Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2016, 8(3):432-437

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Physico-mechanical and combustion analysis of briquettes produced from bambaranut shell

Ilochi N. O.[1], Ikelle I. I.[2], Ehiri R. C.[3], Igwebike-Ossi C. D.[2] and Anyigor M. C.[2]

[1]Department of Chemical Sciences, Evangel University, Okpoto, Nigeria
[2]Department of Industrial Chemistry, Ebonyi State University, Abakaliki, Nigeria
[3]Department of Chemistry/ Biochemistry/ Molecular Biology, Federal University, Ndufu-Alike Ikwo, Nigeria

---

ABSTRACT

This study was conducted to investigate the possibility of utilization of bambaranut shell in briquette production. Bambaranut shell was pulverized and densified into briquettes by a screw press (pressure 12.3kpa) using starch as a binder. Proximate analyses of the bambaranut shell and bambaranut shell briquette were determined. The physio-mechanical and combustion properties of the produced briquettes were also determined. Results showed that bambaranut shell had moisture content 6.4%, volatile matter content 73.31%, ash content 4.25%, fixed carbon 16.02% and calorific value 18.90MJ/kg. Proximate analysis of the briquettes showed moisture content 7.38%, fixed carbon content 15.71%, ash content 3.51%, volatile matter content 73.40%, and calorific value 22.10MJ/kg. Assessment of the mechanical characteristics showed relaxed density (at 7days) 0.950g/cm^3, porosity index 1.81, and durability 83%, while combustion analysis showed ignition time 18.05secs, water boiling time 18.36 minutes, and burning time 33mins. The physical, mechanical and combustion analysis proved that bambaranut shell which is mainly regarded as a waste is very suitable for briquette production.

Key words: Bambaranut, Briquette, Fuel, Starch

INTRODUCTION

With growing development of Nigerian economy, energy consumption is increasing day by day. Nigerians over depend on oil and gas for domestic and industrial purposes since it is the only source of energy that is so far well developed. As a result of this, the demand for oil and gas is higher than its supply. Due to political and economic instability, the price of oil and gas keep on increasing constantly, that most Nigerians cannot afford it. Most of them, especially those in the rural and semi-urban areas, resort to the use of fuel wood. The high and rapid demand for wood fuel consumption is considered as a major contributing factor to the wood fuel crisis in Nigeria. The demand for fuel wood is expected to have risen to about 213.4x10^3 metric tonnes, while the supply would have decreased to about 28.4x10^3 metric tonnes by the year 2030[1]. The use of wood fuel encourages deforestation that causes global warming, soil erosion, desertification, and in some cases, extinction of wild life [1]. For these reasons, a transition to a sustainable energy system is urgently needed in Nigeria.

A lot of researches have been carried out on renewable sources of energy to provide alternate fuel resources to meet the ever-increasing energy demand, and to avoid dependence on crude oil. This source of energy includes briquettes. A briquette is a block of compressed coal, biomass or charcoal that is used as fuel [2]. Common types of briquettes are coal, biomass, bio-coal and charcoal briquettes. These are produced by compressing pulverized coal, biomass materials, coal and biomass, and charcoal dust respectively [3]. Briquettes have been successfully produced and utilized in countries like Japan, India, etc. It is yet to get a stronghold in Nigeria.

Agriculture is the main occupation of most Nigerians and its activities generate so many wastes which are disposed indiscriminately. These wastes can be reintegrated to produce biomass briquettes. Biomasses include all renewable organic materials that contain energy in a chemical form that can be converted to fuel through briquetting. Biomass comprises of residues from agricultural operations and food processing, forest residues, municipal solid wastes and energy plantation [4]. These wastes can be reintegrated to produce biomass briquettes. Biomass briquettes are produced by pulverizing a biomass material and applying pressure, with or without a binder. Briquetting is a process of binding together pulverized materials by applying pressure with or without a binder. Converting agricultural residues to briquettes have many advantages. These include [5]

1. Biomass briquettes provide an easier way of getting energy supply for cooking as briquettes can be transported easily than the agricultural residues.
2. They provide cleaner emission than the fossil fuels.
3. The raw materials for making biomass briquettes are sourced from material that would have been disposed, and as such, it converts waste to energy.
4. They can be used in stoves and boilers, and
5. They increase strength, density, heat emitted per volume of the biomass.

