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Energy use analysis in rice milling: a case study of lafia rice mill nasarawa state, Nigeria

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ABSTRACT

The study examined the energy used for milling rice in Lafia rice mill. A sample of 50 randomly selected rice mills were used for the study. Simple descriptive statistics, production function analysis and correlation analysis were used for data analysis. The result shows that the average total energy used daily for rice milling was 2427.44MJ/mill with diesel energy having the largest share (54.66%) of the average total daily energy used. Furthermore, to mill a bag of paddy about 211.06MJ of energy was required. The energy productivity was 0.37MJ/mill. Diesel and paddy were the most significant inputs that influenced the output of milled rice. The elasticity value range from 0.19 to 7.37 for paddy and diesel respectively. Rice milling in the research area was observed to be dependent on direct and non renewable energy forms especially diesel. The study recommends development of cleaner and safer energy forms such as solar energy for rice milling in the study area.

Introduction

In recent years, there has been an evolution of mechanized farm operations in Nigeria. Small- scale cottage agro based industries are springing up (Jekayinfa, 2006). Some of these agro based industries include; rice mills, feed mills hatcheries and modern poultry. These establishments make use of energy in various forms for their operations. However, for these systems to obtain maximum performance, the production cost must be reduced. This can only be achieved by continuously monitoring the management of energy inputs and making sure that wastage is minimized or eliminated entirely. Energy is an essential input in the growth and development of the various sectors of an economy. Efficient energy use in agriculture is one of the conditions for sustainable agricultural production, since it provides financial savings, fossil fuels preservation and air pollution reduction (Pervanchon, 2002). Throughout Africa, rice milling is one of the most widely spread and important of the rural based agro-processing industries. Rice milling in Nigeria is mainly carried out by small-scale machines with an average hourly capacity of 200kg (Coalition for Africa Rice Development, 2007). Several researchers have conducted studies on energy consumption for the different agricultural processes in Nigeria (Jekayinfa, 2001; Jekayinfa and Olafimihin, 2000; Aiyedun and Onakoya 2000; Megbowon and Adewunmi, 2002; Bamgboye and Jekayinfa, 2006).

However, documented works on energy use analysis in rice milling in Nigeria and Nasarawa state in particular are not available. According to Abubakar and Ahmed (2010), data on energy expenditure and returns in Nigerian agriculture are not enough in Nigeria. Thus, there is an immediate need to conduct a study in order for relevant measures that can help improve rice milling in Nigeria to be formulated. Based on the foregoing, the energy use pattern, energy inputs-output relationship and the productivity of energy inputs utilization in Rice milling were determined.

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Materials and methods

Lafia is located in Nasarawa south geo- political zone of Nasarawa state. It is within latitude 09^0 33N and 09^0 33E with an altitude of 181.33m. The main occupation of the inhabitants is farming. It has a population of 330,712 people (National Population Census, 2006). It has a tropical climate with two main seasons, namely; rainy and dry seasons. The soil structure of the area is suitable for arable crop production and conducive for livestock rearing example sheep and goats. Some of the major crops grown in the area include; Rice, Groundnut, Benniseed, Cassava and Cowpea.

A pre-survey visit to the Lafia rice mill site was conducted to obtain a sampling frame for the rice millers. From the pre-survey, a total of 115 rice mills were observed and 50 mills were sampled using simple random sampling technique. The data required for the study were collected from the operators of the mills through the use of structured questionnaires. Data were collected on inputs and output in rice milling. Each sampled rice mill was tagged and data were collected once a week for a period of three weeks. Simple descriptive statistics, production function analysis, correlation analysis were used for data analysis.

Three functional forms of the production function model (linear, double-log and semi-log) were fitted to the data and the linear model was selected for result discussion based on the following criteria; coefficient of multiple determination (R^2), expected signs of the regression coefficients and number of significant variables. The explicit form of the production function is specified as follows;

$$Y = a + ß_1X_1 + ß_2X_2 + ß_3X_3 + ß_4X_4 + ß_5X_5 + ß_6X_6 + U.$$

Where,

Y = Milled rice output (Kg)

X_1 = Human labour (MJ)

X_2 = Water (MJ)

X_3 = Rice paddy (MJ)

X_4 = Diesel (MJ)
X_5= Machinery (MJ)
X_6= Electricity (MJ)
$ß_1$- $ß_6$ = regression coefficients
a = Constant term
U = error term.

