage and conservation approaches would provide valuable information for commercial producers of these product in order to conserve energy usage. Therefore, estimation of the energy usage and conservation approaches was the focus of this study.Data on energy inputs in each unit operation were obtained by direct measurement and fitted into standard equations.Mean total energy for processing 1kg of raw melon seeds into condiment using traditional approach and conservation approaches I and II were estimated to be 141.75 ± 1.16 MJ, 83.36 ± 1.14 MJ and 73.57 ± 1.73 MJ respectively. Boiling operations were identified as most energy intensive operation with energy values of 126 ± 3.46MJ ≈ 88.89%, 37.96 ± 1.13 MJ ≈ 45.54%, 28.18 ± 0.68MJ ≈ 38.29% for traditional approach and conservation approaches I and II respectively. Mashing operations were identified as the least energy consuming operations with energy values of 0.13 ± 0.01 MJ ≈ 0.09%, 0.13 ± 0.01 MJ ≈ 0.15%, and 0.13 ± 0.02MJ ≈ 0.17% for traditional approach and conservation approaches I and II respectively.Conservation approach II saved 48.09% of energy input as compared with traditional approach and also conserve 11.7% when compared with conservation approach I.

Keywords: Melon seed, Condiment, Energy usage, Energy conservation

INTRODUCTION

Energy is regarded as the prime mover of any economy and the engine of growth around which all sectors of the economy revolve, the sustenance of the good quality of life in any nation requires a careful management of all available energy resources (Aderemi et al., 2009). Excessive energy consumption adds to the costs of goods produced especially in the energy intensive industries. In view of this, attempts should be made for higher efficiency of utilization of fuel, electricity, thermal energy and labour, these being the major components of manufacturing cost. In this regard, the efficiency and conservation of energy is a major issue in energy usage to ensure proper management and as such prevent wastage (NEED, 2010).

Condiments can be described as substances applied to food in the form of sauce, powder, spread or anything similar to enhance or improve the flavour (Oboh, 2006). ‘Ogiriegusi’ is an indigenous fermented soup condiment which is used as flavoring agent whose character and organoleptic properties depend on microbial activities (Nwosu and Ojimelukwe, 2000). It has an oily gray pasty consistency with a very strong pungent smell when it is in its raw state. It is produced by traditional method of uncontrolled solid substrate fermentation of melon seeds (Citrullus vulgaris) (Achi, 2005).The processing of melon seed into food condiment involve series of unit operations after harvesting which are energy dependent. Such unit operations includesdehusking, cleaning, boiling, washing, mashing and then fermentation to produce the food condiment which is used in soup and other food preparation. Attempt has been made at commercializing the process with the inputs of food processing procedures such as the use of mechanized masher, reduction of energy usage during cooking by adopting liquefied propane gas (LPG) fuel and kerosene fuel and incorporation of drying to further extend the shelf life of the product. In all of these innovations, the expected low price of the product by the consuming population cannot be justified by the huge energy expenditure required to make this possible. The need for such great attention to energy management has been highlighted by several published surveys of energy use in agricultural processing operations. These include: cowpea flour, (Akinoso et al. 2013); african locust beans, (Akinoso and Adedayo, 2012); gari, (Akinoso and Kasali, 2012); palm oil, (Akinoso and Omolola, 2011); bread making processes (Le-bail et al., 2010); cashew-nut processing (Jekayinfa and Bamgboye, 2005; Jekayinfa and Bamgboye, 2003) andpalm kernel oil processing, (Jekayinfa and Bamgboye, 2004). As a consequence, there is need for the estimation of the energy usage of the processing operations of the condiment in order to suggest the best means of conserving energy during processing. It will also serve as vital information in developing strategies for better control of production operations and provide valuable information for commercial producers of these product and researchers.

2. MATERIALS AND METHODS

2.1 Sample preparation

Energy requirements in production of condiment from 1kg of melon seeds(Citrullus vulgaris) using three different methods were conducted at Oluwatoyin Locust bean processing Centre in Osogbo, Osun State, Nigeria. Information was obtained on the basis of the unit operations performed, number of person involved and technologies in use for the processing operations. The processing techniques used was described by Akinyele and Oloruntoba, (2013). The melon seeds were washed, dehusked, rewashed and weighed. The melon seeds were boiled for 4h in 10 times volume of water, allowed to cool to about 30ºC, mashed and wrapped in banana leaves to ferment for six days. The fermented product was then packaged in a clean container.

