Croatian Journal of Food Science and Technology
journal homepage: www.ptfos.unios.hr/cjfst/

Original scientific paper
DOI: 10.17508/CJFST.2021.13.1.04

Elucidating the energy-utilization patterns for five methods of groundnut cake *(Kulikuli)* production

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ARTICLE INFO

Article history:
Received: May 30, 2020
Accepted: August 27, 2020

Keywords:
energy demand
energy conservation
semi-mechanized process
groundnut-cake

ABSTRACT

Food industry remains an integral part of the energy-intensive industries. In order to minimise the operating and maintenance cost in the industry, the cost of energy consumption should be monitored. Therefore, energy requirements in groundnut cake production for five alternative methods were elucidated. Groundnut cake was produced using five different methods and energy used for each unit operation was calculated using standard equations. Major energy sources for the production of groundnut cake were fuel, human labour and electrical energy. Sensory attributes of the products were determined by panellists. Data were analyzed using descriptive analysis and analysis of variance at $p \leq 0.05$. Total energy consumed by the traditional and semi-mechanized processes 1-4 were 31,629.12 kJ, 8079.74 kJ, 7932.94 kJ, 8730.58 kJ, and 8519.8 kJ, respectively. Energy intensity for traditional and semi-mechanized processes 1-4 were 9210.93 kJ/kg, 2107.39 kJ/kg, 2069.10 kJ/kg, 2277.15 kJ/kg and 2222.17 kJ/kg, respectively. The frying process was the most energy intensive in both traditional and semi-mechanized process 3 with the energy of 13193.28 kJ and 2232.12 kJ, respectively. Peeling and slicing consumed the least amount of energy (60.4 kJ) in all processes. In semi-mechanized processes 1, 2 and 4, the dry-milling emerged the most energy consuming, with energy of 2240 kJ, 2240 kJ and 2145.6 kJ, respectively. Although, groundnut cake that was produced by traditional method was the most acceptable by the panellist, there was no outright rejection of any sample. Energy consumption pattern and quality attributes of *kulikuli* produced from traditional and semi-mechanisation of production methods were influenced by the type of unit operation, the technology involved and the size of the equipment used. Semi-mechanised methods required the low energy consumption in the production of acceptable *kulikuli*.

Introduction

Globally, energy is regarded as the prime mover of any economy and the engine of growth around which all sectors of economy revolve (Aderemi et al., 2009). Energy availability, management and conservation are pivotal to the economic growth and the development of any country. Therefore, the improvement of energy generation, estimation and conservation is important for the development of industries and nations at large (Wang, 2009). Obviously, current rate of energy generation in developing nations outweighed the supply and rapid growth in energy consumption rate (Jekayinfa and Olajide, 2007; Akinoso et al., 2013). Therefore, diverse approaches to national energy conservation become a *sine-qua-non.* Moreover, the cost of energy consumption can be curtailed by reducing both the operating and maintenance cost to a minimum. Energy consumption, being the prime factor under operating cost in the industries, must be monitored (Wang, 2009). In most of the developing countries, the food processing industries provide an important link

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between the farmer and the consumer (Singh, 1986; Jekayinfa and Bamgboye, 2007). The industry is crucial to ensuring a uniform supply of food throughout the year, but requires a great deal of energy consumption. The energy of diverse forms (human labour, fuel and electrical) or their combinations and quantities are employed to carry-out many operations in these industries, such as cleaning, sorting drying, milling, cooking and the energy can be sourced from oil, gas, coal, solar energy, nuclear energy, wood-fuel, and electricity. Quite often, equipment such as gas-fired ovens, dryers, steam boilers, electric motors, refrigeration equipment, eating systems, and ventilation and air-conditioning systems are involved (Aderemi et al., 2009), with consequentially high energy consumption. It is obvious that the current rate of energy generation and supply cannot match the rapid growth in energy consumption rate (Aiyedun et al., 2008). Therefore, knowledge of energy utilization pattern in food industries is among total energy conservation plans. Small industries are not left out. Among cottage industries with high energy consumption rate, groundnut oil industry together with its bye-product, groundnut cake (*kulikuli)* cannot be neglected. Groundnut cake is a popular bye-product obtained after the extraction of oil from groundnut kernel. It is usually fried and consumed as delicious snack or food supplement (Desai et al., 1996; Adebesin et al., 2001). *Kulikuli* is indigenous to West African coasts and it is a famous food item with long history of consumption in the diet of the low-resource classes of the population in West Africa (Altschul and Wilcks, 1985; Fagbemi et al., 2006). Its consumption has been contributing to overall protein intake for large segment of population and is specifically rampant among the school children and young adults (Emelike and Akusu, 2018). It is the second highest consumed peanut (next to roasted peanuts burger) in Nigeria. The traditional method of processing groundnut seed into *kulikuli* involves different unit operations, like sorting and grading, cleaning, sun drying, roasting, cooling, threshing, salting, pounding, pressing, shaping, deep fat frying and packaging. Most of the unit operations are laborious, time-consuming and energy-demanding, hence energy requirement and processing time of the processing line limit the production of this snack. Thus, devising semi-mechanised processes is imperatively a way out of this menace. Such approach can also improve the textural and other sensory attributes of the product. Improved methods involving replacement of some manual operations with small machines have been suggested in a similar report (Akinoso et al., 2018) during the production of *Robo* (melon-based snacks). Literature, however, reports that energy-consumption patterns in the processing operations of crops, such as rice (Roy et al., 2008), almond (Mohsen et al., 2016), pigeon pea (Akinoso and Odedeji, 2017) and fried melon cake (Akinoso and Are, 2018) are enormous. Literature is sparse on the energy requirements in the production of groundnut cake. Research on energy utilization pattern in processing groundnut seed into cake will assist in suggesting method for conserving energy during its processing. It will help in reducing the production costs and perhaps improve the organoleptic quality of this product. Therefore, this study was designed to elucidate the energy-utilization patterns for five methods of *Kulikuli* production.

