

A STUDY OF THE PHYSICO-MECHANICAL AND COMBUSTION ANALYSIS OF BRIQUETTES PRODUCED FROM BAMBARANUT SHELL.

Abstract

The work involved the usage of bambaranut shell to produce briquette fuel. The bambaranut shell was ground into powdery form which was compacted via screw press method with pressure maintained at 12.3 kpa, the binder used is starch to produce bio-coal briquettes. The bambaranut shell and bambaranut shell briquette was subjected to proximate analyses. The briquettes produced were tested to determine their combustible characteristics. The results of the analysis of the bambaranut shell had the following results, the moisture content was (6.4 %), volatile matter content had (73.31 %), with ash content value of (4.25 %), the value for fixed carbon was (16.02 %) and with calorific value 18.90 MJ/kg. Furthermore, the proximate analysis of the briquettes showed the following results; moisture content 7.38%, fixed carbon content 15.71%, ash content 3.51%, volatile matter content 73.40%, and calorific value 22.10MJ/kg. The results of the mechanical properties of the briquettes produced yielded the following, relaxed density (0.950 g/cm³), porosity

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index (1.81), and durability (83 %) all after 7 days, while combustion characteristics of the briquettes showed ignition time (18.05 secs), water boiling time (18.36 minutes), and burning time (33 mins). These characteristics exhibited in the combustion, mechanical and physical tests result of the bio-coal briquettes showed that bambaranut shell is a good option for production of briquettes.

Keywords: Bambaranut, Briquette, Fuel, Starch.

I. INTRODUCTION

Nigerian economy is witnessing a new development trajectory and requires new sources of energy as energy consumption is on the increase. Nigerians over-dependence on oil and gas for her energy supply both for domestic and industrial purposes has been a problem for the long-while since as an energy source it is well developed. The resultant effect is that supply for oil and gas has been found to be below the demand in the market. The rise in economic unrest has caused drastic increases in the prices of oil and gas. As a result of the increases most residents of rural and sub-urban areas depend on wood as the readily available source of fuel that is used for heating. The pressure on fuel wood as a source of energy has increased tremendously with attendant demand on wood that is tilting towards crisis point. The pressure does not seem to show signs of reduction in the nearest future as it is projected to rise to 2134000 kg as at 2030[1]. The use of wood as fuel source is attributable to such man-made disasters like global warming that resulted from continuous wood felling, erosion of the top soil, desert encroachment, and almost the extinction of wild life in some countries [1]. As a result of the aforementioned reasons, there is need for another energy system in Nigeria.

There has been many researches carried out by people as they search for other new sources of renewable energies with the hope of discovering energy sources that can best be positioned as crude oil alternative. Briquettes as an energy source that has received wide mentioning. This is a block of compressed coal, biomass or charcoal that is used as fuel [2]. Charcoal briquettes, biomass, coal and bio-coal have been used today to produce different ranges of briquettes. The compression of different amounts of pulverized coal, biomass materials, coal and biomass, and charcoal dust have resulted in the successful briquette production [3]. Countries like Japan and India have made tremendous progress in terms of briquetting technology but Nigeria is still lagging behind.

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Agriculture as an occupation enjoys great acceptance among most Nigerians and activities of Agriculture is known to generate wastes that are not properly disposed. The conversion of agricultural wastes finds its application in the production of bio-coal briquettes. Generally, organic material that is made up of energy in chemical energy with renewable properties are called biomass that can easily be converted to fuel by briquette formation. In the course of food processing and agricultural activities, wastes from such agricultural practices are referred to as biomass [4]. The bio-wastes can be reused to produce biomass briquettes. The briquetting of biomass is done when the pulverized bio-waste is compacted in the presence of pressure with or without the aid of a binder. Briquetting is a process of densifying pulverized materials by applying pressure with or without a binder. The conversion of agricultural wastes to briquettes have numerous advantages that includes [5]

1. With regards to movement of agricultural wastes the act of briquetting has provided a suitable means of conversion of these wastes into suitable energy sources for cooking.
2. The gases they produce during usage does not pose much threat to the environmental.
3. In most cases the raw materials used for the production of the briquettes are sourced from disposed biomass wastes such that the whole process is a bio-waste to energy conversion procedure.
4. The briquettes find usage in boilers and stoves.
5. There is an increase in strength, density, heat emitted per volume of the biomass.