2.2 Conservation approaches

The conservation approaches used for this work was the variation in the fuel source by using Kerosene and Liquefied Propane Gas (LPG) for conservation approaches I and II respectively while traditional approach used dried wood.Marketability, storability, acceptability and quality of the products were enhanced by drying to reduce the moisture contents, grindinginto fine particles and packaging in a high density polyethylene for conservation approaches I and II.

2.3 Methods of energy evaluation

At each stage of unit operations, some level of energy input is required in form of human energy, thermal energy and electrical energy. The type and magnitude of the energy consumed is a function of the technology employed, no of person involved and number of sample being processed.The Measured parameters for evaluating energy usage pattern in traditional approach and conservation approaches I and II for melon seed into condiment (ogiri) is presented in Table 1.The following are the equations used in evaluating the energy consumed in the three processing methods;

2.3.1 Manual energy

$Em = 0.75\ Nt\ (MJ)$ Equation 1

Where, 0.75 is the average power of a normal human labour for man in MJ/h, N is the number of persons involved in an operation and t is the useful time to accomplish a given task in hours (Odigboh, 1997).

2.3.2 Thermal energy

$Et = CtW$ Equation 2

WhereE_t is the thermal energy consumed in J, C_t is the calorific value of fuel used in J/kg and W is the quantity of fuel used in kg (Rajput, 2001). Calorific value of typical air dried wood is 15 MJ/kg, calorific value of kerosene is 43.7 MJ/L, calorific value of liquefied propane gas (LPG) is 50.35MJ/kg and calorific value of charcoal is 27 MJ/kg.

2.3.3 Electrical energy

$Ep = \Delta Pt$ Equation 3

WhereE_p is the electrical energy consumed in kWh, P is the rated power of motor in Kw, t is the hour of operation in h and Δ is the power factor (assumed to be 0.8) (Rajput, 2001). Dehuller power factor 0.8, rated power of motor of dehuller 4.48 kW, grinder power factor 0.8,rated power of motor of attrition mill 2.98 kW, packaging power factor 0.8 and rated power of motor of Impulse sealer is 0.26 kW.

2.3.4 Estimation of total energy (Ent) in traditional Processing of melon seed into condiment (ogiri);

$Ent = Eds + Ecl + Eb + Em + Ew + Ef + Epk$ Equation 4

Where; E_{ds}, E_{cl}, E_b, E_m, E_w, $E_f$and E_{pkg} are energy values for dehusking, cleaning, boiling, mashing, wrapping, fermentation and packaging respectively.

2.3.5 Estimation of total energy (Ent) in conservation methods for processing melon seeds into condiment (ogiri);

$Ent = Eds + Ecl + Eb + Em + Ew + Ef + Ed + Eg + Epk$ Equation 5

Where; E_{ds}, E_{cl}, E_b, E_m, E_w, $E_f E_d$, E_g and E_{pkg} are energy values for dehusking, cleaning, boiling, mashing, wrapping, fermentation, drying, grinding and packaging respectively.

2.4 Statistical analysis

The estimation of energy requirements in the three major categories of the unit operations of the condiment processing involved the use of spreadsheet program on Microsoft Excel. This makes the computational procedure easy to follow by any factory operators desiring to compute the energy usage pattern of their processing operations at any accounting period. Descriptive analysis was also carried out on the data obtained and test of significant was carried out at 5% level of significant using the SPSS software.