Materials and methods

Processes of Kulikuli production

Traditional method was employed in process 1 to produce groundnut cake according to a modified method of Emelike and Akusu, (2018). The unit operations involved are sorting and cleaning, roasting, threshing and de-hulling, dry milling, wet milling, kneading, mixing, moulding, deep frying, packaging and sealing. Weighed amount of groundnut (3.834 kg) was cleaned to remove any form of debris, foreign material and dirt by hand picking. It was then sorted out to remove the bad groundnuts. so as to achieve uniform groundnuts for the production. The sorted and cleaned groundnut was then roasted in a frying pan at a temperature of 100 °C for 15 – 20 minutes. This was carried out to facilitate extraction of the oil during the mixing process, for easier threshing and de-hulling and also for the flavour development. The roasted groundnut was then threshed, de-hulled and air aspirated to remove the hull from the de-hulled groundnut. The next unit operation is milling, an attrition milling machine was used to mill the roasted groundnut into smooth paste. Dried pepper was sorted and cleaned, followed by its milling along with the roasted groundnut. Onions were peeled, sliced and wet milled on a manual attrition mill. The groundnut and peppered paste were mixed with salt and onions for flavour enhancement purposes, and the paste was then kneaded for about 55 minutes in a bowl with pestle. There was occasional wetting of the paste with warm water during kneading, until when the cake was formed and oil was extracted from the groundnut cake. The extracted oil was transferred to another bowl and the groundnut cake was further pressed to expel more oil from the cake. The cake was then moulded into shapes and deep fried in the extracted oil until a golden-brown colour was achieved. The fried spiced groundnut cake was put into a sieve for easy removal of oil and was left to cool prior to proper packaging. The fried spiced groundnut cake was packaged in a polyethylene bag. This process is illustrated in Figure 1. A hydraulic screw press is employed to express the oil in the improved mechanised process. Four different alternative processes (Semi-Mechanised Process (SMP 1-4) were developed and tested, including Milling of roasted groundnut seed before oil expression (SMP 1), Milling of roasted groundnut seed after oil expression (SMP 2), Milling of dried groundnut seed before oil expression (SMP 3) and Milling of dried groundnut seed after oil expression (SMP 4). These processes are illustrated in Figures 2-5, respectively. Roasting was done in processes 2 and 3 with aids of an electric stove and heated pan as against the traditional use of firewood stove. By this, temperature control was achieved and large amount of groundnut roasted at a time. Electric blender was used for dry-milling of spices contrary to the traditional use of attrition mill. Equal amount of ingredients was applied in each of five methods. Acceptability test of the groundnut cake was carried out on a nine-point hedonic scale, using twenty-five untrained panellists, positioned in partitioned booths. Samples were evaluated for five attributes (taste, aroma, texture, appearance and overall acceptability). The scale ratings were as follows: 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike moderately, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely. Samples were evaluated under amber light and the appearance was evaluated under bright colour. Samples receiving an overall quality score of ≥ 6 were considered acceptable (Iwe, 2002).

