Proximate and Ultimate Composition of Parboiled Rice Husk from Local Rice Species and their Suitability for use in Bio-Briquette Production

Paul S. Ogbuefi [1], Placid Nwaokafor [2], Ifeanyi J. Njoku [3 *], Emeka D. Nwadinobi [4]

[1] Department of Chemistry, Ebonyi State University, Abakaliki, Ebonyi State, Nigeria

[2,3] Department of Physics, Federal University of Technology, Owerri, Imo State, Nigeria

[4] Department of Physics, University of Benin, Benin City, Edo State

ogbuefipl@gmail.com[1]; fadaplacid@gmail.com[2]; ifeanyinjoku72@gmail.com[3 *]; nobisemeka@gmail.com[4]

Abstract:

This study focused on evaluating the proximate and ultimate compositions of parboiled local rice husk species from Ikwo and Izzi rice clusters. The Izzi R8 and Ikwo CP rice husk species were sampled. Proximate analysis and ultimate analysis was carried out using thermo-gravimetric analyzer and elemental analyzer respectively. The Analysis shows that Izzi R8 and Ikwo CP have relatively high moisture content of 11.76% and 11.84% respectively. The ash content of the Izzi R8 and the Ikwo CP rice husk species were found to be 18.45% and 18.58% respectively. The Ikwo CP rice husk specie has higher composition of fixed carbon than that of Izzi R8. The results of the ultimate analysis show that the Izzi R8 and the Ikwo CP rice husk species have low carbon content of 13.85% and 13.87% respectively. Izzi R8 and Ikwo CP rice husks species show Nitrogen content of 1.18% and 1.20%. Izzi R8 and Ikwo Cp rice husk species show high content of Oxygen (67.48% and 68.34%) respectively and Sulphur (2.47% and 2.52%) respectively. These high contents of Oxygen, Nitrogen and Sulphur suggest the ease of the formation of NO_x and SO_x compounds during combustion. Due to Abakaliki Rice husk species (Izzi R8 and Ikwo CP) having high moisture content and low volatile matter content with moderate ash content, they may not compete well as energy source, that is, as a raw material for briquetting.

Keywords: Rice Husk; Rice Husk Ash; Bio-Briquette; Proximate composition; Ultimate composition

1. Introduction

Availability of energy in the rural as well as urban areas of Nigeria is fast becoming a big problem with the relatively high cost of conventional cooking fuels like gas and kerosene and environmental problems associated with the use of firewood [1]. This has necessitated the need for urgent transition to a more sustainable energy source that would be cheaper and friendlier to the environment. Consequently, several researches are on-going on the prospects of agricultural waste and other biomass for the production of solid fuels known as briquettes which would serve as alternatives to the use of firewood especially in the rural areas.

A briquette is a brick of flammable matter used as fuel to start and maintain a fire. They are produced through a process known as briquetting. This process involves the process of making loose biomass residues, such as sawdust, straw, rice husk etc., into high density solid blocks for use as fuel. Charcoal and biomass briquettes are common types of briquettes. Biomass briquettes could replace fossil fuels or wood for cooking and industrial processes as they are cleaner, cheaper and easier to handle and cut greenhouse gas emissions.

Rice husk is one of the most widely available agricultural wastes in many rice - producing countries around the world. Much of the husk produced by processing rice is either burnt or dumped as waste in majority of rice - producing countries. Burning rice husk leaves a residue, called rice husk ash (RHA) and it makes up approximately 25% of the rice husk. Rice husk is the sheath that covers the rice grain. It is an exceptional biomass normally available with 10-12% moisture. Utilization of rice husk as alternative source of fuel in drying has made it a more valuable agricultural waste. Rice husk has enormous potential for generation of energy and biomass-to-energy projects, protect the environment, reduce poverty and improve the quality of life for the rural poor [2]. Rice husk in its natural form, just like any other agricultural residues, cannot be effective for use for energy conversion. This is because use of agricultural residues is often challenging due to their uneven characteristics. It is widely agreed that the majority of the residues in their natural forms have lower density, higher moisture content and lower energy density. Besides, the low bulk density and dusty characteristics of the biomass also cause transportation, handling and storage problems [3]. Biomass briquetting is an effective way to solve these problems and contribute towards solving the energy shortage problem and environmental pollution [4].