3. RESULTS AND DISCUSSION

3.1 Comparison of total energy expended in the traditional approach andconservation approaches I and II of melon seed into condiment

Table 2, illustrate the energy usage for processing 1kg of melon seed into condiment using traditional approach and conservation approaches I and II. In the three operations, energy utilized during dehusking operation ranged between 15 ± 0.78 MJ in conservation approach II to 13.5 ± 0.30 MJ in traditional approach amounting to 20.31% and 9.52% respectively of the total energy consumed during each technique. There were no significant differences in energy utilized during dehusking operations of the processes ($p > 0.05$). Cleaning accounted for 0.25 MJ with 0.18%, 0.30% and 0.34% of the total energy in traditional, conservation approaches I and II respectively. Energy utilized for the cleaning shows that there were no significant differences ($p > 0.05$) in all the three processes. In the boiling, energy utilized in the traditional process was higher than that of conservation approach I and II with the energy values of 126 ± 3.46 MJ, 37.96 ± 1.13 MJ and 28.18 ± 0.68 MJ corresponding to 88.89%, 45.54% and 38.29% respectively. The result shows that there were significant differences ($p>0.05$) between the three processes. This was attributed to the fact that air dried wood fuels are less efficient with calorific value of 15 MJ/kg as their utilization tend to have low efficiencies as (about 10%) hence a large quantity is required to achieve the heating process (POST, 2002) and thus making traditional approaches more energy intensive. Conservation approach I which utilized kerosene as fuel with calorific value of 43.7 MJ/L consume less energy than traditional approach that utilized wood with calorific value of 15MJ/kg because the release of energy from this fuel is dependent on the technological advancement of appliance use while conservative approach II which utilized liquefied propane gas (LPG) with calorific value of 50.37 MJ/kg as fuel consume the least energy because high proportion of its energy content is converted to heat. LPG can be five times more efficient than traditional fuels, resulting in less energy wastage (UNF, 2014).

Similarly, there was a significant differences ($p>0.05$) between manual mashing in traditional approach and mechanized mashing in both conservation approaches I and II with the energy values of 0.75 ± 0.09 MJ for traditional approach and 0.42 ± 0.04 MJ for both conservation approach I and II. This could be attributed to the reduction in the mashing time because mechanized mashing was used for both conservation approaches I and II which save time as compare with traditional approach that use manual mashing method and this is an agreement with the findings that the duration of processing is a major parameter in estimating energy utilization (Wang, 2009). There was no significant differences ($p>0.05$) between the energy utilized at the mashing, wrapping and fermentation for traditional process, conservation approach I and II as presented in the table 4.2. Similar observation was reported on Africa locust beans (Akinoso and Adedayo, 2012). Drying and grinding was incorporated at both conservation approaches I and II and there was no significant differences in the energy consumed at both unit operations. Electrical energy was utilized for mashing, grinding and packaging operations. Of the processes utilizing this form of energy, packaging accounted for the highest electrical energy input with a value of 0.56 ± 0.04 MJ corresponding to 0.67% for conservation approach I and 0.49 ± 0.04 MJ corresponding to 0.76% for conservation approach II of the total electrical energy input. This was followed by grinding with the energy value of 0.72 MJ corresponding to 0.87% of conservation approach I and 1.59% of total electrical energy input. The least consuming electrical energy input was mashing with energy value of 0.42 MJ corresponding to 0.51% of conservation approach I and 0.58% of conservation approach II of total electrical energy input. The values obtained were mainly a function of the equipment's power output in terms of the rated power of its motor and the time involved in the process (Wang, 2009). In this regard, the highest power output and time taken for the process to complete was obtained from the packaging machine. Although the time taken using grinder was lower than that of the packaging machine, the higher value obtained was due to equipment power output. For both conservation I and II approaches, drying accounted for 27.56 ± 0.90 MJ of the total energy value corresponding to 33.07% for conservation approach I and 37.46% for conservation approach II respectively. Charcoal a manufactured and secondary fuel was the energy source used for drying. Energy required for packaging in conservation approaches I and II was slightly higher than traditional approach with energy values of 0.56 ± 0.04 MJ and 0.49 ± 0.04 MJ for both conservation approaches I and II and 0.39 ± 0.02

MJ for traditional approaches. This was so because electrical energy was utilized for packaging in the conservation approaches I and II which added to energy usage during processing. In all the three processes, the total mean values obtained for the energy consumption depicts that there were significant differences ($p< 0.05$) in the traditional, conservation approaches with energy values of 141.75 ± 1.16, 83.36 ± 1.14 and 73.57 ± 1.73 MJ. The energy consumption pattern revealed that the effort to conserve the traditional process paid off because there was drastic reduction in the energy usage at each different processes. Procedural and behavioral changes have been reported to able to save about 30% energy without capital investment. (Fischer et al., 2007). This could be attributed to the alternative source of fuel (kerosene and LPG) and the use of mechanized masher which as contributed immensely to the reduction of energy usage when compared to traditional approach that used biomass (wood) and manual mashing techniques.

