



Research Paper

Comparative Studies on Energy Requirements in Production of Condiment from Castor seeds (*Ricinus communis*) and Melon seeds (*Citrullus vulgaris*)

Accepted 18th February, 2016

ABSTRACT

Energy requirements in production of condiments from castor seeds and melon seeds were estimated. This was targeted towards providing information that will enhance better strategies for controlling their energy usage during production operations. Data on energy inputs in each unit operation was obtained by direct measurement and fitted into standard equations. The mean total energy for processing 1 kg of raw castor oil seeds into condiment was estimated to be 300.30 ± 3.46 MJ, while the mean total energy for processing 1kg of raw melon seeds into condiment was 141.75 ± 1.16 MJ. Comparing the two production processes, boiling operation was identified as the most energy intensive operation during the conversion of melon seeds into condiment with energy value of 126 ± 3.46 MJ $\approx 88.89\%$ and energy value of 252 ± 2.66 MJ $\approx 83.92\%$ for castor oil seeds into condiment. Mashing and fermentation were identified as the least energy consuming operation with energy value of 0.13 ± 0.01 MJ $\approx 0.04\%$ and 0.13 ± 0.01 MJ $\approx 0.09\%$ respectively. Castor seeds required more energy than melon seeds in conversion to condiment.

Key words: Energy requirement, castor seeds, melon seeds, condiment.

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INTRODUCTION

Energy is one of the most essential resources in the manufacturing industries. Most times energy cost exceeds the costs of other resources such as raw material, personnel, depreciation and maintenance (Fadare, 2003). Effective energy utilization and energy source management in food processing facilities are desirable for reduction of processing costs; serve as vital information in developing strategies for better control of production operations, reduction of non-renewable energy and reduction of environmental impact (Wang, 2009). Castor and melon seeds can be fermented into condiment widely known as *Ogiri* in Nigeria. The fermented seeds can be ground to make an oily paste '*Ogiri*' which has a characteristic ammoniacal odour. This characteristic flavor enhances the taste of traditional soups and sauces (Omafuvbe, 2006). It also contributes to protein and

essential fatty acid intake in West Africa (Oke and Umoh, 1998).

The processing of melon and castor seeds into food condiment involve series of unit operations after harvesting which are energy dependent. The expected low price of the condiment by the consuming population cannot be justified by the huge energy expenditure required to make this possible. As a consequence, there is the need for the estimation of energy requirements in the processing operations of the two seeds into condiment. This will 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. 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) and palm kernel oil processing (Jekayinfa and Bamgboye, 2004). In all these, there is however little or no information on the estimation of the energy requirements in the production of condiment (*ogiri*) from Melon and castor oil seeds as practiced in Nigeria.

MATERIALS AND METHODS

Sample preparation

Condiments were produced from 1 kg of castor (*Ricinus communis*) seeds and melon (*Citrullus vulgaris*) seeds using semi-mechanized method. Information was obtained on the basis of the unit operations performed and technologies in use for the processing operation. The processing technique was adopted from the work of Ojimekwe et al. (2011) and Akinyele and Oloruntoba (2013). The melon seeds were washed, dehulled, rewashed and weighed respectively. It was then boiled ten times for 4 h in volume of water, allowed to cool to about 30°C, mashed and wrapped in banana leaves to ferment for six days. The fermented product was then packaged in a clean container. For castor seeds, it was dehulled, winnowed, weighed, and boiled for six hours. Thereafter, it was dehulled and subsequently washed with water to remove the hulls. The dehulled seeds were boiled again for another two hours and then mashed in a clean mortar into paste, then, wrapped in banana leaves and allowed to ferment for six days at room temperature (30°C). The fermented condiment (*ogiri*) was then pressed and molded before being packaged into a clean container.

