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Comparative Assessment of Energy Values of Briquettes from Some Agricultural By-Products with Different Binders

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Abstract: The effect on environment by agricultural and other industrial wastes is on the increase and is causing a lot of problem. Adequate means of disposing these wastes are lacking, hence, converting them to other useful products such as briquettes for domestic fuel is desirable. In this work, the energy values of briquettes made from some of these agricultural by-products using two binders were assessed. Wastes from rice husk, maize cob, groundnut shell and sugarcane baggasse were turned to briquettes using two different types of agricultural by-product binders (banana peel and cassava peel gel). The briquettes were subjected to energy evaluation test using the Fulton XRY-1B Oxygen Bomb Calorimeter. The mean bulk densities of the briquettes produced from rice husk, maize cob, groundnut shell and sugar cane baggasse were $0.75g/cm^3$, $0.69g/cm^3$, $0.81g/cm^3$ and $0.65g/cm^3$, respectively. The results obtained showed that the average energy values of the briquettes produced using cassava peel as binder from rice husk, maize cob, groundnut shell and sugarcane baggasse were 26.612MJ/Kg, 28.255MJ/Kg, 33.703MJ/Kg and 32.762MJ/Kg, respectively. The corresponding average values for those produced using banana peel as binders were 29.980MJ/g, 28.981MJ/g, 32.432MJ/g, 31.508MJ/g for rice husk, maize cob, groundnut shell and sugarcane baggasse, respectively. The results indicate that briquettes produced from groundnut shell using cassava peel gave the highest energy value of 33.70 MJ/kg while those obtained from rice husk using cassava peel gave the lowest calorific value of 26.61MJ/kg and these were significantly different($p \leq 0.05$). The briquette from groundnut shell is therefore more suitable for starting and maintaining fire for cooking and other domestic heating. The briquettes from these by-products in terms of energy values are ranked as follows: groundnut shell > sugar cane baggasse > maize cob > rice husk. The effective utilization of these agricultural by-products as high grade solid fuel can reduce environmental pollution resulting from the wastes and also help in minimizing the energy crisis resulting from non- renewable energy sources like petroleum products as domestic fuel.

Keywords: *agricultural by-products, binding materials, briquettes, energy values*

I. INTRODUCTION

Agricultural waste (by-products) management during processing is one of the most serious rural-urban environmental problems in developing countries. Several tonnes of agricultural by-products such as groundnut shell, sugar cane baggasse, rice husk, maize stalk, palm kernel shell and others are generated in Nigeria annually which constitute environmental hazard and when burnt off result in air pollution. The average tonnage of excess baggasse produced per year is over 24,000 tons [1]. Some of these agricultural by-products have values and could be utilized based on the popular slogan of four "R's" (Reduce, Reuse, Recover and Recycle). By-products from Agricultural processing can be transformed into more useful products like briquettes, which provide important alternative sources of energy for domestic use (cooking fuel).

It is noted that wood in form of fuel wood and charcoal constituted the major source of renewable energy accounting for about 51% of the total energy consumption in Nigeria. Others include natural gas (5.2%), hydro electricity (3.1%) and petroleum products (41.3%) [2]. However, the decreasing availability of wood, coupled with the ever rising cost of kerosene and cooking gas in Nigeria is forcing energy users to consider alternative sources of energy for domestic uses. One energy source that could find ready utilization is the fuel briquette.

Uses of biomass fuel such as composite sawdust briquette have been found to be a good source of renewable energy for domestic cooking [3]. In seventeenth century, the rural poor often burn dried cow dung because of the acute shortage of wood fuel and wide spread deforestation. The conversion of Agricultural by-products, wood waste and coal dust to high energy value briquettes for cooking and drying have been investigated and found to be feasible [4].

However, the performance of any solid biomass fuel such as sawdust briquette is evaluated effectively when it is combusted [4; 5]. The energy content of the briquettes vary depending on the materials used. It is thus important to assess the energy values of some of the briquettes made from some of these readily available agricultural by-products with a view to ascertaining the economic viability of embarking on mass production of such briquettes. It is also important to evaluate the effect of binders on such energy values of briquettes.