Determination of energy input in groundnut cake production

Processing of groundnut seed (3.834 kg) into cake was done in the food processing laboratory, Department of Food Technology, University of Ibadan, as described above. Direct measurement and data collection of the applicable parameters in each unit operation during production (Table 1) was used to determine the energy input for the cake production, by fixing the data to standard equations (Eqs. 1-6). The procedures were repeated three times, and the mean data were recorded. A descriptive analysis was performed on the data obtained, as well as the analysis of variance. Significance was accepted at 0.05 probability level.

$$EP = \Omega Pt \quad (1)$$

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

$$Em = MNt \quad (3)$$

$$Ef = FNt \quad (4)$$

$$Te = \sum En \quad (5)$$

$$Ein = \sum En / Q \quad (6)$$

where, EP is the electrical energy consumed (kWh); P is the rated power of the motor (kW); t is the operation time (h), Ω = 0.8 is the power factor; Et is the fuel energy consumed (MJ); C is the calorific value of fuel used (MJ/kg), which is 17.51 and 43.1 MJ/kg for wood and kerosene, respectively; W is the quantity of fuel used (kg); M is the average power input by a male labourer (0.75 MJ/h) (Abubakar et al., 2010); F is the average power input by a female labourer (0.68 MJ/h) (Abubakar et al., 2010); N is the number of human labourers involved. E_M and E_F are human labour energy used by male and female, respectively. Q is the quantity of materials processed. E_n is the number of energy sources. T_e is the total energy consumed (MJ) and E_{in} is the energy intensity (MJ/kg).

Results and discussion

Energy demand for traditional process

The average total energy for converting 3,834 g of groundnut seed into spiced groundnut cake using the traditional process (Table 2) was estimated as 31,629.12 kJ, with the energy intensity of 9,210.93 kJ/kg. This comprises of 69.57% (2,4567 kJ/kg) fuel energy, 24.09% (8,507.72 kJ/kg) human labour energy and 6.34% (2,240 kJ/kg) electrical energy. The peeling/slicing and deep frying operations were the least and most energy intensive, with energy intensities of 60.4 kJ/kg (0.17%) and 13193.28 kJ/kg (37.36%), respectively. The energy input during frying process has the highest energy input, which may be due to two types of energy involved (fuel and human labour input), and the high calorific value of kerosene. Roasting was the second most energy intensive process with (12272.68 kJ/kg), which is 34.75% of the total energy. The energy flow diagram for traditional process was shown in Figure 1.

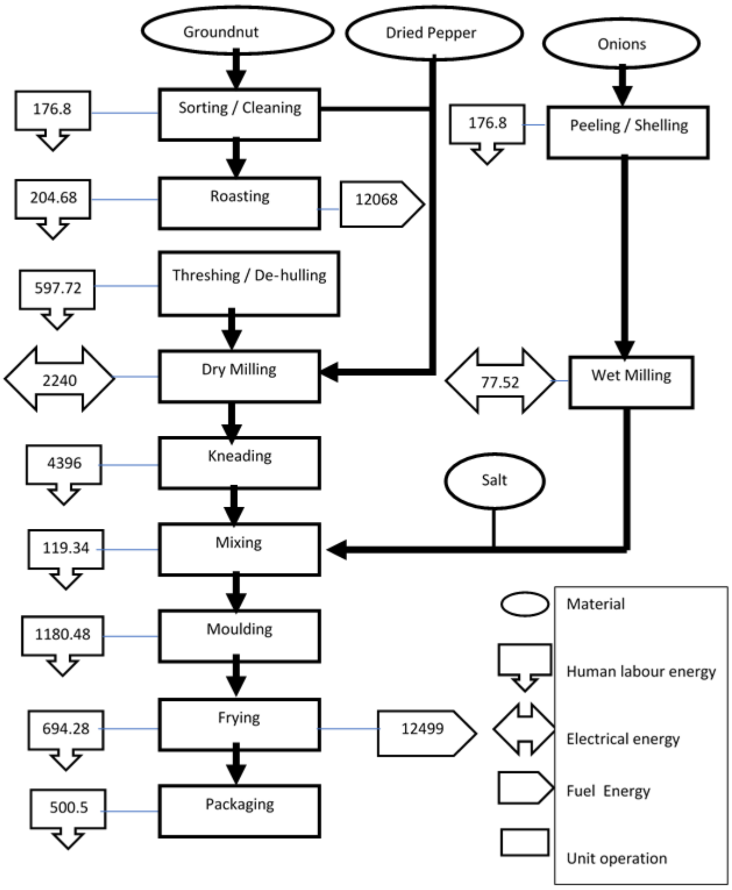

Fig. 1. Energy-flow diagram for process 1 (Traditional method).