Energy evaluation

The condiment production went through some sequential processing operations that converted the seeds to the final primary product known as condiment (*Ogiri*). At each stage of the unit operation, some level of energy input was required in form of human energy and thermal energy. The type and magnitude of the energy consumed is a function

RESULTS AND DISCUSSION

Energy requirements in the processing of castor seeds into condiment

From Table 2, the mean total energy for processing 1 kg of castor seed into condiment (*ogiri*) was estimated to be 300.30 ± 3.46 MJ. The energy expended was higher than

of the technology employed and number of sample being processed. Measured parameters during the evaluation of the energy requirements in the production of condiment from castor and melon seeds are presented in Table 1. The equations for evaluating the energy requirements are presented as:

Manual energy:

$$Em = 0.75 N t (MJ) \quad (1)$$

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

Thermal energy:

$$Et = CtW \quad (2)$$

Where; E_t is the thermal energy consumed in J, C_t is the calorific value of fuel used in J/kg and W the quantity of fuel used in kg (Rajput, 2001). Calorific value of typical air dried wood was 15 MJ/kg.

Estimation of total energy (E_n) in the processing of Castor seeds into condiment (*ogiri*):

$$EnT = Eds + Ecl + Eb1 + Edh + Eb2 + Em + Ew + Ef + Epkg \quad (3)$$

Where; E_{ds} , E_{cl} , E_{b1} , E_{dh} , E_{b2} , E_m , E_w , E_f and E_{pkg} are energy values for dehulling, cleaning, first boiling, dehulling, second boiling, mashing, wrapping, fermentation and packaging respectively.

Estimation of total energy (E_n) in the processing of melon seeds into condiment (*ogiri*):

$$Ent = Eds + Ecl + Eb + Em + Ew + Ef + Ep \quad (4)$$

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

0.177 MJ/kg reported for recovery crude palm oil (Jekayinfa and Bamgboye, 2007); 59.82 MJ/kg for African locust beans (Akinoso and Adedayo, 2012) and 7.2 MJ/kg for palm oil processing using electrical energy (Mahila et al., 2001). The differences may be traced to the crops physiology, technology involved and source of energy. The first boiling operation was the most energy intensive process with an energy value of 189 ± 2.31 MJ corresponding to 62.86% of the total energy input while mashing was the least energy consuming process with 0.13

Table 1. Measured parameters during the evaluation of the energy requirements in the production of *condiment* from castor and melon seeds.

Unit operations	Required parameters	Castor seeds	Melon seeds
Dehusking	Number of persons involved in	2	2
	Time taken for dehusking (h)	24	9
Cleaning	Number of persons involved in cleaning	2	2
	Time taken for cleaning (h)	0.33	0.167
Boiling	Fuel consumed wood (kg)	12	8
	Number of Persons involved in boiling	2	2
	Time taken for boiling (h)	6	4
Dehulling	Number of persons involved in	2	Nil
	Time taken for dehulling and washing (h)	7	Nil
Boiling	Fuel consumed wood (kg)	4	Nil
	No of persons involved in boiling	2	Nil
	Time taken for boiling (h)	2	Nil
Mashing	Number of persons involved in mashing	1	2
	Time taken for mashing (h)	0.167	0.5
Wrapping	Number of persons involved in	2	2
	Time taken for wrapping	0.5	0.5
Fermentation	Number of persons involved in fermentation	1	1
	Time taken for fermentation (h)	0.25	0.167
Packaging	Number of persons involved	2	2
	Time taken (h)	0.167	0.25

± 0.01 MJ of energy input, which amounted to 0.05% of the total input. The two boiling processes accounted for 83.81% of the total energy input. Dehusking, cleaning and dehulling accounted for 15.64% of the total energy input while mashing, wrapping, fermentation and packaging amounted to 0.62% of the total energy input. This method was used in processing the two major forms of utilized energy, which were thermal and manual energy. Thermal energy accounted for 80% (240 MJ) of the total energy input while manual energy accounted for 20% (60.30 MJ) of the total energy input. Thermal energy that accounted for the highest energy input utilized solid biomass (wood) as the energy source during the first and second boiling stage.