Fuel briquettes produced under different conditions have been reported to have different properties. These properties are also determined by the raw material properties. If agricultural waste briquettes are to be used efficiently and rationally as fuel, they must be analyzed to determine parameters such as the moisture content, ash content and volatile matter among others. The result of these determinations indicates the suitability of the agricultural waste as briquette. Agricultural waste briquettes should have low moisture content, high crushing strength, high density, slow flame propagation, low ash content, high amount of carbon, and substantial heating value. According to Yang et al. (2005) [5], a very important property which affects the burning characteristics of biomass is the moisture content. Volatile matter content has also been reported to influence the thermal behavior of solid fuels [6]. Consequently, this study investigates the proximate and ultimate compositions of parboiled local rice husk species Izzi R8 and Ikwo CP and their suitability in bio-briquette production.

2. Materials and Methods

2.1Collection of Samples

The different varieties of rice grain were collected from different Rice farmers (R8 1zzi rice farmers and CP from Ikwo rice farmers) in Izzi and Ikwo Local government areas of Ebonyi State. Rice grain was preferred to already discard rice husk to avoid contamination that could occur during the milling process and to ensure sample specificity of the different varieties of interest.

2.2 Sample Pretreatment

The collected Rice grain varieties were washed differently in distilled water and dried in open air for three (3) days. De-husking was done using agate mortar and pestle. Each of the sample was carefully de-husked. 3 kg of the rice husk species was recovered, rewashed with 0.5 M HCl to remove every impurity and further sun dried in open air for 7 days to reduce the moisture content. The well dried husk was taken to the grinding machine for grinding. The machine was thoroughly washed, dried and used to grind the husk into fine powder of about 0.98 mm – 2 mm mesh size. 1 mm sieve was used to sieve the ground particles to ensure uniform size which was used for ultimate and proximate analysis.

2.3 Proximate Analysis

Proximate analysis, which is a standardized procedure that gives an idea of the bulk components that make up a fuel, was done to determine the percentage volatile matter content, percentage ash content, moisture content and percentage content of fixed carbon of the samples. This was done using a thermal gravimetric analyzer 7 TGA7 at the National Research Institute for Chemical Technology (NARICT), Zaria, Kaduna State, Nigeria.

2.3.1 Percentage Determination of the Volatile Matter

Exactly 20 g of pulverized rice husk samples were weighed in a crucible and set at a temperature of 700 °C for 10 minutes, cooled and was re-weighed again. The volatile matters present were then calculated as a percentage as follows:

$$\% \text{ Volatile matter } = \frac{a-b}{c} \times 100 \quad (1)$$

where,

a = weight of the dry sample after removing moisture

b = weight of the residue after heating

c = initial weight of the sample.

2.3.2 Percentage Determination of Ash content

The ash content of the samples was determined by weighing 4.0 g of each sample; heating the pulverized rice husk samples using crucible in a furnace set ready at 700 °C for 2 hours. Crucible and its contents were cooled to about 200 °C in air, and finally at room temperature in a desiccator. These were weighed again and the percentage ash content is calculated as follows:

$$\% \text{ Ash content } = \frac{a}{b} \times 100 \quad (2)$$

where

a = weight of the dry samples after heating

b = weight of the sample prior heating.