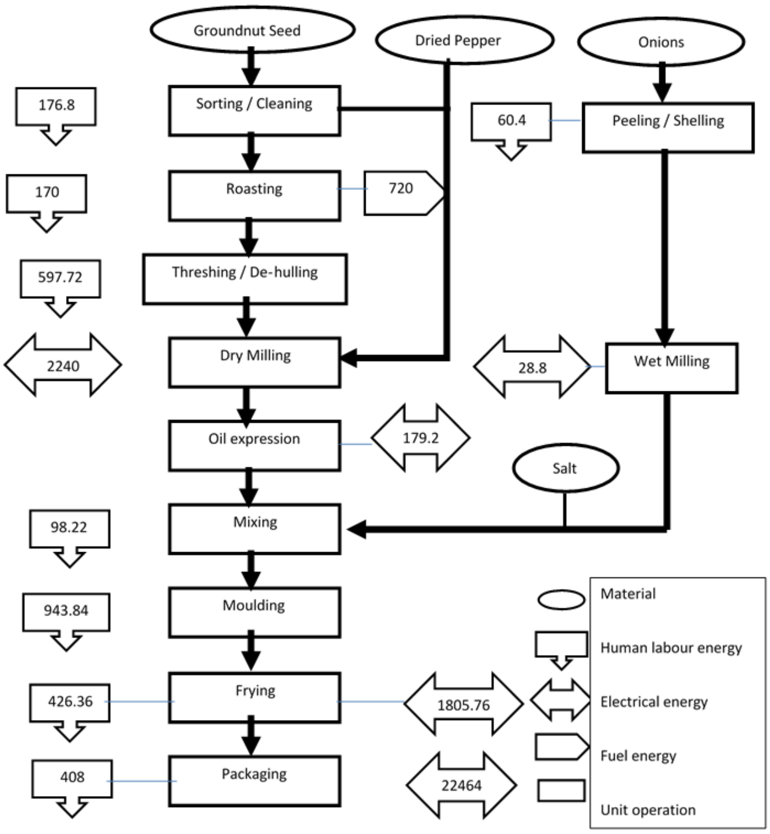

Fig. 2. Energy-flow diagram for SMP1

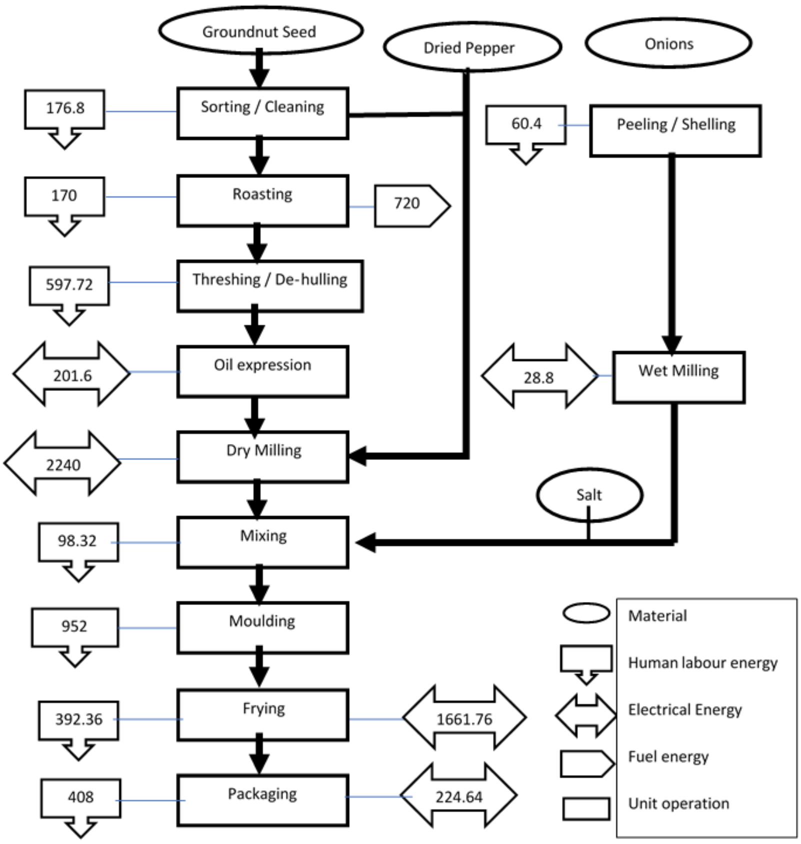

Fig. 3. Energy-flow diagram for SMP2

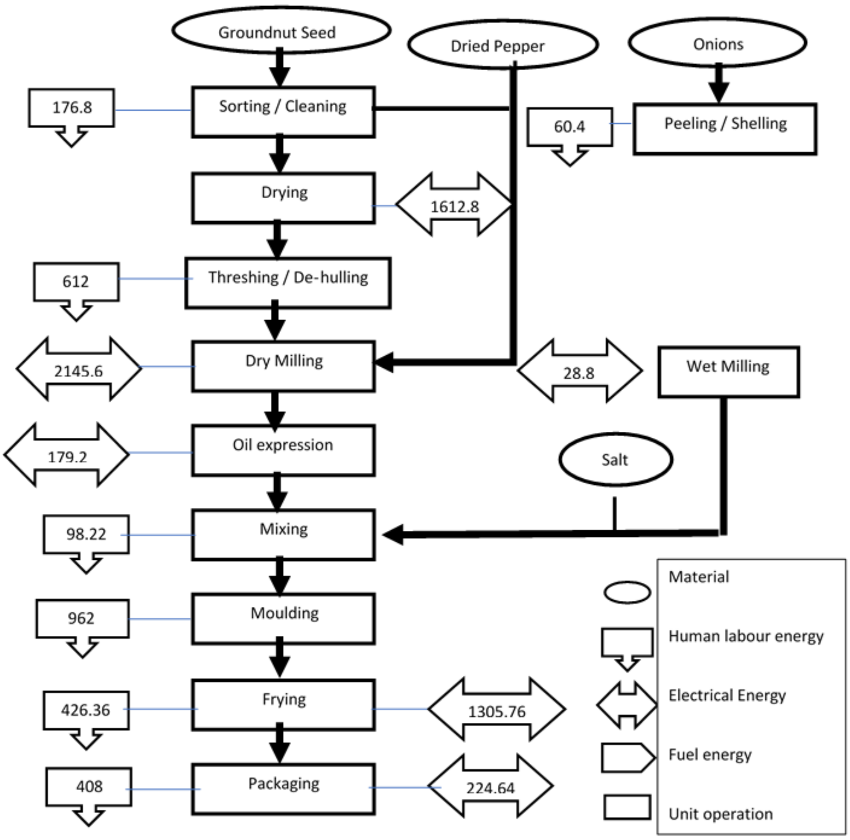

Fig. 4. Energy-flow diagram for SMP3

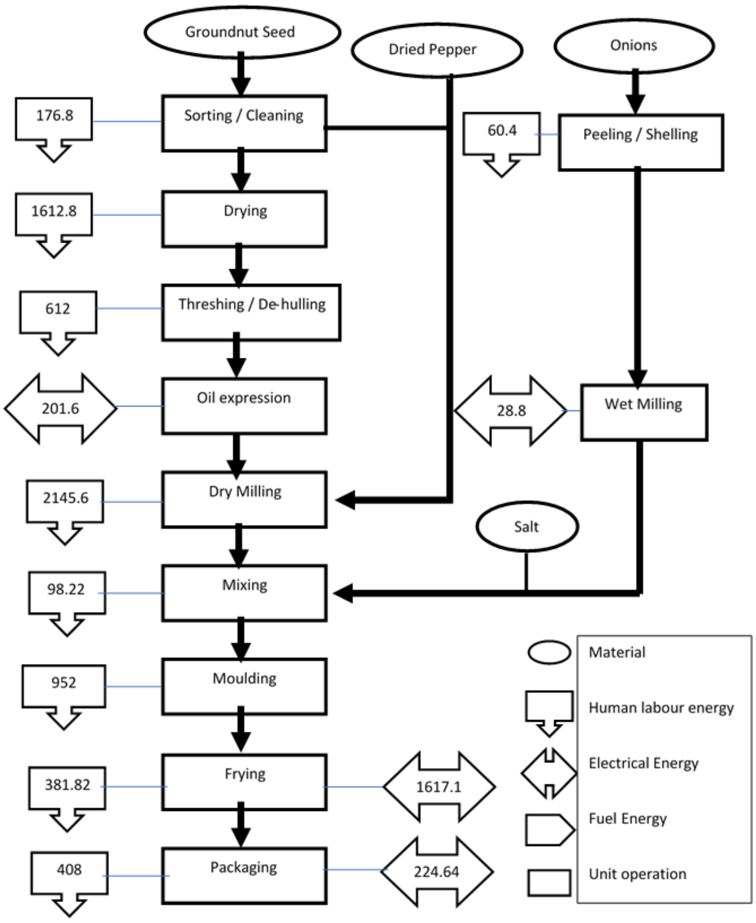

Fig. 5. Energy-flow diagram for SMP4

Energy demand for SMP 1

By using SMP 1 process, the conversion of 3,834 g groundnut seed into cake demanded a total energy of 8,079.74 kJ (Table 2), an energy intensity equivalence of 2,107.39 kJ/kg. Dry milling process was the most energy intensive with a total energy of 2240 kJ. This corresponded to 27.72% of the total energy input what is perhaps a consequence of the high time taken for the milling of groundnut. However, peeling and slicing claimed the least energy input of 60.4 kJ, amounted to 0.74% of human labour energy. In comparison with kneading process, oil expression required low energy input. This may be associated to lower time involved during the course of expression using a hydraulic press, which drastically reduced the time from an hour to less than 3 minutes. In all, human labour and electrical energies were consumed. The total energy for human labour energy was estimated to be 28881.34 kJ, which corresponded to 35.66% of the total energy input, while electrical energy consumption was estimated to be 5198.32 kJ, which corresponded to 64.33% of the total energy. The energy flow diagram for semi-mechanized process 1 was as shown in Figure 2.