Energy requirements in the processing of melon seeds into condiment

Energy utilization during the processing of 1 kg of melon seed to condiment (*Ogiri*) was estimated to be 141.75 ± 1.16 MJ as shown in Table 2. The energy expended was

higher than 0.177 MJ/kg as reported for recovery crude palm oil (Jekayinfa and Bamgboye, 2007); 59.82 MJ/kg for African locust beans (Akinoso and Adedayo, 2012) and 7.2 MJ/kg for palm oil processing using electrical energy (Mahila et al., 2001). The differences could also be traced to the crops physiology, technology involved and source of energy. The energy consumed for dehusking, cleaning, boiling, mashing, wrapping, fermentation and packaging were 13.5 ± 0.30 MJ, 0.25 ± 0.12 MJ, 126 ± 3.46 MJ, 0.75 ± 0.09 MJ, 0.75 ± 0.03 MJ, 0.13 ± 0.01 MJ and 0.39 ± 0.02 MJ respectively. The boiling operation was the most energy intensive process with an energy value of 126 ± 3.46 MJ corresponding to 88.89% of the total energy input while fermentation was the least energy consuming process with 0.13 ± 0.01 MJ of energy input, which amounted to 0.09% of the total input. Dehusking and cleaning accounted for 9.7% of the total energy input while mashing, wrapping, fermentation and packaging amount to 1.41% of the total energy input. This method was used in processing the two major forms of utilized energy, which are thermal and manual energy. Thermal energy accounted for 85%

Table 2. Energy requirements in the production of *condiment* from castor and melon seeds.

Unit operations	Castor seeds		Melon seeds	
	Energy (MJ)	Percentage (%)	Energy (MJ)	Percentage (%)
Dehusking	36.00 ± 0.11	11.98	13.5 ± 0.30	9.52
Cleaning	0.50 ± 0.17	0.17	0.25 ± 0.12	0.18
First boiling	189 ± 2.31	62.9	126 ± 3.46	88.89
Dehulling	10.5 ± 0.58	3.49	Nil	Nil
Second Boiling	63.00 ± 0.35	20.98	Nil	Nil
Mashing	0.13 ± 0.01	0.04	0.75 ± 0.090.	0.53
Wrapping	0.75 ± 0.02	0.25	0.75 ± 0.03	0.53
Fermentation	0.19 ± 0.01	0.06	0.13 ± 0.01	0.09
Packaging	0.25 ± 0.02	0.08	0.39 ± 0.02	0.26
Total	300.30 ± 3.46	100	141.75 ± 1.16	100

(120MJ) of the total energy input while manual energy accounted for 15% (21.75MJ) of the total energy input. Thermal energy which accounted for the highest energy input was obtained from solid biomass, which is wood for the boiling process. Air dried wood which is natural and the primary fuel was used for the processing because its Castor and melon seeds were processed into condiment. The energy required to process 1 kg of castor oil seeds and melon seeds into condiment was 300.30 ± 3.46 MJ and 141.75 ± 1.16 MJ respectively. The study showed that the total energy requirements for producing condiment from castor seeds, utilized higher amount of energy input than condiment produced from melon seeds in the processing operations. Boiling operation was identified as the most energy intensive operation while fermentation and mashing were identified as the least energy consuming operation respectively. Alternative source of energy during boiling could be tried in order to conserve the overall energy requirements.

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usage can be attributed to their abundance and availability as domestic fuels in tropical countries (Gupta, 2005).

Conclusion

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Cite this article as:

Saheed SM, Rahman A, Babatunde AI (2016). Comparative Studies on Energy Requirements in Production of Condiment from Castor seeds (*Ricinus communis*) and Melon seeds (*Citrullus vulgaris*). Acad. J. Food. Res. 4(1): 011-014.

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