2.3.3 Percentage Determination of Moisture Content

After the successive days of sun drying in an open air, 4.2 g of pulverized fine particles of the husks were weighed in a crucible. Then, the samples in the crucible were together transferred into an oven set at 120 **℃** for exactly 24 hours. The samples were removed from the oven and allowed to cool for 15 minutes in a desiccator and re-weighed and the percentage moisture content estimated as follows:

$$\% \text{ Moisture content } = \frac{c - y}{c} \times 100 \qquad (3)$$

c = initial weight of the sample

y = weight of the sample after drying

2.3.4 Percentage Determination of Fixed Carbon Content

Percentage fixed Carbon is always estimated as full percentage less the sum total of % ash, % volatile and % moisture, as follows:

$$\% \text{ Fixed Carbon } (\% \text{ FC}) = 100 - \% (\text{ash} + \text{volatile matter} + \text{moisture}) \qquad (4)$$

2.4 Ultimate Analysis

Estimations of important chemical elements that make up the samples, namely Carbon, Hydrogen, Oxygen, Nitrogen and Sulphur were determined through ultimate analysis using an Elemental analyzer model AE 2400 A.E at the National Research Institute for Chemical Technology (NARICT), Zaria, Kaduna State, Nigeria.

3. Results and Discussions

3.1 Proximate Composition of the samples

Table 1 gives a summary of proximate content of the two species. Izzi R8 and Ikwo CP rice husk species have relatively high moisture content of 11.76% and 11.84% respectively. These compare favorably with other studies: Milla et. al. (2013) [7] reported 11.3%, Ekwe (2013) [8], Mhilu (2014) [9] and Efomah & Gbabo (2015) [10] reported 9.93%, 8.80% and 12.67% respectively. Agrafioti et al. (2014) [11] reported 10.1% for rice husk biochar used for Arsenic and Chromium removal from water.

On the other hand, the ash content of the Izzi R8 and the Ikwo CP rice husk species are 18.45% and 18.58% respectively. [9], [12] and [10] all reported lower values of 12.63%, 17.9% and 16.1% respectively. [8] and [9] reported significantly higher values of 25.82% for Abakaliki rice and 26.20% respectively.

Ikwo CP rice husk has higher composition of fixed carbon than Izzi R8 rice husk and relatively higher than that reported by Wannapeera et al. (2008) [12], 9.3%, Mhilu (2014) [9], 14.60% and Efomah & Gbabo (2015) [10], 15.70% for rice husk briquette.

The volatile matter content of Izzi R8 rice husk is much higher than that of Ikwo CP rice husk. These values are considerably higher than reported by Milla et. al. (2013) [2013], 2.42% for fresh rice husk although relatively lower than reported lower than the values reported in [12], 72.8% and [9], 59.2%.

The relatively high moisture content, low volatile matter content with moderate ash content of Abakaliki Rice husk species (Izzi R8 and Ikwo CP) suggests that it may not compete well as an energy source, that is, as a raw material for briquetting. High fixed carbon suggests high calorific value and vice versa. High moisture content implies longer drying days after its use as a raw material for briquetting. The proximate compositions of the samples are represented in fig. 1.

Table 2 gives the mean proximate composition of the samples. The data on table 2 is shown on fig. 2. On the average, the dry matter content is the highest for both samples with 41% while the crude fat content is the lowest at 1%.

3.2 Ultimate Composition of the samples

Table 3 gives a summary of the ultimate composition of rice husk species Izzi R8 and Ikwo CP. The results show that the composition of the elements, Carbon, Hydrogen, Oxygen, Nitrogen, Sulphur for both samples are within the range of 0.5% - 1.0% of each other.

The samples show an exceptionally low value of carbon of 13.85% and 13.87% in Izzi R8 and Ikwo CP rice husk species respectively. [12], [9] and [10] reported much higher values of 48.90%, 45.60% and 45.20% respectively.

Izzi R8 and Ikwo CP rice husks species show high contents of Nitrogen, 1.18% and 1.20% respectively compared to literature.

Sulphur content of Izzi R8 and Ikwo Cp rice husk species is considerably higher than reported by [9], 0.02%.