Advances have been made in briquette production from various biomass materials, e.g. rice straw and husk [6], maize cob [7], grass [8], cotton plant residue [9], etc. Biomass resources are of great interest as briquette materials because of associated miscellaneous advantages such as abundance, low price, and very high worldwide potential. Bambaranut shells have proved satisfactory in briquette production. Bambaranut *(Vigna subterranean*) is the third most commonly eaten legume after groundnut and cowpea in Nigeria [10], because it is a very good source of protein and energy. It therefore helps to alleviate nutritional disorders in humans and livestock [11]. The annual world production is 330,000 tonnes, 45-50% of which are produced in West Africa (Nigeria, Ghana, Niger, BurkinaFaso, etc) [11]. In Nigeria, it is mostly grown in the north. The seeds are cooked, roasted and chewed, or milled into flour and used to prepare a steamed gel known as Okpa by people in the urban and rural areas of eastern part of Nigeria. It is also used to prepare snacks called gurujia by the northerners. Bambaranut is one of the major foods of the semi urban and rural dwellers of eastern and middle belt part of Nigeria. Bambaranut shell is the by-product of processing the seeds into flour for human consumption. In Nigeria, they are produced in large quantities and discarded indiscriminately as agricultural waste, constituting environmental nuisance. Therefore, their use in the manufacture of biomass briquette will not only provide an alternative source of energy to oil and gas, wood, etc, but create a safe and hygienic way of disposing the waste, and help maintain a healthy and neat environment.

Aim of study

This work is aimed at determining some physical and combustion properties of briquettes produced from bambaranut shell. The need to protect our forest, mitigate health hazards faced by people from the use of fuel wood for cooking, and seek for effective agro-waste management has necessitated this work. This work will also provide an alternative source of energy which will reduce Nigerians' overdependence on oil and gas.

EXPERIMENTAL SECTION

Bambaranut shells were collected from Abakaliki Metropolis, Nigerian, at various milling stations where the pods were brought to be opened to get the nuts, farming communities where the nuts are produced in large qualities, and from different dumpsites where they are discarded as wastes.

Preparation of the Materials:

The bambaranut shells were sundried for two weeks in order to reduce their moisture content. They were pulverized using electrical milling machine and sieved using a standard sieve to obtain materials of particle size ≤3mm in diameter. The pulverized material was stored in a polyethylene bag to prevent caking.

Plate 1: Bambaranut shell

Analysis of the bambaranut shell:
Proximate analysis of the bambaranut shell was carried out following the procedures of ASTM E711 -87[12] and calorific value obtained using an Oxygen Bomb Calorimeter Bulk Model XRY-IA. Sulphur content was analyzed following the procedures of [3].

Formulation of the briquettes:
The bambaranut shells were made to briquettes using cassava starch as binder 20% by mass of starch was used as binder. The starch was prepared from raw cassava root which was peeled, washed, sundried and pulverized [5].

100g of cassava flour was mixed with 100ml of water to make a paste of it. 400ml of water was put to boil in a container. The boiling water was added into the cassava paste and mixed properly to get the starch gel. While the starch gel was still warm, 500g of the pulverized bambaranut shell was gradually added into the gel and mixed thoroughly using a stirring stick, until a homogenous mixture was obtained. The mixture was briquetted using a manual screw press, at a pressure of 12.3kpa and dwell time of 2 mins. The briquettes were sundried for one week.

Plate 2: Bambaranut shell briquettes produced

Characterization of the briquettes:
Proximate analysis:
The proximate analysis of the briquettes was determined following the procedures of ASTM E711-87[12]. The calorific value was determined using an Oxygen Bomb Calorimeter Bulk Model XRY-IA

Mechanical properties:
The compressed and relaxed densities of the briquettes were determined following the procedures of [11]. Compressive strength of the briquettes was determined using Instron Machine, Model 2914 [13]. Porosity was determined and porosity index calculated as described by [14]. Durability was determined in accordance with the chartered index described by [15].

