Iranica Journal of Energy & Environment

Journal Homepage: www.ijee.net

IJEE an official peer review journal of Babol Noshirvani University of Technology, ISSN:2079-2115

Characterization of Briquettes Produced from Groundnut Shell and Waste Paper Admixture

O. A. Oyelaran[1*], B. O. Bolaji[2], M. A. Waheed[2] and M. F. Adekunle[3]

[1]*Department of Research and Development, Hydraulic Equipment Development Institute, Kano, Nigeria*
[2] *Department of Mechanical Engineering, Federal University of Agriculture, Abeokuta, Nigeria*
[3]*Department of Forestry, Federal University of Agriculture, Abeokuta, Nigeria*

P A P E R I N F O

Paper history:
Received 15 October 2014
Accepted in revised form 19 December2014

Keywords:
Groundnut Shell
Waste Paper
Density
Relaxation
Durability
Stability

A B S T R A C T

Desertification and deforestation are great problems facing developing nations. Adequate means of disposing wastes are also lacking, hence, converting them to other useful products such as briquettes for domestic fuel is desirable. The purpose of this work is to study some properties of briquettes made from groundnut shell and waste paper admixture with a view of addressing handling, transportation, and storage problems which is associated with biomass when used as fuels. Briquettes were manufactured using a motorized briquetting machine using five groundnut shells, waste paper mixing ratios (by weight), i.e., 10:90; 20:80; 30:70; 40:60; and 50:50. Obtained results showed that briquette produced using 10:90 waste groundnut shell - waste paper ratios exhibited the largest (though minimal) linear expansion on drying. While the compressed (maximum) density of the briquettes ranged between 627.59 kg/m^3 and 878.10 kg/m^3. For the relax density ranged from 281.43 kg/m^3 and 499.38 kg/m^3, there was little variation in the relax ratio of 2.22 or 2.23. The durability rating of the briquettes ranged in 55 and 91%. It was concluded that stable briquettes could be formed from waste paper mixed with groundnut shell of up to 20% groundnut shell admixture.

***doi**: DOI:10.5829/idosi.ijee.2015.06.01.07*

INTRODUCTION

Wood in form of fuel wood, twigs and charcoal has been the major source of renewable energy in Nigeria, accounting for about 51% of the total annual energy consumption. The other sources of energy include natural gas 5.2%, hydroelectricity 3.1%, and petroleum products 41.3% [1]. As searches are conducted for a way out of future possible global energy crisis resulting from total exhaustion of conventional energy resources and global warming due to high carbon emission, decreasing availability of fuel wood and menace of desertification and deforestation drew our attention to the need to consider alternative sources of energy for domestic and cottage level industrial use. Such energy sources should be renewable and also should be accessible to low income class of society [2].

*Corresponding author: O. A. Oyelaran.
E-mail: ajanioyelaran@gmail.com Phone:+2348028253912

Biomass in form of agricultural waste can play a significant role in alternative energy generation and utilisation. Briquetting of agro-residues can alleviate some of the problems of energy shortage being encountered world-wide. By general definition biomass is the organic matter in trees, agricultural crops, living organisms, human, plants materials and organic compounds used to produce heat or to generate electricity. In a simpler term biomass is a plant materials and animal waste used as fuel or to generate electricity e.g. groundnut shell, coconut shell, rice husk, corn cob etc.

Briquetting can be done with or without a binder. Doing without the binder is more convenient but it requires sophisticated and costly presses and drying equipment which makes such processes unsuitable in a developing country like Nigeria [3]. In Nigeria, large quantities of agricultural and forestry residues produced annually are vastly under-utilized. The common practice is to burn these residues or leave them in the nature to decompose [4, 5]. However, previous studies have

Please cite this article as: O. A. Oyelaran, B. O. Bolaji, M. A. Waheed and M. F. Adekunle, 2015. Characterization of Briquettes Produced from Groundnut Shell and Waste Paper Admixture. Iranica Journal of Energy and Environment, 6 (1): 34-38.

shown that these residues could be processed into upgraded liquid fuel products such as briquettes. This work investigated briquetting of ground shell and waste paper admixture.