The production of briquettes has progressed from use of bio-wastes like rice husks [6], maize cobs [7], grasses [8] and residues of cotton plants [9]. There are some reasons why biomass wastes are of great interest in briquette materials because of related miscellaneous advantages such as abundance, low price, and very high worldwide potential. Bambaranut shells have proved satisfactory in briquette production. Bambaranut (*Vigna subterranean*) is among the most

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commonly eaten legume that includes groundnut and cowpea in Nigeria [10], as a result of its rich content of protein and energy. It has helped to solve the problem of poor dietary 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, Burkina Faso) [11]. In Nigeria, it is mostly grown in the north. The seeds can be 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. *Gurujia* a popular snacks in the northern part of the country is prepared from bambaranut. In Nigeria, large quantities of agro-wastes are produced in the processing line of bambaranut and are discarded indiscriminately as agricultural waste, which constitutes nuisance to the environment. It becomes imperative to state that beyond the conversion of the wastes into useful sources of fuel by briquetting, there is also the advantage of proper disposal of the wastes resulting in a healthy and clean environment.

II. RESEARCH OBJECTIVES

The research is geared towards the determination of some physico-combustion characteristics of briquettes produced using bambaranut shell. There is also the need to reduce the level of deforestation, find a way to reduce the impact of usage of wood fuel to the health of people cooking with fuel wood, and seek for effective agro-waste management has necessitated this work. The work is also an avenue to provide another source of energy and reduce the overdependence on fossil fuel.

III. MATERIALS AND METHODS

The bambaranut shells were collected from various milling sites that pods were cracked in Abakaliki Metropolis. The shells were also sourced from different dumpsites where they were disposed off.

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Plate 1: Bambaranut shell.

Materials Preparation: The bambaranut shells were sundried to reduce their moisture content for two weeks. This is followed by pulverization using electrical milling machine and the pulverized material are sieved using a standard sieve to obtain materials of particle size ≤ 3 mm in diameter. After sieving the pulverized material was stored in a polyethylene bag to prevent caking.

Analysis of the Bambaranut Shell: The pulverized bambaranut shell was subjected to proximate analyses according to the procedures of ASTM E711-87[12] and the Oxygen Bomb Calorimeter Bulk Model XRY-IA was used to determine the calorific value. The amount of sulphur content was analyzed according to procedures of [3].

Production of the Briquettes: Briquette samples were produced using the pulverized bambaranut shells with a 20% by mass of cassava starch serving as the binder during the briquette production. Starch from raw cassava root was used for the work [5].

A known quantity 100g of cassava flour was dissolved in 100ml of water to make a paste of it. To the cassava dissolved in water was

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added 400ml of boiling water, turned properly until a starchy gel is formed. The starch gel was poured into a big bowl, 500g of the pulverized bambaranut shell was added continuously followed by stirring to obtain a homogenous mixture. The homogenous mixture was added to the manual screw press, briquettes were produced at a pressure of 12.3kpa and dwell time of 2 mins. After the production the briquettes were dried in the sun for one week.



Plate 2: Briquettes of Bambaranut Shell

IV. CHARACTERIZATION OF THE BRIQUETTES

Proximate Analysis: The ASTM E711-87[12] procedures were employed for the determination of the proximate analyses of the briquettes. Using the Oxygen Bomb Calorimeter Bulk with Model XRY-IA, the calorific values of the briquettes were determined.

Mechanical Properties: According to procedures in [11] the analysis of the briquettes compressed and relaxed densities were carried out. Using the Instron Machine, Model 2914 [13], the Compressive strength of the briquettes were determined. The porosity index of the briquettes produced was determined according to the process

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described by [14]. The durability was determined in accordance with the chartered index described by [15].