Correlation analysis was used to determine the relationship between energy forms and milled rice. The energy forms considered include; indirect energy (machinery), direct energy (water, diesel, electricity, human labour), renewable energy (water, human labour) and non-renewable energy (electricity, machinery, diesel). The expression below was used to compute the value for energy productivity.

$$\text{Energy productivity} = \frac{\text{Milled rice output (Kg)}}{\text{Energy input (MJ)}}$$

The inputs (water, electricity, diesel, paddy rice, machinery hour and human labour) used in rice milling as well as the output (milled rice) were converted into energy equivalent units using the values giving in Table 1.

Results and discussion

Daily inputs and output level for rice milling per mill

The daily energy inputs and output in rice milling are presented in Table 2. The result shows that the quantity of paddy milled daily range from 500kg to 4500kg with an average of 1150kg which is equal to 16,905MJ in energy equivalent. The result also reveals that the quantity of labour used range from 12 to 1100 Man hrs with an average of 115.7 Man hrs which in the energy equivalent is equal to 226.77MJ. The average quantity of diesel used (23.58Liters) in energy equivalent was 1327.7 MJ, while an average of 13.94KW of electricity equivalent to 147.62MJ of the energy was used. The result also shows that an average of 9.8 machine hours and 948 liters of water were used. This corresponds to 1279MJ and 597.45MJ of energy respectively. On a daily basis the quantity of milled rice obtained range from 375kg to 3750kg with an average of 950kg equivalent to 13,680MJ of energy. However, to mill a bag of paddy (100kg), an average of 211.08MJ of energy was required.

Energy use pattern in rice milling

The energy consumption pattern for milled rice is presented in Table 3. The average total daily energy used for rice milling was 2427.44MJ/mill. Water energy had 25.10% diesel 54.60%, labour 9.34% electricity and machinery were 6.08% and 5.26% respectively. Diesel energy had a significant share of the total energy input used. This was because the milling centre use diesel as the major source of power due to the epileptic power supply in the study area. This was closely followed by water, labour and electricity energy respectively. On a daily basis, a total of 2427.44MJ/mill of energy was consumed.

Energy forms in rice milling

Direct indirect and renewable non-renewable energy forms used in rice milling are presented in Table 4. The result shows that the share of direct energy was 95% in the total energy, while indirect energy forms was 5%. On the other hand, renewable and non-renewable energy forms contributed 34% and 66% respectively to the total energy used for rice milling. The share of non-renewable energy was higher than the renewable energy forms. This was due to the fact that diesel energy accounted for about 58% of the total direct energy used. This indicates that rice milling in the research area depends mainly on a fossil fuel especially diesel. This dependence on fossil fuels is not sustainable in the long run because it leads to carbon emission, global warming and climate change. The share of the direct energy form was quite higher than the indirect energy form. It is very clear from these results that rice milling in the study area is mainly dependent on both direct and non renewable energy forms.

Relationship between energy inputs and output in Rice milling

The linear model gave the best fit to the data. The result from Table 5 implies that about 72% of the variation in output of milled rice was explained by the energy inputs included in the model. The result shows that paddy and diesel were positive and significant at ($p<0.10$) and ($p<0.05$) respectively. However, machine hours, electricity and labour energy had a positive signs but were not significant.

The result in Table 6 shows that the elasticity estimates for the significant energy inputs. The result shows that the elasticity for diesel and paddy were 7.37 and 0.19 respectively. A 1% increase in diesel and paddy will lead to a 7.37% and 0.19% increase in the output of milled rice respectively. The sum of the elasticity was computed to be 7.56. This means that a 1% increase in all the energy input will lead to 7.56% increase in the output of milled rice.