MATERIALS AND METHODS

In the production of fuel pellets and briquettes, the feedstock has to be ground before converting it into a denser product. Waste paper in form of disused typing sheets, photocopying and printing paper (excluding cardboard papers) was obtained from an office waste paper bin of Hydraulic Equipment Development Institute, Kano - Nigeria. The papers were manually shredded into small bits, mixed together, and soaked in cold water at room temperature (22 ±30^{o}C) for a period of three days. Thereafter, the water was drained off and the paper was converted into pulp by manual pounding with a pestle and a mortal as suggested by Olorunnisola [6]. Groundnut shells were collected from the processing sites at Dawanu, Kano state. The shells were hammer- milled and sieved. Particles that passed through the 850μm sieves and were retained on the 600μm sieves were used. The groundnut shell was sundried for about three days before stocking. The reason to choose waste papers in this research is because due to the properties of papers which can provide good properties for combustion and can also be used as a binder.

The digested waste paper and groundnut shell were thoroughly mixed in order to obtain a uniformly blended mixture. Mixtures were prepared at the following groundnut shell: waste paper weight ratios, i.e. 50:50, 40:60, 30:70, 20:80, and 10:90. In each case, a fixed quantity of the groundnut shell -waste paper mixture was hand-fed into the design and produced press and compacted. The dwell time was 5 minutes as suggested by Oyelaran [7]. The machine is a motorized briquetting machine, according to the design of the moulds, twelve (12) briquettes were produced per batch.

Immediately after extrusion from the mould, the briquette length, breath and height were measured using vernier caliper. Briquette mass was also determined with a digital scale. Therefore, the (initial) density of each and every newly formed briquette was evaluated for each combination of material. Additionally, the dimensions of each briquette formed were measured after 5, 10, 30, 60, 1440, 10080 minutes and 19 day period to determine the diametral and longitudinal expansion, along with the relaxed density of briquette.

The compressed density also called maximum density (density immediately after compression) of the briquette was determined immediately after ejection from the moulds as the ratio of measured weight to the calculated volume. The relaxed density (density determined when dried) and relaxation ratio (ratio of compressed density to relaxed density) of the briquette were determined in dry condition of the briquette after about 19 days of sun drying to a constant weight. The relaxed density was calculated as the ratio of the briquette weight (g) to the new volume (cm^3). This gave an indication of the relative stability of the briquette after compression.

Durability represents the measure of shear and impact forces a briquette could withstand during handling, storage and transportation processes[8]. The durability test was carried out according to Sah *et al.*[9], Oyelaran, *et al.*[10] and Suparin *et al.* [11] method, where the briquettes were dropped from a height of 1.85 m on a flat steel plate four times. The durability (%) was calculated as the ratio of the final weight of the briquette retained after four drops to the initial weight of the briquette. The fraction of the briquette that remained unshattered was used as an index of briquette durability. The durability rating of the briquette was expressed as a percentage of the initial mass of the material remaining on the metal plate and this gave an indication of the ability of the briquette to withstand mechanical handling.

The Ash content was determined according to Oyelaran, [7] where 1 gram of briquette sample was measured into known weighted ash tray with lid. The sample was then transferred into a high temperature carborlite furnace already set at 825^{0}C and heated for 1 hour. Then, the ash tray is taken out from the furnace and it is cooled in the desiccator until it reaches room temperature, both initial (W_i) and final (W_f) weights were recorded. The ash content was calculated as in equation 1.

$$\text{Ash Content, \%} = \frac{W_f}{W_i} \quad (1)$$

The heating value (calorific value) of briquettes were determined according to Oyelaran, *et al*. [10] were Leco AC-350 Oxygen Bomb Calorimeter interfaced with a microcomputer was used to assess the heat values of the produced briquettes. Two grams 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 data and result of the experiment are displayed on computer screen.

RESULTS AND DISCUSSION

Samples of the sun dried briquettes are shown in Figure 1. The average dimension of the briquettes was 19.3 cm. The briquettes assumed different shades of brown colorations, which depend on the quantity of the groundnut shell added. As indicated earlier, the dependent variables in this work included briquette physial durability, stability, along with the closely related relaxed density and water resistance.

The relevant aspect of briquette stability is the briquette expansion in the transverse (lateral) and axial directions. It is a well known fact that briquettes and/or pellets compressed in a closed cylinder have a tendency to expand as the pressure is released. The expansion takes place primarily in the direction in which the load is applied [7]; in this case axial direction. Table 1 shows increase in axial direction (thickness) of briquettes with respect to time after 5, 10, 60, 1440, 10080 minutes and 19 days (T_1, T_2, T_3, T_4, T_5 and T_6, respectively). While Table 2 shows the increase in lateral direction (length) of briquettes with time after 5, 10, 60, 1440, 10080 minutes and 19 days, respectively (L_1, L_2, L_3, L_4, L_5 and L_6,respectively).