Results from recent studies have shown that agricultural by-products mixed with biomass materials especially palm kernel shells of appropriate grain size in certain proportion have improved calorific value [6]. The addition of palm kernel shell to ordinary saw dust improves the calorific value of the formed briquette from 18 MJ/kg to about 23 MJ/kg

[4, 7,5]. It could be seen from available data that the utilization of agricultural by-products apart from sawdust for briquetting in Nigeria is at very low ebb compared to other developing countries. One major reason could be attributed to lack of adequate information on the viability of these wastes for briquetting and the energy values contained there-off.

In this study, the energy values of briquettes produced from four agricultural by-products using two different agricultural-products binders were quantified to ascertain which of these by-products is more viable as far as renewable energy production for domestic fuel is concerned.

II. MATERIALS AND METHODS

2.1 Raw Materials Preparation

The following combustible agricultural by-products from different waste dump sites were considered for this project: Rice husk, Groundnut shell, Sugarcane baggasse and Maize cob.

Rice husk was collected from the dump site and gel made from cassava peel was mashed and weighed (166.67g) using a Mettler PM 200 electrical weighing balance(0.01 sensitivity) and placed in a cylindrical mould of known volume. The physical properties (volume and density) of the material were determined. This mould was fed into hydraulic briquetting machine which was operated at a maximum pressure of 60kN/m^2 to enhance perfect compaction. The mould was placed over an appropriate opening and the formed cylindrical briquettes were extracted by gradual application of pressure at the hydraulic jack. The same process was repeated with rice husk mashed with banana peel as binder. The above processes were repeated for maize cob, sugar cane baggasse and groundnut shell using the same cassava peel gel and banana peel as binders. The briquettes produced were allowed to dry in the sun for seven days and then assessed for their energy.

A Fulton XRY-1B Oxygen Bomb Calorimeter interfaced with a microcomputer (Plate 9) was used to assess the heat values of the produced briquettes. One (1) gramme of the briquettes was measured and the screw mould bracket was used to re-mould the briquette to the appropriate calorimeter bucket size. Ten (10) ml distilled water was poured into the bomb and the industrial oxygen cylinder was connected to the bomb and the valves were opened and bomb was filled slowly at pressure range of 2.5 – 3.0 Mpa for a minute. The bomb was placed inside a canister bracket containing the distilled water and the bomb lid was covered. The switch was turned on and the microcomputer was set for the determinations which automatically calibrate and measure the energy values and display the values on the screen for recording after feeding the necessary data on the briquettes. The residues (ash content) after burning were removed and weighed. The data obtained were subjected to statistical analysis using SPSS 7.0, to ascertain if there were significant differences between the means of the values obtained.

III. RESULTS AND DISCUSSION

3.1Physical Parameters of Briquettes

The physical properties of the materials before and after briquetting were determined and the results are presented in Table 1. The results showed that the mean values the bulk densities of the briquettes produced from rice husk, maize cob, groundnut shell and sugar cane baggasse were 0.75 g/cm^3, 0.69g/cm^3, 0.81 g/cm^3 and 0.65 g/cm^3, respectively. The average values of the desensities obtained fell within the values obtained in earlier studies, especially for the rice husk [8] which gave the value of density of extruded rice husk char briquette as 0.81g/cm^3.

One very important parameter in briquette production is the density. The density of biowaste briquettes depends on the density of the original biowaste, the pressure, temperature and time of desensification. The higher the density, the higher is the energy/volume ratio.

Sample	Materials	Volume before briquetting (cm^3)	Bulk Density before briquetting }g/cm^3}	Volume after briquetting (cm^3)	Bulk Density after briquetting {g/cm^3}	Mean
A1.	Rice husk & cassava peel gel	100.53	1.67	67.86	0.72	
A2.	Rice husk/banana peel	100.53	1.67	72.89	0.78	0.75
B1.	Maize cob/cassava peel gel	100.53	1.67	60.32	0.68	
B2.	Maize cob/banana peel	100.53	1.67	65.35	0.69	0.69
C1.	Groundnut shell/cassava peel gel	100.53	1.67	76.66	0.81	
C2.	Groundnut shell/banana peel	100.53	1.67	80.42	0.80	0.81
D1.	Sugarcane baggasse/cassava peel gel	100.53	1.67	56.55	0.66	
D2.	Sugarcane baggasse/banana peel	100.53	1.67	62.83	0.63	0.65