Relationship between energy forms and output of milled rice

The relationship between energy forms and milled rice output in Table 7 shows that the direct and non-renewable forms of energy had a positive and significant relationship ($p<0.05$) with the output of milled rice. However, renewable and indirect energy forms had a positive, weak and not significant relationship with the output of milled rice. This implies that milled rice output is dependent on both direct and non-renewable forms of energy. This is in line with result obtained in Table 5.

Energy inputs productivity in Rice milling

The result in Table 8 shows that the energy productivity of energy input used in rice milling range from 0.67 to 7.03. However, the total energy productivity for all input was 0.37. The result implies that the most productive energy input for rice milling in the research area was the number of machine hours used, while the least productive energy input was quantity of diesel used. This implies that an increase in the number of machine hours will lead to an increase in milled rice output. The energy productivity value of 0.37 means that 1MJ of energy will produce about 0.37Kg of milled rice.

Conclusion/ Recommendations

Rice milling in the study area is mainly depended on direct and non- renewable energy forms especially diesel as a result, the productivity of rice milling in the study area is very low. To enhance energy productivity in rice milling and to save cost, there is need to introduce more fuel efficient rice milling machines. The potentials of cleaner and safer energy forms for rice milling especially solar energy should be exploited. The rice millers need both institutional and technical advice to enable them use energy inputs more efficiently. The rice millers should be sensitized by Nasarawa Agricultural Development Project (NADP) on impact of fossil fuels especially diesel on global warming and climate change. Trees should be planted around rice mills to help trap carbon emitted and mitigate climate change.

References

1. Abubakar, M.S., and Ahmed, O. (2010). Pattern of energy consumption in millet production for selected farms in Jigawa, *Nigeria. Australian Journal of Basic and Applied Sciences*, 4(4): 665-672.

2. Aiyedun P.O., and Onakoya B.A..(2000). Energy Efficiency in a Private Sector - A Case Study of Seven - Up Bottling Company, Ibadan. A Paper Presented at the Annual Conference of Nigerian Institute of Industrial Engineers, Ibadan. 13pp.
3. Akinbami J.F., Ilori M.O., Adeniyi A.A., and Sanni S.A. (2001) "Improving Efficiency of Energy Use in Nigeria's Industrial Sector": A Case Study of a Beverage Plant. *Nigerian Journal of Engineering Management* 2(2):1-8.
4. Bamgboye, A. and S. Jekayinfa (2006). "Energy Consumption Pattern in Palm Kernel Processing Operations". Agricultural Engineering International: the CIGR Ejournal. Manuscript EE 05 013. Vol. VIII. March.
5. Canakci M., Topakci M., Akinci I., and Ozmerzi A. (2005.) Energy use pattern of some field crops and vegetable production: Case study for Antalya Region, Turkey. *Energy and Conversion Management* 46(4):655–666.
6. Coalition for Africa Rice Development,(2007). National Rice Development Strategy (NRDS). Federal Republic of Nigeria.Retrieved from www.jica .go.se March 27,2010
7. Jekayinfa S.O., and Olafimihan E.O.,(2000). "A Study and Analysis of Energy Consumption in Beverage Producing Plants in Nigeria". A Paper Presented at the Annual Conference of Nigeria Institute of Industrial Engineers, Ibadan. 12th-17th, October.
8. Jekayinfa S.O. (2001). Energy Accounting in Industrialised Agriculture – A Review. *Journal of Applied Sciences* 4 (1): 1562 – 1577.
9. Jekayinfa S. O. (2006). "Energy Consumption Pattern of Selected Mechanized Farms in Southwestern Nigeria". Agricultural Engineering International: the CIGR Ejournal. Manuscript EE 06 001. Vol. VIII. April.
10. Megbowon I.O. and Adewunmi S.O. (2002). Effect of failure of NEPA electricity on the finance of small and medium scale industries: case study of two agro-allied industries in Ondo State. Nigerian *Journal of Industrial Safety and Systems* .1(1): 28 – 31.
11. National Population Commission NPC (2006). National Population Census, NPC: Abuja
12. Ozkan, B., H. Akcaoz and F. Karadeniz. (2004). Energy requirement and economic analysis of citrus production in Turkey. *Energy Conversion and Management* 45: 1821-1830.
13. Pervanchon, F., Bockstaller, C. and P. Girardin, P. (2002). Assessment of energy use in arable farming systems by means of an agro-ecological indicator: the energy indicator. *Agricultural Systems* 72:149–172
14. Singh, H., Mishra, D. and Nahar, N.M. (2002). Energy use pattern in production agriculture of a typical village in Arid Zone India-Part I. *Energy Conversion and Management* 43(16):2275-2286.