4. CONCLUSION

Conclusively, traditional approach of processing melon seeds into condiment utilized highest energy (141.75 MJ) followed by conservation approach I (83.36 MJ) and conservation approach II (73.57 MJ) was least in energy demand.Conservation approach II saved 48.09% of energy input when compared with traditional approach in the production.

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***Table 1**Measured parameters for evaluating energy usage pattern in traditional approach and conservation approaches I and II for melon seed into condiment (ogiri)*

Unit Operation	*Required Parameters*	*Traditional approach*	*Conservation approaches I and II*
Dehusking	Number of persons involved in dehusking	2	2
	Time taken for dehusking (h)	9	8
Cleaning	Number of persons involved in cleaning	2	2
	Time taken for cleaning (h)	0.167	0.167
Boiling	Fuel consumed kg (Wood)	8	Nil
	Fuel consumed l (Kerosene)	Nil	0.8
	Fuel consumed kg (LPG)	Nil	0.5
	Number of persons involved in boiling	2	1
	Time taken for boiling (h)	4	4
Mashing	Number of persons involved in mashing	2	2
	Time taken for mashing (h)	0.5	0.083
Wrapping	Number of person involved in wrapping	2	2
	Time taken for wrapping (h)	0.5	0.5
Fermentation	Number of persons involved in fermentation	1	0.167
	Time taken for fermentation (h)	0.167	
Drying	Number of persons involved in drying	Nil	1
	Time taken for drying (h)	Nil	0.5
Grinding	Number of persons involved in grinding	Nil	0.167
	Time taken for grinding (h)	Nil	1
Packaging	Number of persons involved	2	2
	Time taken (h)	0.25	0.25

Table 2 Energy requirements for processing 1kg of melon seed into condiment (ogiri) using traditional and conservation approaches I and II

Unit Operations	*Traditional approach*		*Conservation approach I*		*Conservation approach II*	
	Energy (MJ)	*Percentage (%)*	*Energy (MJ)*	*Percentage (%)*	*Energy (MJ)*	*Percentage (%)*
Dehusking	13.5 ± 0.30[a]	9.52	15.00 ± 0.86[a]	17.99	15.00± 0.76[a]	20.38
Cleaning	0.25 ± 0.12[a]	0.18	0.25 ± 0.03[a]	0.30	0.25 ± 0.02[a]	0.34
Boiling	126 ± 3.46[a]	88.89	37.96 ± 1.13[b]	45.54	28.18 ± 0.68[c]	38.29
Mashing	0.75 ± 0.09[b]	0.53	0.42 ± 0.04[a]	0.51	0.42 ± 0.04[a]	0.58
Wrapping	0.75± 0.03[a]	0.53	0.75 ± 0.01[a]	0.89	0.75 ± 0.02[a]	1.02
Fermentation	0.13 ± 0.01[a]	0.09	0.13 ± 0.01[a]	0.15	0.13 ± 0.02[a]	0.17
Drying	NA	NA	27.56 ± 0.90[a]	33.07	27.56 ± 1.47[a]	37.46
Grinding	NA	NA	0.72 ± 0.04[a]	0.87	0.72 ± 0.12[a]	0.98
Packaging	0.39 ± 0.02[b]	0.26	0.56 ± 0.04[a]	0.67	0.49 ± 0.04[a]	0.76
TOTAL	141.75 ± 1.16[a]	100	83.36 ± 1.14[b]	100	73.57 ± 1.73[c]	100

**Mean of three determinations, value with different superscripts is significantly different at $p<0.05$, NA is not Applicable