Energy demand for SMP 2

When SMP 2 process was employed to process 3,834 g groundnut seed into cake, the total energy input was estimated to be 7,932.94 kJ and energy intensity was 2,069.10 kJ/Kg (Table 2). The values were lower than those of SMP 1, possibly due to higher energy consumption during frying process. SMP 1 undergoes frying process with energy value 2232.12 kJ, while SMP 2 undergoes the same unit process with energy value of 2054.12 kJ. However, dry-milling operation was still the most energy intensive with a total energy of 2,240 kJ, equivalent to 28.24% of the total energy. In SMP 2, oil expression claimed higher energy input (201.6 kJ) than that of SMP 1 (179.2 kJ). It may be due to the fact that oil was expressed from a non-milled groundnut seed which took a longer period of time as compared with SMP 1, where the oil was expressed after milling of the groundnut seed. Human labour and electrical energies were consumed in this process, with the human labour energy estimated to be 2855.5 kJ (36%) and electrical energy estimated to be 5076.8 kJ (64.33%). In general, SMP 2 has the lowest energy consumption among all the processes. The energy flow diagram for Semi- mechanised process 2 is as shown in Figure 3.

Table 1. Measured parameters for evaluating energy consumption pattern

Unit operation	Required parameter	TP	SMP 1	SMP 2	SMP 3	SMP 4
C and S	Number of persons	3	3	3	3	3
	Time taken (S)	312	312	312	312	312
Roasting	Number of persons	1	1	1	NA	NA
	Fuel (L)	0.28	NA	NA	NA	NA
	Time taken(S)	1200	900	900	NA	NA
	Electric stove power (kW)	NA	1	1	NA	NA
Drying	Number of persons	NA	NA	NA	1	1
	Time taken (S)	NA	NA	NA	720	720
	Rated power (kW)	NA	NA	NA	2.8	2.8
T and D	Number of persons	3	3	3	3	3
	Time taken (S)	1053.6	1053.6	1053.6	1080	1080
Dry milling	Number of persons	1	1	1	1	1
	Time taken (S)	939.6	939.6	936.6	900	900
	Rated power (kW)	2.98	2.98	2.98	2.98	2.98
P and S	Number of persons	NA	NA	1	1	1
	Time taken (S)	NA	NA	320	320	320
Wet milling	Number of persons	1	1	1	1	1
	Time taken (S)	408.6	120	120	120	120
	Rated power (kW)	0.3	0.3	0.3	0.3	0.3
Kneading	Number of persons	2	NA	NA	NA	NA
	Time taken (S)	3600	NA	NA	NA	NA
OEX	Number of persons	NA	1	1	1	1
	Time taken (S)	NA	80	90	80	90
	Rated power (kW)	NA	2.8	2.8	2.8	2.8
Mixing	Number of persons	1	1	1	1	1
	Time taken (S)	631.8	520	520	520	520
Moulding	Number of persons	2	2	2	2	2
	Time taken (S)	3123	2500	2520	2520	2520
Frying	Number of persons	1	1	1	1	1
	Time taken (S)	3675.6	2257.2	2077.2	2257.2	2021.4
	Rated power (kW)	1	1	1	1	1
Packaging	Number of persons	3	2	2	2	2
	Time taken (S)	1260	1080	1080	1080	1080
	Rated power (kW)	0.26	0.26	0.26	0.26	0.26

*C and S Cleaning and Sorting; *T and D Threshing and De-hulling; *SMP 1 Semi-Mechanized Process 1; *P and S Peeling and Slicing; *SMP 2 Semi-Mechanized Process 2; *OEX Oil Expression; *SMP 3 Semi-Mechanized process 3; “NA” means “not applicable; *SMP 4 Semi-Mechanised Process 4; *TP Traditional process

Table 2. Comparison of the energy consumption per unit operation between traditional and semi-mechanized processes

Unit operations	*TP*	*SMP 1*	*SMP 2*	*SMP 3*	*SMP4*
Cleaning and sorting	176.8	176.8	176.8	176.8	176.8
Roasting	12272.68	890	890	N/A	N/A
Drying	N/A	N/A	N/A	1612.8	1612.8
Threshing and de-hulling	597.72	597.72	597.72	612	612
Dry milling	2240	2240	2240	2145.6	2145.6
Peeling and slicing	60.4	60.4	60.4	60.4	60.4
Wet milling	77.52	28.8	28.8	28.8	28.8
Kneading	4896	N/A	N/A	N/A	N/A
Oil expression	N/A	179.2	201.6	179.2	201.6
Mixing	119.34	98.22	98.22	98.22	98.22
Moulding	1180.48	943.84	952	952	952
Frying	13193.28	2232.12	2054.12	2232.12	1998.94
Packaging	500.5	632.64	632.64	632.64	632.64
Total	31,629.12	8,079.74	7,932.94	8,730.58	8,519.8

**TP: Traditional Process. *SMP 1: Semi-Mechanized Process 1 *SMP2: Semi-Mechanized Process 2 *SMP3: Semi-Mechanized process 3 *SMP4: Semi-Mechanised Process 4*
**N/A: Not applicable*

