

Comparative Performance of Composite Sawdust Briquette with Kerosene Fuel under Domestic Cooking Conditions

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Abstract

A comparative performance of composite sawdust briquette with kerosene fuel during domestic cooking conditions is discussed in this paper. Controlled cooking test (CCT) was carried out on three food items namely white yam, rice and white beans, respectively using composite sawdust briquette fuel and kerosene. Yam has the lowest specific fuel consumption (SFC) value of 0.12kg/kg when sawdust briquette was used and 0.0635kg/kg when kerosene was used. Rice had SFC of 0.195kg/kg when composite sawdust briquette was and 0.0795kg/kg when kerosene was used while Beans had the highest SFC value of 0.32kg/kg and 0.1425kg/kg for kerosene. On the other hand from the time spent to cook food items, yam has the lowest time spent in cooking per kg of 40.34min/kg for briquette fuel and 30.36min/kg for kerosene fuel. Rice has a cooking time of 40.38min/kg for composite sawdust briquette and 31.1min/kg for kerosene fuel. Beans had the highest cooking time of 75.83min/kg for composite sawdust briquette and 74.7min/kg for kerosene. From the result of the ANOVA carried out, the effect of the type of cooked food item on the SFC as well as the time spent in cooking 1kg of food item is highly significant at 0.05 and 0.01 levels of significance. On the other hand, the effect of the type of fuel used for cooking on the SFC and the time spent in cooking per kg is not significant at any level of significance. There is no interaction between the type of cooked food item and the type of fuel used at 0.05 and 0.01 levels of significance.

Keywords: *Controlled cooking test, specific fuel consumption, yam, rice, beans.*

Introduction

The energy demand of the entire world is getting more and more since this is needed to raise and satisfy the standard of living. Nations consuming more energy per capital always have better standard of living. In search of improving the standard of living, the world energy consumption is seriously increasing at a critical rate when compared to the world population.

It is obvious that most of the world's energy demand especially is met by fossil fuels mainly coal, petroleum and natural gas. Fossil

fuels provide about 80% of man's energy usage now and this makes them enjoy widespread use especially in domestic cooking. For example, kerosene fuel finds useful application in most developing countries of the world for domestic cooking, lighting and heating. These fuels, which we have depended on so much, are non-renewable and it is obvious that their supply is not keeping up with people's demand. The world production of fossil fuels will start to depreciate in the next 20 to 30 years and this has been the major concern of the entire world (Adegoke and Mohammed 2002). Also associated with the fossil fuels are their contributions to global warming. Their end product of combustion such as NO_x, CO, SO_x, particulate emissions etc. also known as pollutants have been found to be a major threat to the world climate thus affecting human health. Hike in petroleum price is another

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phenomenon associated with shortage of fuels. People especially those in the rural areas of the developing countries cannot afford the high price of this conventional fuel such as kerosene, to meet their daily domestic needs most especially for cooking.

It is in view of this that much attention is being given to the search for alternative energy sources that will be renewable. This renewable energy includes solar energy in its direct form, wind, geothermal, water and biomass.

Out of all these types of renewable energy, Biomass which is the generic name given to all dry plant materials and organic waste has found more recognition. This is because its development always results in a cleaner environment and at the same time can provide the means to recycle wastes to some valuable product. Another advantage of biomass over other sources of renewable energy is its ready availability and energy conversion that is not so expensive.

Biomass can be derived from plant and animal materials through a variety of conversion and end use. Examples of biomass include; sawdust, rice husk, palm kernel shell, paper and animal dung. According to Probst and Hicks (1982), plant biomass in the form of wood is the largest potential source of biomass when compared to others. Most of these potentials lie in wood processing by products known as sawdust. The presence of sawdust in large quantity creates disposal challenges for the wood processing industries. On the other hand, another problem associated with the use of plant biomass, i.e., wood is deforestation. Therefore, in eradicating deforestation, wood processing by products i.e. sawdust wastes can be converted to a high- grade solid fuel by a process known as briquetting. Briquetting is a process of converting loose wastes into a dense, compact and consolidated unit through the application of high temperature and pressure with or without a binding agent. This has been found to be a better way of turning waste to wealth. Also the fuel in this form when used for cooking burns with a bluish free flame (Adegoke 2002). The addition of charred or carbonized palm kernel shell makes the briquette to be a composite fuel. Kuti (2007) observed that the addition of charred palm

kernel increased considerably the calorific value of composite sawdust briquette.