All the rice husk species analyzed show very high content of Oxygen (67.48 and 68.34) %. [12] and [9] respectively reported lower values of 44.1% and 33.40%.

High content of Oxygen, Nitrogen and Sulphur suggests the ease of the formation of NO_x and SO_x compounds during combustion. Invariably the smoldering burning of rice husk which oozes much smoke could have high content of SO_x, CO_x, NO_x compounds. Fig. 3 depicts the ultimate composition of the samples.

The ultimate analysis showed high level of Sulphur and nitrogen. High content of Sulphur and Nitrogen obviously contribute to the amount of NO_X and SO_X produced during combustion. These gases are air pollutants which contribute to greenhouse effect and environmental pollution which can affects health and the natural environment.

The mean ultimate composition of the samples is given in table 4. Fig. 4 shows that for the two samples, Oxygen has the highest mean percentage composition of 65% while Nitrogen has the lowest mean percentage concentration of 1%.

Table 1. Proximate Composition of the Samples

S/N	Parameter	% Composition	
		Izzi R8	Ikwo CP
1	Moisture content	11.76	11.84
2	Ash content	18.45	18.58
3	Dry matter	88.24	88.16
4	Crude fat	3.17	3.14
5	Crude fiber	16.87	16.85
6	Crude protein	7.45	7.84
7	Fixed carbon	12.65	16.48
8	Volatile matter	57.14	53.10

Table 2. Mean Proximate Compositions of the Samples

S/N	Parameter	% Composition (± SE)
1	Moisture content	11.800 (± 0.040)
2	Ash content	18.515 (± 0.065)
3	Dry matter	88.200 (± 0.040)
4	Crude fat	3.155 (± 0.015)
5	Crude fiber	16.860 (± 0.010)

CC BY

6	Crude protein	7.645 (± 0.195)
7	Fixed carbon	14.565 (± 1.915)
8	Volatile matter	55.120 (± 2.020)

SE: Standard error with 95% confidence interval

Table 3. Ultimate Composition of the Samples

Elements	**% Composition**	
	Izzi R8	**Ikwo CP**
Carbon	13.85	13.89
Hydrogen	14.60	14.53
Oxygen	67.48	68.34
Nitrogen	1.18	1.20
Sulphur	2.47	2.52