Energy demand for SMP 3

In SMP 3, the total energy demand to convert 3,834 g groundnut seed into cake was 8,730.58 kJ with an estimated energy intensity 2,277 kJ/kg. The energy consumed was higher than those of SMP 1 and SPM 2. The observed disparity could be a consequence of energy consumption caused by the replacement of roasting with drying carried out in semi-mechanised processes 1 and 2. There is also a change of energy form from fuel energy to electrical energy. SMP 3 undergoes drying process with energy value 1612.8 kJ, while SMP 1 and 2 undergo roasting process with energy value of 890 kJ. Frying operation was the most energy intensive with a total energy of 2,232 kJ corresponding to 25.57% of the total energy input due to the longer length of time involved during frying. Oil expression energy input is of the same value with semi-mechanised process 1, with the energy input of 179.2 kJ. As shown in Table 2, human labour and electrical energies were consumed in this process, with the manual energy estimated to be 2,733.78 kJ (31.31%) and electrical energy 5,996.8 kJ (68.69%). The energy flow diagram for semi-mechanized process 3 is shown in Figure 4.

Energy demand for SMP 4

The estimated total energy in this process to convert 3,834 g groundnut seed into cake was 8519.8 kJ as shown in Table 2 and the average energy intensity is 2,222.17 kJ/kg. The energy consumed in semi-mechanised process 4 was higher than those of semi-mechanised processes 1 and 2 due to higher energy consumption caused by the substitution of roasting process which was done in semi-mechanized processes 1 and 2 by drying process. This also involved a change of energy usage from fuel energy to electrical energy. Semi-mechanized process 4 undergoes drying process with energy value 1612.8 kJ, while semi-mechanized processes 1 and 2 undergo roasting process at energy value of 890 kJ. Dry milling was the most energy intensive with a total energy of 2,145.6 kJ, an amount equivalent to 25.18% of the total energy input. This may be associated with the length of time involved during milling. The energy input for oil expression is of the same value as in semi-mechanized process 2, i.e. (179.2 kJ). With reference to Table 2, human labour and electrical energies were consumed in this process. The manual energy used was 2,689.24 kJ (31.56%), while the electrical energy utilized equals 5,830 kJ (68.44%). The energy flow diagram for Semi-mechanized process 4 is shown in Figure 5.

Comparison of energy-consumption pattern of processes

The total energy consumption for the traditional process, SMP 1 (Milling of roasted groundnut seed before oil expression), SMP 2 (Milling of roasted groundnut seed after oil expression), SMP 3 (Milling of dried groundnut seed before oil expression) and SMP 4 (Milling of dried groundnut seed after il expression) was 31,629.12 kJ, 8079.74 kJ, 7932.94 kJ, 8730.58 kJ and 8519.8 kJ, respectively. Their respective energy intensities were 9210.93 kJ/kg, 2107.39 kJ/kg, 2069.10 kJ/kg, 2277.15 kJ/kg and 2222.17 kJ/kg. The hydraulic screw press employed to express the oil in the improved mechanised processes obviously reduces the energy consumption. Similar result was reported by Akinoso and Are (2018) in a study involving energy requirement of five alternative methods of *Robo* production. By far, higher amount of energy (12272.68 kJ) was used for roasting in traditional process than those of semi-mechanised processes 1-2 with values of 890 kJ each. It was also higher than (1612.8 kJ) each, utilized for drying in processes 3-4 (Table 2). Possible reasons for these disparities may be attributed to the use of an electric stove and heated pan in SMP 1 and 2 as against the traditional use of firewood stove for roasting. By this, temperature control was achieved and a large amount of groundnut roasted at a time, thereby reducing the length of time used. Less energy consumption (1612.8 kJ) for drying process in SMP 3 and 4 than roasting (12272.68 kJ) used in the traditional method is attributable to the low energy efficiency of the burner used for roasting. According to Mohod et al. (2010), with better utilization of the installed production capacity, the energy efficiency improved. Additionally, the energy accounted for roasting in TP is 34.75%, as compared with SMP 1 and SMP 2, possessing lower values 11.02% and 11.23%, respectively. Utilization of electrical energy (hotplate) in place of fuel energy (kerosene) in the semi-mechanized process could be responsible for this observed trend. Similar trend was observed for drying in SMP 3 and SMP 4 with values (18.47%) and (18.93%), respectively. The same energy utilization patterns were observed for mixing, moulding and kneading, with the ones of traditional processes being the highest. Kneading employed in the traditional process consumed over 27 times the amount of energy for mechanical oil expeller in SMP 1-4 and this was quite equivalent to 13.86% of total energy used via the traditional method. The percentage of total energy for SMP 1-4 was 2.22%, 2.54%, 2.05%

and 2.37%. Frying was the most energy intensive operation, not only in the traditional process, but in all the semi-mechanised processes, too. However, energy consumption for frying in the traditional process (13193.28 kJ) was almost always in folds of six when compared to those of SMP 1 (2232.12 kJ), SMP 2 (2054.12 kJ), SMP 3 (2232.12 kJ) and SMP 4 (1998.94 kJ). These margins, when translated to money, have definite implications on energy cost and national growth (Aiyedun et al., 2008). It implies that SMP 1-4 possess better energy conservation potential than the traditional process. Procedural and behavioural approaches in food processing have been described as potential means of saving energy and its cost (Akinoso and Olatoye, 2013).