In this paper comparative performance of composite sawdust briquette fuel with kerosene under cooking conditions is embarked upon. The evaluation of the effect of parameters such as S.F.C and the time taken to cook 1kg of food is carried out. These parameters are important means of expressing the performance of a solid fuel when burnt in a stove. According to Anon. (1987) and Danshehu *et al.* (1992), the specific fuel consumption expresses the amount of dry sawdust required to obtain 1kg of cooked food.

Methodology

Sawdust and charred palm kernel shell were collected from the dumping site, screened and converted into composite briquettes using a manually-operated hydraulic briquette making machine in percentage mixing ratio of 70:30 (sawdust to charred palm kernel). Charred palm kernel shell of size 1.18mm was utilized. Starch gel was used as a binder. The composite sawdust briquette was left in the sun to dry properly. The calorific value, i.e. net energy content of the composite briquette, was determined using the Gallenkamp Ballistic Bomb Calorimeter.

Controlled cooking test (CCT) was carried out using food items such as white yam (*Discorea rotundata*), rice and beans (*Vigna unguiculata* subsp. *dekintiana*). The cooking performance of the composite briquette was compared with that of kerosene. For the CCT, the mass of empty pot and initial mass of the fuel were measured. The fuel was stacked inside the internally lined stove and ignited. Equal quantity of foodstuff and water, by mass, was used in the course of the experiment. The first experiment was carried out using yam. The pot containing water and yam was placed on the glowing fuel and left to cook. When the cooking was properly done, the mass of the cooked yam and time to achieve cooking were recorded with the aid of a stopwatch. Also, the mass of the fuel remaining after cooking was also recorded. The same process was repeated using rice and beans respectively. Alongside using the briquettes for cooking, CCTs were also carried out using kerosene fuel for cooking the foodstuffs; yam,

rice and beans respectively. This is achieved in order to compare the performance of the sawdust briquette produced with kerosene fuel under same cooking condition. The experiment was repeated two times. The data collected were computed and analyzed. The experiment was also arranged in a 2 x 3 factorial design approach using ANOVA technique with three replicates. The factors taken into consideration are the type of fuels used and the type of cooked food items. Detailed discussion on ANOVA technique could be found in Akindele (1996).

Data analysis

According to Danshehu *et al.* (1992), the SFC and the time (T) spent to cook 1 kg of food were computed from the data as follows:

$$S.F.C = \frac{\text{Mass of consumed fuel}}{\text{Total mass of cooked food}} = \frac{(m_{f0} - m_{f1})(1 - x) - 1.5m_c}{m_{pc} - m_p}, \quad (1)$$

and

$$T = \frac{\text{Total time spent in cooking}}{\text{Total mass of cooked food}} = \frac{T_0 - T_1}{m_{pc} - m_p}, \quad (2)$$

where:

T = Cooking time for 1kg of foodstuff, (min/kg);

T_0 = Initial time before cooking (min);

T_1 = final time after cooking (min);

m_{pc} = mass of pot with cooked food (kg);

m_p = mass of empty pot (kg);

x = moisture content value of fuel assumed to be zero, i.e., 100% dryness;

m_c = mass of charcoal left (kg);

m_{f0} = Initial mass of fuel before combustion (kg);

m_{f1} = final mass of fuel after combustion (kg).

The following hypotheses were set up under the ANOVA to justify the factorial experiment:

Factor A: Type of Cooked Food Item

Null hypothesis, H_0 : The effect of the type of cooked food item on S.F.C and Time Spent in cooking is not significant

Alternative Hypothesis, H_a : The effect of the type of cooked food item on SFC and Time Spent in cooking is significant.

Factor B: Type of Fuel Used

Null hypothesis, H_0 : The effect of the type of fuel used on SFC and time spent in cooking is not significant.