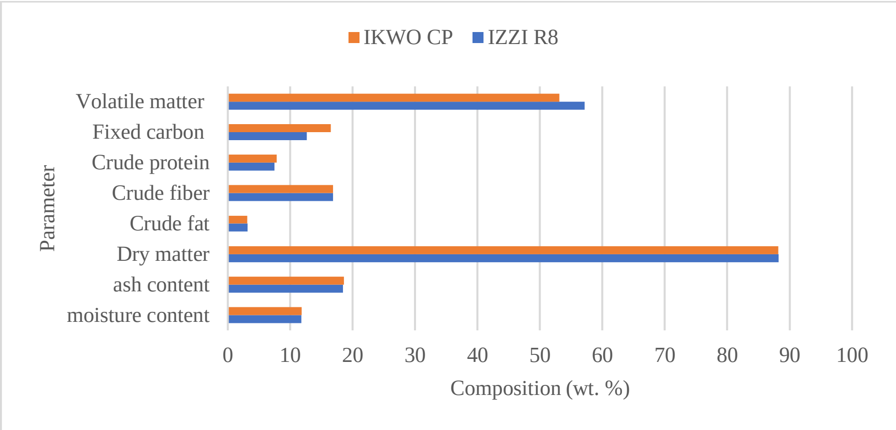

Fig. 1. Proximate Composition of Izzi R8 and Ikwo CP Rice Husk Species

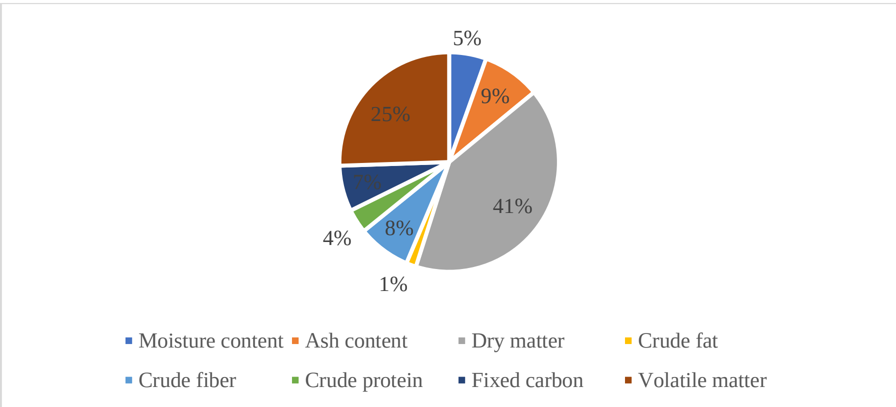

Fig. 2 Mean Proximate Compositions of the Samples

CC BY

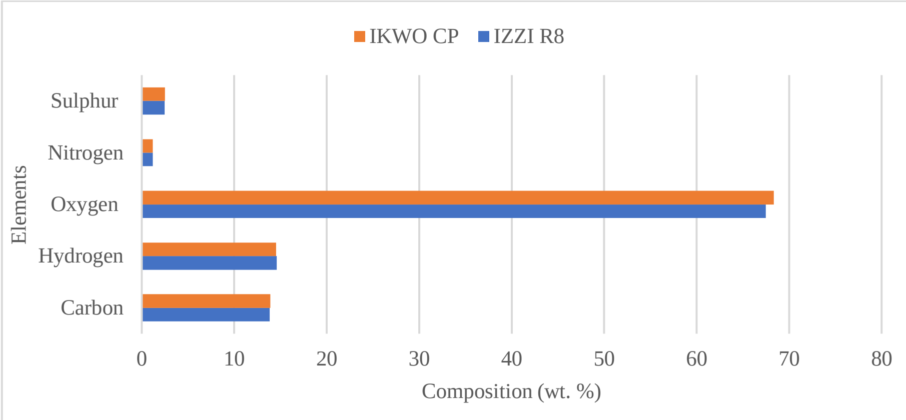

Fig. 3. Ultimate Composition of Izzi R8 and Ikwo CP Rice Husk Species

Table 4. Mean Ultimate Composition of the Samples

Elements	% Composition (± SE)
Carbon	13.870 (± 0.020)
Hydrogen	14.565 (± 0.035)
Oxygen	67.910 (± 0.430)
Nitrogen	1.190 (± 0.01)
Sulphur	2.495 (± 0.025)