Table 1: Mean values of the Physical Parameters of materials and their briquettes

3.2 Calorific Values of Briquettes

The measured energy values of the produced briquettes from the selected agricultural by- products are shown in Table 2. The results showed that irrespective the binders used, the average calorific values of the briquettes from rice husk, maize cob, groundnut shells and sugar cane baggasse were 28.30 MJ/kg, 28.62 MJ/kg, 33.07 MJ/kg and 32.30 MJ/kg, respectively. The corresponding ash contents measured were 0.17g/100g, 0.05g/100g, 0.06g/100g and 0.03g/100g for rice husk, maize cob, groundnut shells and sugar cane baggasse, respectively.

Table 2: Mean Calorific Values and Ash contents of Briquettes

Sample	Briquette	Heat value {MJ/kg}	Mean	Ash content {g}	Mean
A1.	Rice Husk & cassava peel gel	26.612		0.18	
A2.	Rice Husk & banana peel	29.980	28.30a	0.16	0.17
B1.	Maize cob & cassava peel gel	28.255		0.06	
B2.	Maize cob & banana peel	28.981	28.62a	0.03	0.05
C1.	Ground nut shell & cassava peel gel	33.703		0.04	
C2.	Ground nut shell & banana peel	32.432	33.07b	0.08	0.06
D1.	Sugar cane baggasse & cassava peel	32.762		0.02	
D2.	Sugar cane		32.14b		0.03

baggasse & banana peel	31.508	0.04

Mean values in the column with same letters are not significantly different ($p \leq 0.05$)

IV. DISCUSSION

Energy problems are well known. Natural resources and primary energy sources are becoming scarce. Supply of new and alternative energy sources has become a necessity in order to provide better outcome from energy cost and efficiency. In this regard, briquetting of agricultural wastes /crop residues provides an excellent energy source and an environmental friendly combustible fuel. This actually prompted this present studies which is aimed at comparing the calorific values of briquettes produced from some available agricultural residues using also biomaterial by-products as binders.

The results in Table 1 show that the volume and bulk density of agricultural by-products were reduced by about thirty percent (30%) after conversion to a more useful product like briquette. This in essence helps in reducing the cost and labour involved in handling the raw bulk materials which usually constitute hazard in the dump ground. The reduction in the volume also saves space for storage of these products.

The moisture contents of the biomass used for the production of the briquettes were in the range of 12 – 16 % (wet basis) and this actually facilitated the compaction of the materials. However, the average moisture content of the briquettes produced was 8 % (wet basis). This average moisture content of the briquettes though slightly higher than the 5 % obtained for sawdust briquettes [2] however, falls within the range (7.7 – 15.1 %) reported by [9] for sawdust and wheat straw briquettes. The ranges recommended for good storability and combustibility of briquettes are 12 – 20 % (wet basis). It is noted that moisture content in excess of 20 % would result in considerable loss of energy during combustion.

The results showed that the average heat value or calorific value of briquettes obtained from agricultural wastes used in this study ranged from 28.30MJ/kg to 33.07MJ/kg using the oxygen bomb calorimeter irrespective of binders used. The average values compared favourably with values given in literature although with some slight differences. For instance, much research work has been carried out on sawdust briquettes and some agricultural by-products briquettes in respect to their energy values. These values ranges between 18MJ/kg – 23MJ/kg [4;7;5] for briquettes produced from sawdust mixed with palm kernel shells and also those given by [10] for some other biomaterials. It has been noted that the calorific content of materials vary depending on the calorimetry method [10].

It can be seen from the results (Table 2) that briquettes produced from groundnut shells using cassava peel as binder gave the highest energy value of 33.70MJ/kg, while the briquettes obtained from the rice husk using cassava peel produced the least energy value of 26.61 MJ/kg and these values are significantly different ($p \leq 0.05$). It can be seen that the briquettes from the groundnut shells also have the highest values of bulk density and the energy values of the briquette are influenced by the density. The higher the density the higher the energy values [8]. It has been noted [11] that groundnut shell is an excellent material for briquetting because of its low ash content and moisture content of less than 10% (wet basis).

Similarly, rice husk could make excellent fuel but its calorific value is less than wood and other agro-residue [11]. The other agro-residues, maize cob and sugar cane baggasse, used here gave calorific values which fell in between these two extremes.