Alternative Hypothesis, H_a : The effect of the type of fuel used on SFC and time spent in cooking is significant.

Effect of interaction of factor A and factor B (A x B)

Null hypothesis, H_0 : The added variance component due to the interaction of the factors is not significant.

Alternative hypothesis, H_a : There is significance in the added variance component due to interaction of the factors.

The hypotheses set up were tested at 0.01 and 0.05 levels of significance using F-test. The following inferences are to be deduced from the ANOVA table: when F-calculated is greater than F-tabulated - reject H_0 and accept H_a ; when F-calculated is less than F-tabulated - Accept H_0 and reject H_a .

Results and Discussion

Figs. 1 and 2, respectively, show the graphical relationship between the Specific Fuel Consumption (SFC), time spent in cooking per kg and cooked food types using the 70/30 percentage composition briquette and kerosene fuel. The net calorific value of the composite briquette was found to be 22.41MJ/kg as against that of kerosene which is around 43.1MJ/kg (Karen 2004).

Fig. 1 shows that yam has the lowest SFC value of 0.12kg/kg when sawdust briquette was used and 0.0635kg/kg when kerosene was used; rice had SFC of 0.195kg/kg when composite sawdust briquette was used and 0.0795kg/kg when kerosene was used. Beans had the highest SFC value of 0.32kg/kg and 0.1425kg/kg for kerosene.

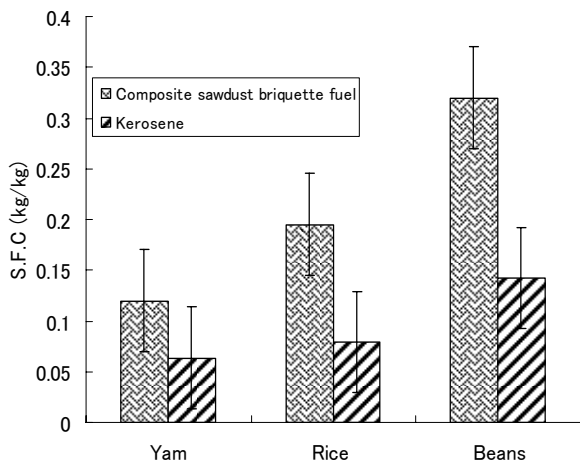


Fig.1. Comparison of S.F.C under Controlled Cooking Test.

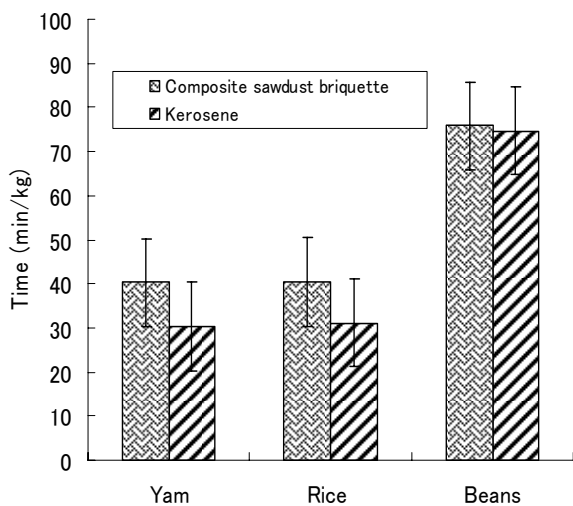


Fig. 1. Comparison of time spent in cooking under controlled cooking test.

These indicate that the higher the SFC, the higher the quantity and mass of fuel required achieving cooking tasks. Also looking at the SFC values, a lit bit above twice the amount of kerosene fuel will be required for cooking if composite sawdust briquette is utilized. On the other hand, Fig. 2 shows that yam has the lowest time spent in cooking per kg of 40.34min/kg for briquette fuel and 30.36min/kg for kerosene fuel. Rice has a cooking time of 40.38min/kg for composite sawdust briquette and 31.1min/kg for kerosene fuel. Beans had the highest cooking time of 75.83min/kg for composite sawdust briquette and 74.7min/kg for kerosene. This indicates that there is closeness in the time of cooking for both fuels. Therefore, in cooking

beans composite sawdust briquette will be preferred to kerosene considering factors like availability and cost.