Briquettes experienced larger percentage changes in the axial dimension than in lateral. Relative to the original dimensions the change in the axial direction reached up to about 9.78% compared to a maximum of about 4.56% in the lateral direction for briquettes produced with 100% waste paper. Other researchers reported a similar trend Mani et al. [12] during compaction of corn stover, Al- Widyan et al. [10] during briquetting of olive cake and Oladeji[13] during briquetting of two Species of Corncob.

Figure 1. Comparative variation in colour of briquettes produced

TABLE 1. Result of increase of length with time in the axial direction.

Sample	T_1 (cm)	T_2 (cm)	T_3 (cm)	T_4 (cm)	T_5 (cm)	T_6 (cm)
A	4.55	4.85	4.93	4.94	4.94	4.94
B	4.55	4.65	4.65	4.65	4.65	4.67
C	4.54	4.65	4.65	4.65	4.65	4.67
D	4.54	4.59	4.59	4.59	4.59	4.61
E	4.53	4.59	4.59	4.59	4.59	4.61

TABLE 2. Result of length with time in the lateral direction.

Sample	L_1 (cm)	L_2 (cm)	L_3 (cm)	L_4 (cm)	L_5 (cm)	L_6 (cm)
A	19.38	19.95	19.20	19.96	20.11	20.18
B	19.36	19.45	19.76	19.79	19.82	19.88
C	19.36	19.43	19.72	19.75	19.77	19.82
D	19.36	19.42	19.65	19.67	19.68	19.76
E	19.35	19.42	19.59	19.60	19.61	19.71

The axial expansion of briquettes decreased as the percentage ground shell increased, which resulted in reduced relaxed density as can be seen in Table 3. However, the overall axial and lateral expansions reduced with an increase in groundnut shell. Therefore, it was observed that percentage waste paper had a significant effect on briquette stability. It was observed, that briquette stability is best investigated by evaluating the relaxed density of briquettes. This is because relaxed density offers a better and single quantitative indicator of stability [7].

TABLE 3. Percentage axial and (thickness) and lateral (length) change after 19 days

Sample	% axial change	% lateral change
A	9.78	4.56
B	3.78	3.01
C	3.78	2.69
D	2.44	2.38
E	2.44	2.12

Furthermore, changes in briquette density result from changes in briquette mass and/or volume. Changes in briquette volume are a direct consequence of briquette expansion or shrinkage.

Examining the results in Figure 2 readily reveals that increased in groundnut shell significantly have effected on durability of the briquettes. An increase in the ratio of the groundnut shell resulted in decrease of durability. From the graph it can be seen that up to 20% of groundnut shell in the admixture the durability is above 90%. Therefore, a stable biomass briquette can be made of waste paper and up to 20% groundnut shell admixture without addition of binder.The observed decline in briquette durability with decrease in waste paper content could also be attributed to the adhesive role the waste paper played in the briquettes. Cellulose, the main constituent of paper, is known to contain proteinaceous materials which tend to have excellent adhesive properties [14].

Relaxed density offers a better and single quantitative index of stability. Furthermore, changes in briquette density result from changes in briquette mass and/or volume. Changes in briquette volume are a direct consequence of briquette expansion or shrinkage. The average compressed density of the briquettes (i.e. the density determined immediately after ejection) ranged between 627.59 and 701.91 kg/m^3 while the relax density ranges between 281.43 and 314.97 kg/m^3 as summarized in Table 4. In this study, relaxed density of a briquette was taken as the density (mass-to-volume ratio) the briquettes had immediately before dropping for durability evaluation. In terms of relax density and relaxation ratio briquettes produced from sample "A" appears better than the other four specimens. This is because, the lower the value of relaxation ratio and the higher the value of relaxed density, the higher is the stability of briquettes produced [15]. Generally, all the relaxation ratios obtained are good enough and they are close to the values obtained by Olorunnisola[6], where a relaxation ratio of between 1.80 and 2.25 was achieved for briquetting of waste paper plus the admixture of coconut husk and Oladeji[16],where relation ratio of 1.69, 1.78, 1.92, 195 and 2.22 was obtained for briquetting corncob, yam peels, cassava peels, melon shell and groundnut shell. A decrease in the maximum density was observed as the percentage of groundnut shell increases.