Combustion analysis:
The combustion analysis was conducted to understand the combustion characteristics of the briquette fuel. The ignition time, burning time, water boiling time, specific fuel consumption, burning rate, and thermal efficiency were determined following the procedures of [16-18].

RESULTS AND DISCUSSION

Table 1: Proximate analysis of bambaranut shell

Moisture content (%)	6.42
Volatile matter content (%)	73.31
Ash content (%)	4.25
Fixed carbon content (%)	16.02
Calorific content (MJ/kg)	18.90
Sulphur content (%)	0.100 .

From the results, bambaranut shell has low moisture content, 6.42%, and ash content 4.25%. These are characteristics of good biomass materials for briquette production [15]. The volatile matter content 73.31% is high which implies easy ignition [15]. Fixed carbon content is also low, 16.02%. The calorific value, 18MJ/kg is high and comparable to that of other materials, e.g. 14.66MJ/kg for *Pennisetum purpurem* grass [3], 16.39MJ/kg for cassava stalk [19], 13.2MJ/kg for rice husk, 14.3MJ/kg for maize stalk [20].
\

Table 2: Physico-mechanical properties of the briquette

Moisture content (%)	7.38
Volatile mater (%)	73.40
Ash content (%)	3.51
Fixed carbon content (%)	15.71
Calorific value (MJ/kg)	22.71
Compressed density (0 mins) (g/cm^3)	1.611
Relaxed density (30mins) (g/cm^3)	1.597
Relaxed density (60mins) (g/cm^3)	1.547
Relaxed density (1440mins) (g/cm^3)	1.327
Relaxed density (10,080mins) (g/cm^3)	0.950
Compressive strength (N/mm^2)	3.19
Porosity index	1.81
Durability (%)	83
Ignition time (secs)	18.05
Burning rate (g/mins)	18.36
Specific fuel consumption (kg)	0.55
Thermal efficiency (%)	12.19

The moisture content of the briquette is low, 7.38%, (<10%), showing that it is good for combustibility as reported by [21]. The ash content is low, 3.51%, and calorific value high (22.10MJ/kg), therefore it will not cause an increase in the combustion remnant in the form of ash [15]. The calorific value is comparable to those obtained by [14], 16.13MJ/kg for spear grass briquettes, [7], 14.1MJ/kg for maize cob briquettes, [3], 15.98 MJ/kg for *Pennisetum purpurem* briquettes. The volatile matter content was high, 73.40%, implying easy ignition of the briquette as reported by [22]. Ignition time is 18.05 secs.

The briquette is highly durable 83%, with relaxed density (at 7 days) of 0.950g/cm^3, and compressive strength of 3.19 N/mm^2. This implies that the briquettes can easily be stored and transported. The compressive strength of the briquette is comparable to those reported by [14], 2.10N/mm^2 for spear grass briquettes and [3], 3.50 N/mm^2 for *Pennisetum purpurem* briquettes. The density result obtained is higher than that reported by [3], 0.319g/cm^3 for *Pennisetum purpurem* briquettes, and [5], 1.65g/cm^3 for palm kernel shell charcoal briquettes. Porosity index is 1.81, indicating adequate porosity. The higher the porosity, the higher is the rate of infiltration of air, and outflow of pyrolysis products, ensuring uniform combustion of the briquette. But highly porous briquettes may split during transportation and storage, causing handling problems. The porosity index can be compared to those reported by [14], 3.5 for spear grass briquettes.

The briquette ignited at 18.05seconds, and boiled 500ml of water at 18.36 minutes. The value was below that reported by [5], 8 minutes for palm kernel shell charcoal briquettes, although the later is a charcoal briquette which has a higher calorific value than biomass briquettes. The specific fuel consumed is 0.55g, and it is comparable to that reported by [14], 0.32g for spear grass briquettes. Thermal efficiency (12.19%) was higher than that reported by [5], 3.2% for palm kernel shell briquettes. The burning rate of 9.09g/minutes was also higher than 3.2g/minutes as reported by [5].