On the bases of the binders used, there are no clear cut pattern regarding the calorific values of the briquettes produced using these two types of binders. Whereas the calorific values of the briquettes produced from rice husk and maize cob using banana peel are higher than those of briquettes produced using cassava peel as binders, the reverse is the case with those briquettes produced from groundnut shells and sugar cane baggasse. However, it is noted that variation in energy values could be attributed to the choice of the binders used for briquetting. For instance, cement, clay, animal dung, bitumen, gum Arabic have often been used in the past as binders for briquetting. These binders are not economically viable for briquetting as there are other competing needs in their usage compared to banana and cassava peels binders used in this work which essentially have no other valuable uses. It is also revealed that the combustibility and energy values of briquettes from these binders especially those from cement, clay and adhesive minerals are low and that combustible binders are preferred [12].

Currently, the production and utilization of briquettes especially from agricultural by-products which abound in large quantities in Nigeria is not well established. Part of the reasons for low utilization of these biomass materials for briquetting could be attributed to lack of adequate data/information on their potentials. Some samples of the briquettes produced are as shown in Plates 1 – 8.

V. CONCLUSION

The large volume of agricultural by-products being generated in Nigeria and which constitute environmental hazard calls for effective utilization of these high grade biomass materials for solid fuel called briquettes. In this study, a comparative assessment of the calorific values of briquettes produced from four of these biomass materials was carried out. It is concluded that briquettes made from groundnut shells using cassava peel as binder gave the highest energy value during combustion while the least energy was produced by briquettes produced from rice husk using cassava peel as binder.

In view of this, the production of agricultural by-products briquettes can greatly provide alternative energy sources for domestic cooking in Nigeria and also serve as a measure in curbing the environmental hazard posed by poor methods of agricultural waste disposal in addition to reducing the popular use of charcoal which has an adverse effect on our environment (deforestation).

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Plate1: Briquettes produced from rice husk and cassava peel gel binder

Plate 2: Briquettes produced from rice husk and banana peel binder

Plate 3: Briquettes produced from maize cob and cassava peel gel binder

Plate 4: Briquettes produced from maize cob and banana peel binder

Plate 5: Briquettes produced from sugarcane baggasse and cassava peel gel binder

Plate 6: Briquettes produced from sugarcane baggasse and banana peel binder

Plate 7: Briquettes produced from groundnut shell and cassava peel gel binder

Plate 8: Briquettes produced from groundnut shell and banana peel binder

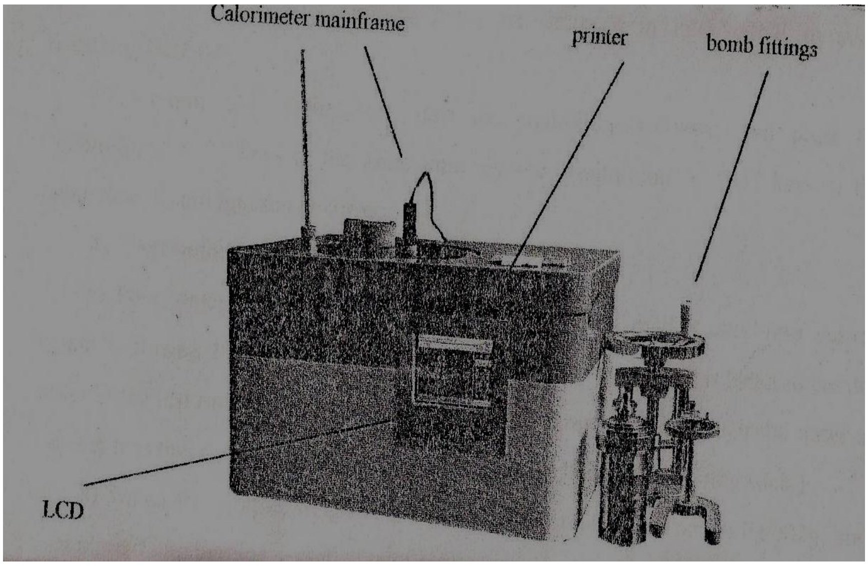

Plate 9: The XRY – B1 Oxygen Bomb Calorimeter