Heat value or calorific value determines the energy content of a fuel. It is the property of biomass fuel that depends on its chemical composition and moisture content. The most important fuel property is its calorific or heat value [17]. The result in Table 5 shows that, as the percentage by weight of paper paste decreases, ash content and calorific values decreases. However, it was noted that as the paper paste exceeded 20% there was a drastic decrease in the calorific value. Hence for optimum calorific value, the appropriate percentage paper paste should range between 10 and 20%. This energy value can produce enough heat required for household cooking and small-scale industrial cottage applications. The results of the calorific value of the briquettes compare well with the results of the heating value of sawdust briquette obtained [11] and almond shell briquette (19,490 kJ/kg) [18], cowpea (14,372.93 kJ/kg) and soybeans (12,953 kJ/kg) [19].

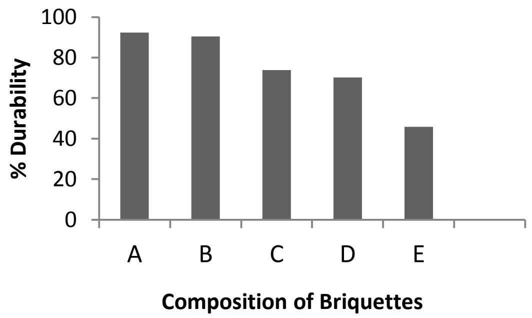

Figure 2. percentage durability of briquettes

TABLE 4. Result of Compressed (maximum) density, Relax density and Relaxation ratio of briquette Samples.

Samples	Compressed density, kg/m^3	Relax density kg/m^3	Relaxation ratio kg/m^3
A	699.23	314.97	2.22
B	701.91	314.76	2.23
C	676.61	304.78	2.22
D	657.31	294.76	2.23
E	627.59	281.43	2.23

TABLE 5. Result of Calorific value and Ash content of briquette Samples.

Sample	C.V. (MJ/kg)	Ash content (%)
A	20.18	1.92
B	20.02	2.11
C	19.60	2.48
D	19.40	2.72
E	19.32	2.81

CONCLUSION

From the experiment carried out, it was generally found out that the characteristics of biomass briquettes produced from compaction of groundnut shell and waste paper were satisfactory and compatible with the other researches. Nevertheless, the results obtained have met the objectives set at the early stage of the research. The objective to develop a solid fuel from the mixing of groundnut shell and waste paper at different ratios has been achieved successfully by producing sample briquettes in five different ratios. It can be concluded that waste paper and upto 20% groundnut shell admixture (Sample "A" and "B") briquettes gives the best properties. The briquettes were compatible with each others and it is suitable as a new solid fuel sources that can be utilized in many application. The blending of groundnut shell with waste paper can improve its physical and mechanical properties. . In view of this, the utilization of ground shell in the production of briquettes can greatly provide alternative energy sources for domestic cooking 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).

REFERENCE

1. Akinbami, J.-F.K., 2001. Renewable energy resources and technologies in Nigeria: present situation, future prospects and policy framework. Mitigation and adaptation strategies for global change, 6(2): 155-182.
2. Sambo, A.S., 2001. Renewable energy technologies for national development: status,. prospects and policy directions, The Nigerian Engineers.
3. Janczak J., 1980. Compendium of simple technologies for agglomerating and/or densifying wood, crop and animal residues. FAO Report, . Forestry Department, Rome.1-45

4. Olorunnisola, A., 2004. Briquetting of rattan furniture waste. Journal of Bamboo and Rattan, 3(2): 139-149.

5. Jekayinfa, S. and O. Omisakin, 2005. The energy potentials of some agricultural wastes as local fuel materials in Nigeria. Agricultural Engineering International, CIGR EJournal, 7:1-10

6. Olorunnisola, A., 2007. Production of fuel briquettes from waste paper and coconut husk admixtures. Agricultural Engineering International: CIGR EJournal, 6:1-11.

7. Oyelaran, O. A, Development of a Motorized Biomass Briquetting Machine, in Department of Mechanical Engineering,2014, Federal University of Agriculture, Abeokuta-Nigeria.

8. Adapa, P., L. Tabil and G. Schoenau, 2009. Compaction characteristics of barley, canola, oat and wheat straw. Biosystems engineering, 104(3): 335-344.