Combustion Analysis: The combustion analysis was carried out to determine the combustion properties of the briquette fuel. These includes the ignition time, burning time, water boiling time, specific fuel consumption, burning rate, and thermal efficiency of the briquette fuel was determined according to the procedures of [16-18].

V. RESULTS

Table 1: The Result of Proximate Analyses 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

According to table 1, the bambaranut shell possesses low moisture content of 6.42%, and ash content of 4.25%. The features are very indicative of biomass that are suitable for briquettes production [15]. With a high volatile matter content of 73.31% this implies faster ignitable property when used to produce briquettes [15]. The value for fixed carbon content is 16.02 %. The calorific value, 18MJ/kg is significantly high and comparable to other biomass materials suitable for briquette formation like *Pennisetum purpurem* grass with 14.66MJ/kg [3], cassava stalk with 16.39MJ/kg [19], rice husk with 13.2MJ/kg and maize stalk with 14.3MJ/kg as calorific values [20].

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Table 2: The Physico-mechanical Properties of the Briquettes

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/min)	18.36
Specific fuel consumption (kg)	0.55
Thermal efficiency (%)	12.19

VI. DISCUSSION

According to table 2, the briquettes produced showed low moisture content of 7.38%, (<10%), indicating good combustibility property according to the report of Mills (1998) [21]. The briquette has low ash content of 3.51%, significantly high calorific value of 22.10MJ/kg, the briquettes would generate less ash upon combustion [15]. With a high volatile matter content of 73.40%, this implies readily ignitability with regards to the briquettes produced according to [22]. The ignition time of the briquettes formed is 18.05 secs.

The briquette showed high durability of 83%, relaxed density (at 7 days) of 0.950g/cm³, and with compressive strength of 3.19 N/mm². The implication is that the briquettes formed can be easily stored and transported from one place to another. The compressive strength of

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the briquette is comparable to those spear grass briquettes with 2.10N/mm^2 [3] and *Pennisetum purpurem* briquettes with 3.50N/mm^2 [14]. The density result obtained is higher than according to the work of Onuegbu *et. al.*, [3], 0.319g/cm^3 for *Pennisetum purpurem* briquettes, and [5], 1.65g/cm^3 for palm kernel shell charcoal briquettes. With porosity index value of 1.81 signifying adequate porosity, there is higher tendency for air inflow into the briquette and helping in ensuring uniform combustion of the briquette. To avoid the issue of briquettes breaking into pieces during handling and movement, production of briquettes with high porosity index should be discouraged.

The briquettes produced had ignition time of 18.05seconds, and was able to boil a specified volume of water in 18.36 minutes. Although the value was below that of palm kernel shell charcoal briquettes a charcoal briquette, the bambaranut shell briquette is made from biomass. The specific fuel consumed is 0.55g, the value seems similar to the work of Onuegbu *et.al.*, (2010). For the thermal efficiency of the briquettes at (12.19%), it was found to higher than the work done by Ugwu and Agbo (2010) with the palm kernel briquettes recording 3.2% [5]. The same can also be found for the burning rate with 9.09 g/minutes which was higher than 3.2 g/minutes that was reported in [5].

VII. SUMMARY

In summary, the research showed a suitable and adjustable procedure for the production of briquettes using bambaranut shell. The knowledge gained from the research is of great importance with regards to the means of disposing bambaranut shell wastes. It was discovered that the briquettes produced was fast to ignite, produced significant heat during burning with fewer amount of ash during cooking. With regards to their non-fragile nature, the briquettes did not pose any danger in terms of movement and storing them. The briquetting technology exhibits great potential for conversion of waste

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biomass into a fuel for household use with an attendant affordability, reliable and environmental non-toxic effect. It has been discovered that briquette making procedure is less expensive, easy to learn and practice, even the average families can also adopt the procedure to create wealth for themselves. It is noteworthy to say that the use of bambaranut shell for briquette production goes a long way to increase financial status of those into agricultural practices, the process would definitely stimulate the idea of more production of briquettes with bambaranut shells. It will also create job opportunities. It is also imperative to advocate for the wider usage of briquettes in Sub-Saharan as a result of the continuous felling down of wood for mankind consumption.

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