Table 1 Energy equivalents for inputs and output in rice milling

Inputs	Energy Equivalent (MJ/ Unit)	Reference
Human labour (Mhr)	01.96	Singh *et al* (2002)
Machinery (hr)	13.06	Singh *et al* (2002)
Diesel oil (Litre)	56.31	Singh *et al* (2002)
Paddy (Kg)	14.70	Singh *et al* (2002)
Electricity (Kw)	10.59	Ozkan *et al* (2004)
Milled rice (Kg)	15.20	Canakci *et al* (2009)

Table 2 Daily energy inputs and outputs in rice milling per mill

	Paddy (Kg)	Human Labour (Mandays)	Diesel (Litres)	Electricity (Kilowatt)	Machinery (Hours)	Water (Litres)	Output (Kg)
Average	1150.0	115.2	23.8	13.9	9.8	948.0	900.0
	(16905.0)	226.8	(1327.7)	(149.6)	(127.9)	(597.5)	(14440.0)
Minimum	500 .0	12.0	7.1	11.5	8.0	100.0	375.0
	(7350.0)	(23.5)	(402.2)	(121.2)	(104.5)	(63.0)	(5700.0)
Maximum	4500.0	1100.0	42.9	17.2	12.0	2000.0	3750.0
	(6650.0)	(2156.0)	(2413.3)	(181.9)	(156.8)	(1260.0)	(5700.0)

The figures in parentheses are the energy equivalents in Mega joules

Table 3: Composition of energy used per rice mill

Inputs	Quantity	Energy equivalent (MJ)	Percentage
Water	948.0	597.5	25.1
Diesel	22.6	1327.5	54.6
Labour	115.7	226.8	09.3
Electricity	13.9	147.6	06.1
Machinery	09.8	127.9	05.3
Total energy input	-	2427.4	100.0

Table 4: Total energy input in form of direct, indirect and renewable and non-renewable energy for rice milling

Energy forms	Total energy input	Percentage
Direct energy[a]	2299.5	95.00
Indirect energy[b]	127.9	05.00
Total	2427.4	100.00
Renewable energy[c]	824.2	34.00
Non-renewable[d]	1603.2	66.00
Total	2427.4	100.00

a-Water, diesel, electricity and human labour, b-machinery, c- Water, human labour, d-Electricity, machinery and diesel.

Table 5: Relationship between energy inputs and milled rice

Variables	Coefficient	Standard error	T-value
Constant	-6719.4	13655.20	-0.492
Labour (X_1)	06.7	06.04	1.111
Water (X_2)	-07.3	12.10	-0.603
Diesel (X_3)	13.5	06.23	2.168**
Paddy (X_4)	0.17	0.08	2.071*
Machinery (X_5)	31.94	109.04	0.305
Electricity (X_6)	56.40	47.60	1.185
R^2= 0.726			

**=significant as 5%, *= Significant at 10%

Table 6: Elasticity estimates for energy inputs.

Energy input	Elasticity
Diesel	7.37
Paddy	0.19
Sum of elasticity	7.56

Table 7: Relationship between energy forms and output of milled rice

Energy forms	Correlation coefficient
Indirect energy	0.222[NS]
Direct energy	0.614**
Renewable energy	0.434[NS]
Non-renewable energy	0.602**

** Significant at 5 %

Table 8: Productivity of energy inputs per mill

Input	Quantity per day	Energy equivalent	Energy productivity
Water (Lt)	948.00	597.45	1.50
Diesel (Lt)	23.58	1327.70	0.67
Labour (mhr)	115.70	226.77	3.90
Electricity (Kw)	13.94	147.60	6.09
Machinery (hr)	09.80	127.90	7.03
Total energy input (MJ)	-	2427.00	-
Milled rice output (Kg)	900.0	14440.00	0.37