9. Sah, P., B. Singh and U. Agarwal, 1981. Compaction behaviour of straw. Journal of agricultural engineering,18(1):89-96

10. Oyelaran, O., B. Bolaji, M. Waheed and M. Adekunle, Effects of Binding Ratios on Some Densification Characteristics of Groundnut Shell Briquette,5(2):167-172.

11. Chaiklangmuang, S., S. Supa and P. Kaewpet, 2008. Development of fuel briquettes from biomass-lignite blends. Chiang Mai J. Sci, 35(1): 43-50.

12. Mani, S., S. Sokhansanj, X. Bi and L.G. Tabil, 2004. Compaction of corn stover.(2004):1239-1249

13. Oladeji, J., 2012. A comparative study of effects of some processing parameters on densification characteristics of briquettes produced from two species of corncob. The Pacific Journal of Science and Technology, 13(1): 182-192.

14. Immergut, E.H., 1975. Cellulose, in Browning, B.L. (ed.) The chemistry of wood. Robert E. Krieger Publishing Company, New York, USA.

15. Ryu, C., Y.B. Yang, A. Khor, N.E. Yates, V.N. Sharifi and J. Swithenbank, 2006. Effect of fuel properties on biomass combustion: Part I. Experiments—fuel type, equivalence ratio and particle size. Fuel, 85(7): 1039-1046.

16. Oladeji, J., 2012. Comparative Study of Briquetting of Few Selected Agro-Residues Commonly Found in Nigeria. Pacific Journal of Science and Technology, 13(2): 80-86.

17. Aina, O., A. Adetogun and K. Iyiola, 2009. Heat Energy From Value-Added Sawdust Briquettes Of Albizia Zygia. Ethiopian Journal of Environmental Studies and Management, 2(1):42-49.

18. Grover, P., S. Mishra and J. Clancy, 1994. Development of an appropriate biomass briquetting technology suitable for production and use in developing countries. Energy for Sustainable Development, 1(1): 45-48.

19. Enweremadu, C. and J. Ojediran, 2004. Evaluation of energy potential in husks from soy-bean and cowpea, (8):18-23.

Persian Abstract

DOI: 10.5829/idosi.ijee.2015.06.01.07

چکیده

گسترش بیابان و جنگل زدایی مشکلات بزرگی هستند که کشورهای در حال توسعه با آن مواجه می شوند. ابزار کافی برای دفع مواد زائد نیز ندارد، از این رو، تبدیل آنها به دیگر محصولات مفید مانند بریکت برای سوخت داخلی مطلوب است. هدف از این کار این است که برخی از خواص بریکت ساخته شده از پوسته بادام زمینی و ترکیب ضایعات کاغذ با پرداختن به مشکلات مدیریت، حمل و نقل و ذخیره سازی مرتبط با زیست توده زمانی که به عنوان سوخت مورد استفاده قرار می گیرد. بریکت با استفاده از یک دستگاه پرس بریکت موتوردار با استفاده از مخلوط پنج پوسته بادام زمینی و ضایعات کاغذ با نسبت (وزنی) به عنوان مثال،۹۰:۱۰،۸۰:۲۰،۷۰:۳۰،۶۰:۴۰ و۵۰:۵۰ تولید شد. نتایج به دست آمده نشان داد که بریکت تولید شده با استفاده از نسبت ۹۰:۱۰ زباله پوسته بادام زمینی-ضایعات کاغذ گسترش خطی بزرگتری (هرچند بسیار ناچیز) در خشک کردن دارد. در حالی که غلظت فشرده (حداکثر) بریکت در محدوده بین ۶۲۷/۵۹ kg/m^3 و ۸۷۸/۱۰ kg/m^3 مرتب شد. برای چگالی آزاد بین ۲۸۱/۴۳ kg/m^3 و ۴۹۹/۳۸ kg/m^3 مرتب شد. تغییرات کمی در نسبت آزاد ۲/۲۲ یا ۲/۲۳ وجود دارد. رتبه بندی دوام بریکت در محدوده ۵۵ و ۹۱٪ مرتب شد. نتیجه گیری شد که بریکت پایدار از ضایعات کاغذ مخلوط شده با پوسته بادام زمینی می تواند تا ۲۰٪ از مواد افزودنی پوسته بادام زمینی تشکیل شده باشد.