SE: Standard error with 95% confidence interval

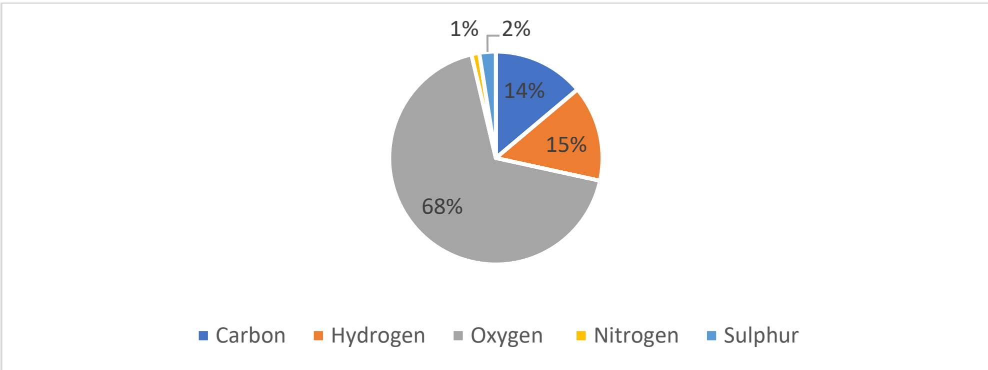

Fig. 4 Mean Ultimate compositions of the samples

4. Conclusion

In terms of raw material for bioenergy production, the Abakaliki rice husk species sampled in this study may not compete well. The high contents of Nitrogen and Sulphur in the species pose considerable health and environmental concerns during combustion due to the formation of hazardous NO_x and SO_x gases. Consequently, it could be concluded that Abakaliki rice husk species (Izzi R8 and Ikwo CP) is not suitable for bio-briquette production.

CC BY

Conflicts of Interest

All authors have declared no competing interests as regards the publication of this work.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

[1] J.T. Oladeji, Pyrolytic Conversion of Cow Dung into Medium-Grade Biomass Fuels. (2011a). International Journal of Pure and Applied Sciences. 4(2): 173-178.

[2] M. Ahiduzzaman. (2007). Rice Husk Energy Technologies in Bangladesh, Agricultural Engineering International: the CIGR E journal Invited Overview. 9(1).

[3] Z. Husain, Z. Zainac, Z. Abdullah. (2002). Briquetting of Palm Fibre and Shell from the Processing of Palm Nuts to Palm Oil, Biomass and Bioenergy. 22(6): 505-509. https://doi.org/10.1016/S0961-9534(02)00022-3.

[4] E.A. El-Saeidy. (2004). Technological Fundamentals of Briquetting Cotton Stalks as a Biofuel, An unpublished Ph.D. Thesis. Faculty of Agriculture and Horticulture, Humboldt Germany. 56-70.

[5] Y. B. Yang, C. Ryu, A. Khor, N. E. Yates, V. N. Sharifi, J. Swithenbank. (2005). Effect of fuel properties on biomass combustion. Part II. Modelling approach—identification of the controlling factors, Fuel. 84(16): 2116–2130. https://doi.org/10.1016/j.fuel.2005.04.023.

[6] S. V. Loo, J. Koppejan. (2008). The Handbook of Biomass Combustion and Co-firing, Earthscan, London. https://doi.org/10.4324/9781849773041.

[7] O. V. Milla, E. B. Rivera, W.J. Huang, C. C. Chien & Y. M. Wang. (2013). Agronomic Properties and characterization of rice husk and wood biochar and their effect on the growth of water spinach in a field test, Journal of Soil Science and Plant Nutrition. 13(2): 251-266. https://dx.doi.org/10.4067/S0718-95162013005000022.

[8] N. B. Ekwe. (2013). Analysis of Abakaliki Rice husk. Der Chemica Sinica. 4(1): 67-74.

[9] C. F. Mhilu. (2014). Analysis of Energy Characteristics of Rice and Coffee Husk Blends, ISRN Chemical Engineering. Volume 6 pages. Article ID 196103. https://doi.org/10.1155/2014/196103.

[10] A. N. Efomah, A. Gbabo. (2015). The Physical, Proximate and Ultimate Analysis of Rice Husk Briquettes produced from vibrating block mould briquetting machine. International Journal of Innovative Science and Technology. 2(5): 814-822.

[11] E. Agrafioti, D. Kalderis, E. Diamadopoulos. (2014). Arsenic and Chromium removal from water using biochar derived from Rice husk, Organic solid wastes and Sewage sludge. J. Environ. Manage. 133: 309-314. https://doi.org/10.1016/j.jenvman.2013.12.007.

[12] J. Wannapeera, N. Worasuwannarak, S. Pipatmanomai. (2008). Product Yields and Characteristics of Rice husk, Rice straw and Corn cob during fast pyrolysis in a drop-tube/fixed-tube reactor, Songklanakari J. Sci. Technol. 30(3): 393-40.