Sensory characteristics of kulikuli produced from five alternative methods

Sensory attributes of the products varied significantly ($p \leq 0.05$) among the processes (Table 3). Groundnut seed cake produced from Traditional process (TP) had the highest mean scores for all the sensory attributes, perhaps as a consequence of experience of panellist. Similar result was documented by Akusu and Emelike, (2018). This was closely followed by SMP 3 (Milling of dried groundnut seed before oil expression). However, there was no rejection of any product, considering the range (6.20-7.80) of the overall acceptability scores. It showed that all the cakes were generally acceptable for all evaluated parameters, as none scored below the minimum acceptable rating of five on a 9-point hedonic scale in accordance with (Alozie et al., 2009). In addition, Table 4 depicted comparative rating of sensory scores and energy requirement. Conversely, TP was rated the least in terms of energy efficiency, as it required the highest amount of energy compared to semi-mechanised processes (1-4). SMP 2 (Milling of roasted groundnut seed after oil expression) is the best in terms of energy efficiency. From the foregoing, groundnut seed cake of sensory attributes similar to those of traditional process and with lower energy demand can be obtained using SMP (1-4), especially SMP 2.

Table 3. Sensory characteristics of groundnut cake produced from five different processing methods.

Processing methods	*Appearance*	*Flavour*	*Taste*	*Texture*	*Mouth feel*	*Overall acceptability*
TP	*8.20^{a}*	*7.30^{a}*	*7.90a*	*7.30^{a}*	*7.70^{a}*	*7.80^{a}*
SMP 1	*6.80^{c}*	*5.90^{d}*	*6.20^{c}*	*6.00^{d}*	*5.80^{d}*	*6.30^{d}*
SMP 2	*6.70^{d}*	*6.70^{b}*	*6.20^{c}*	*6.10^{c}*	*6.20^{b}*	*6.70^{c}*
SMP 3	*7.10^{d}*	*5.70^{e}*	*6.30^{b}*	*6.40^{b}*	*6.20^{b}*	*7.00^{b}*
SMP 4	*6.50^{e}*	*6.00^{d}*	*5.60^{d}*	*5.70^{e}*	*6.10^{c}*	*6.20^{e}*

Values with the same superscript within a column are not significantly different at $p \leq 0.05$

Table 4. Comparative ratings of consumers' acceptability and total energy requirements of groundnut cake produced from different processing methods

Processing methods	*Consumers acceptability(X)*	*X-Rating*	*Energy requirements(Y)*	*Y-Rating*
TP	7.80^{a}	1st	31,629.12	5th
SMP 1	6.30^{d}	4th	8,079.74	2nd
SMP 2	6.70^{c}	3rd	7,932.94	1st
SMP 3	7.00^{b}	2nd	8,730.58	4th
SMP 4	6.20^{e}	5th	8,519.80	3rd

Values with the same superscript in a column are not significantly different at $p < 0.05$. TP: Traditional process; X-Rating: Rating in terms of high acceptability; Y-Rating: Rating in terms of the lowest energy requirement.

Conclusion

The energy requirements for the traditional and SMP 1,2,3 and 4 to transform 3843 g of groundnut seed to cake was estimated at 31629.12 kJ, 8079.74 kJ, 7932.94 kJ, 8730.58kJ and 8519.8kJ, respectively. The corresponding energy intensities were 9,210.93 kJ/Kg, 2107.39 kJ/Kg, 2069.10 kJ/Kg, 2277.15 kJ/Kg and 2222.17 kJ/Kg. Apparently, the involvement of machine in some unit operation during production of *kulikuli*-groundnut based cake conserved time, saved energy and reduced drudgery. Groundnut seed cake of similar sensory attributes to that of traditional process and with lower energy demand can be obtained using SMP (1-4), especially SMP 2 (Milling of roasted groundnut seed after oil expression). Application of semi-mechanised methods could substantially save energy consumption in the production of acceptable *kulikuli* and similar products.

Author Contributions: This work was carried out in collaboration among three authors. Author RA designed the study, wrote the protocol and interpreted the data. Authors KKO and YRA anchored the field study, gathered the initial data and performed preliminary data analysis. The authors RA, KKO and YRA managed the literature searches and produced the initial draft. All authors read and approved the final manuscript.

Funding: This research received no external funding

Conflicts of Interest: The authors declare no conflict of interest.

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