CONCLUSION

This study has described the convenient and adaptable method of making bambaranut shell briquettes. Therefore, the problems associated with disposal of bambaranut shell wastes can be overcomed by producing briquettes from them. The briquettes produced provided sufficient heat, ignited easily without any danger, generated less dust (ash) during cooking, and can be transported and stored easily. The technology has a great potential for converting waste biomass into a fuel for household use in an affordable, efficient and environment friendly manner. The briquetting process is economical, cheap and affordable to the rural and low income urban dwellers. Moreover, using bambaranut shell for briquette production will increase the farmer’s income, thereby encouraging more production. It will also create job opportunities. The use of briquette should be given wide publicity and encouraged in Nigeria due to the imminent wood shortage and scarcity of other energy sources.

REFERENCES

[1] Emerhi, E.A, (**2011**), *Advances in Applied Sciences Research*, 2(6): 236-246.
[2] Granger and Gibson, (**1981**), Coal Utilization Technology Economics and Policy, Graham and Trotman Limited, pp 3-7.
[3] Onuegbu T.U., Ogbu I.M., Ilochi N.O., Okafor I., Obumselu F., and Ekpunobi U.F., (**2010**), *Advances in Natural and Applied Science* (3): 299-304.
[4] United States. Agency for International Development (USAID), (**2010**), Biomass Briquetting in Sudan: A Feasibility Study Women’s Refugee Commission, www.scribol.com/doc/.../USAID.
[5] Ugwu, K.E, and Agbo K.E., (**2010**), *Journal of Applied Science and Environment Management*, 15(3):447-460
[6] Ndiemia, C.K.W., Manga N.P., and Ruttoh, C.R., (**2002**), *Manage*, 43:2157-2161
[7] Wilaipon, P (**2007**), A.M.*J. Applied Science*, 4: 995-998.
[8] Finell, M., Nilsson, C., Olsson R., Agnemo, R., and Svensson S., (**2002**), *Ind Crops Prod*. 16:185-192.
[9] Coates W, (**2002**), *Biomass Bioenergy*, 18:201-208.
[10] Onyimonyi, A.E., and Okeke, G.C., (**2007**), *Pakistan J.Nutr*., 6(3): 264-266
[11] Tembe E.T., Adetogun A.C., and Agbidye, F.S., (**2014**), *Journal of Natural Sciences Research* 4(24): 21-25.
[12] ASTM Standard E711-87, (**2004**), Standard Test Method for Gross Calorific Value of Refuse-Derived Fuel by the Bomb Calorific Calorimeter. Annual Book of ASTM Standard, ASTM International, http//www.astm.info/standard/E711.htm.
[13] Standard Organization of Nigeria, (**2010**), Compressive Strength and Hardness of Briquette, pp 1-6.
[14] Onuegbu T.U., Ogbu I.M., Ilochi N.O., Ekpunobi U.E., and Ogbuagu A.S., (**2010**), *Leonard’s Journal of Science* (17): 47-58.
[15] Sotannde O.A, Oluyeye A.O, and Abah G.B., (**2010**), *Int. Agrophysics*, (24): 189-194.
[16] Davies R.M and Abolude D.S., (**2013**), *Journal of Scientific Research and Report*, 2(1): 111-120
[17] Kuti, O.A., (**2009**), Performance of Composite Sawdust Briquetted Fuel in A Biomass Stove Under Simulated Condition, Department of Mechanical Engineering, University of Hiroshima, Japan, pp 284-288.

[18] Birwatker, V.R., Khandetod, V.P, Mohod A.G., and Dhande K.G, (**2014**), Physical and Thermal Properties of Biomass Briquetted Fuel. Ind J. Sci Research and Technology, pp 55-62.
[19] Wilaipon P, (**2010**), *American Journal of Applied Sciences*, 7 (5): 698-701.
[20] Garivait G., Chaiyo U., Patumsawad S., and Deakhuntod J., (2006), The 2nd Joint International Conference on "Sustainable Energy and Environment (SEE **2006**)", Bangkok, Thailand
[21] Mills, J.E, (**1998**), Binders for Coal Briquettes, US Geological Survey, Bulletin 343, pp 5-59
[22] Loo, S.V., and Koppejan J., (**2008**), The Handbook of Biomass Combustion And Co-firing Earthscan London, pp 7-11.