From the ANOVA table as displayed in Table 1, the effect of the type of fuel used for cooking on the SFC is not significant since F-calculated is less than the F-tabulated. Hence the null hypothesis holds. On the other hand, the SFC has a significant effect on the type of food cooked. Same effect holds also for the time spent in cooking per kg (Table 2). As shown in Tables 1 and 2, respectively, there is no significant interaction between the two factors (i.e., the type of cooked food and the type of fuel used) under consideration at any level of significance.

From the ANOVA, therefore, it can be concluded that only the type of cooked food has significant effects on the SFC ratio and the cooking time irrespective of the type of fuel used. This is in accordance with the result obtained by Figs. 1 and 2, respectively.

Conclusion

Comparative performance of composite sawdust briquette with kerosene fuel under domestic cooking conditions has been studied. It has been established in this work that composite sawdust briquette when used for the cooking of yam, rice and beans has higher SFC and time spent per kg as compared with kerosene. This implies that more composite sawdust briquette will be needed to achieve cooking task. Also, the SFC and the time spent for the cooking task are dependent on the type of fuel used. In terms of performance, one may want to conclude that kerosene is better when compared with composite sawdust briquette. But considering other factors such as cost effectiveness, availability and affordability, composite sawdust briquette could be more economical than kerosene. Also considering the long term negative impact conventional fuels have on the environment, the use of composite sawdust briquette could be one of the better options of reducing global warming effects. Briquetting of sawdust waste could also be a better way of reducing deforestation.

Table 1. ANOVA for specific fuel consumption.

Source of Variance	Degree of Freedom	Sum of Squares	Mean of Squares	F-Calculated	F-Tabulated 0.05	F-Tabulated 0.01	Comment
Factor A	2	0.26260	0.13130	43.62	5.14	10.92	**
Factor B	1	0.20045	0.20045	-2.24	19.00	99.00	n.s.
Interaction (A x B)	2	-0.17903	-0.08950	-29.73	5.14	10.92	n.s.
Error	6	0.01801	0.00301				

Note: ** = highly significant, n.s. = not significant

Table 2. ANOVA for time spent in cooking.

Source of Variance	Degree of Freedom	Sum of Squares	Mean of Squares	F-Calculated	F-Tabulated 0.05	F-Tabulated 0.01	Comment
Factor A	2	4245.03	2122.52	100.540	5.14	10.92	**
Factor B	1	136.96	136.96	5.235	19.00	99.00	n.s.
Interaction (A x B)	2	52.31	26.16	1.239	5.14	10.92	n.s.
Error	6	127.68	21.28				

Note: ** = highly significant , n.s. = not significant

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References

Adegoke, C.O. 2002. Energy as veritable tool for sustainable environment. Inaugural Lecture Series 31 of the Federal University of Technology, Akure, Nigeria.

Adegoke, C.O.; and Mohammed, T.I. 2002. Investigation of sawdust briquette as high grade fuel. West Indian J. Engin. 25(1): 1-8.

Akindede, S.O. 1996. Basic Experimental Designs in Agriculture Research. Montem Paperbacks, Akure, Nigeria.

Anon. 1987. Improved wood, waste and charcoal burning stoves. A practical manual. Intermediate technology publications, Covent Garden, London, UK.

Danshehu, B.G.; Sambo, A.S.; and Musa, M. 1992. Comparative performance of sawdust and wood-burning stoves. Nigerian J. Renewable Energy 3(1&2): 50-55.

Karen, T. 2004. Energy statistics working group meeting. Special issue paper 8. Net calorific value. Available: http://www.iea.org/Textbase/work/2004/eswg/21_NCV.pdf

Kuti, O.A. 2007. Impact of charred palm kernel shell on the calorific value of composite sawdust briquette. Medwell J. Engin. Appl. Sci. 2(1): 62-65.

Probstein, R.F.; and Hicks, R.E. 1982. Synthetic 2004 Fuels. McGraw-Hill, New York, NY, USA.