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PHYSICO-CHEMICAL PROPERTIES OF BRIQUETTES FROM RICE HUSK – SAW DUST MIXTURES AND ITS ENERGY POTENTIAL IN THE RENEWABLE ENERGY MATRIX.

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ABSTRACT

The energy potentials of briquettes produced from a mixture of rice husk and saw dust have been investigated from the physic-chemical properties under strict laboratory analysis using the compression and dewatering methods. The parameters indicated that briquettes from rice husk and saw dust using cassava starch as binders, are reddish brown while briquettes from rice husk and saw dust with gum Arabic are dark brown in colours. Furthermore, the moisture content of briquettes from rice husk and cassava starch is lower compared to that from saw dust and cassava starch (Table 1 and 2). Under intense pressure, briquettes from rice husk and cassava starch burn at 40oC in 3minutes, while rice husk with gum Arabic burn at 54oC in 3minutes. At the ratio of 50 – 50, briquettes with gum Arabic as binders is the best in calorific values at 0.694g/sec (Table 5). Saw dust has high thermal efficiency than rice husk while starch is more combustible than gum arabic. Equations 1 and 2 are determinants in the weight measurement processes and the ratio of materials for the right proportion of rice husk and saw dust with the different binders at different times. The moisture contents and burning rates of these briquettes are fundamental to the determinations of the energy potentials as alternative renewable energy source in Nigeria, equation 2. Briquettes produced from rice husk and saw dust is compatible with fuel needs in the rural areas and makes good biomass fuel as alternative energy sources if properly harness for both domestic and industrial use. This paper therefore, is useful for policy decisions on renewable energy industrialization, energy diversification and agro-economics for environmental preservation in Nigeria.

Keywords: Briquettes, Renewable Energy, Saw dust, Rice Husk, Gum Arabic.

INTRODUCTION:

Environmental pollution ranging from refuse heap on our streets and in drainage system and water ways, which results to flooding on rainy days due to the blockage of the waterways are noticeable problems globally. Deforestation has likewise lead to the unavailability of fuel-like wood which helped in the regularly rising costs of lamp oil and cooking gas, especially in West African sub-region. All these has drawn attention to the need to consider recycling and alternative sources of energy for residential and cabin level mechanical use in the nation (Lucas and Adegoke, 2008). As properly noted by (Stout and Best, 200l), progress to a renewable energy system is urgently needed in the developing countries such as Nigeria. Renewable power sources are been sought for domestic cooking in developing countries due to the fact that their non-renewable counterpart such as kerosene, cooking gas etc., are not keeping up with peoples' demand (Olawole *et al*, 2008). Additionally, the staggering expenses of non-renewable power sources are beyond the reach of the average Nigerians, making the utilization of renewable power hotspots for residential cooking. Therefore, recycling of agricultural waste products into useful briquette product as alternative energy source is in high demand in Nigeria.

Briquetting is an innovation for densification of agricultural deposits to expand their mass thickness, bring down their dampness substance and make briquettes of uniform shapes and sizes for simple handling, transport and capacity. Briquettes can be characterized as product framed from physico-mechanical change of free and modest molecule size materials with or without binder in various shapes and sizes. An examination on rice husk briquettes at Sylhet, Khulna and Dinaj Pur regions of Bangladish was carried out to distinguish the issues and prospects of utilizing the briquettes as an elective fuel for cooking. Rice is the staple nourishment for the individuals of Bangladish. The all out yearly generation of agricultural residue is about 28million ton (FAO, 1992) and about 20% of this (5.6million ton) is rice husk. The examination likewise inferred that to avert natural perils brought about by quick deforestation exercises, rice husk briquettes might be presented as an elective fuel which is less unsafe, high calorific worth and similarly modest (Maih *et al.,* 1999). However, rice husk in its present structure, much the same as some other agricultural residues, can't be viably utilized for energy transformation. Rice husks are the hard ensuring covers of grains of rice. It is framed from hard materials, including silica and lignin, to secure the seed during the developing season. The debris contains less alkaline minerals and it is an unprecedented biomass typically accessible with 10 – 12% dampness. It makes a fantastic fuel despite the fact that its calorific worth is not as much as wood. Rice husk can be put to use as building material, compost, insulation material, or fuel. Rice husk are a piece of the refuse of the rice (Inegbenebor, 2002). If these agricultural and industrial wastes can be appropriately recycled, into valuable products, more products will be made accessible to our general public and natural contamination would decreased. The utilization of biomass fuel, for example, composite sawdust briquette has been proposed to be a good source of renewable energy for domestic cooking (Kuti and Adegoke, 2008). Moreover, deforestation which advances contamination will be radically diminished if the utilization of sawdust waste is upgraded. Sawdust is a modest bit of wood that falls as powder from wood as it is cut by a saw. Sawdust is essentially a misuse of little particles accessible in observed processing ventures, mash plant and paper enterprises just as wood preparing businesses especially in the southern parts of Nigeria, in a very huge volume and generally consumed off bringing about the ecological contamination (Alhassan and Olaoye 2017). Sawdust is commonly considered as a timber-modern waste that contaminates nature however can turn into a significant item either as a crude material in assembling enterprises for wood sheets, light development materials, for example, racks, see sheets, divider and rooftop sheeting for versatile houses, as a protector in the refrigerating framework, (Yusuf et al 2021).

MATERIALS AND METHODS

Selected samples of Rice husk were collected from a rice mill at Shango, Chanchaga road in Chanchaga local government area, Niger state. Saw dusts were also collected from a saw mill at Bosso, Randan ruwa in Bosso local government area Niger state. Binders made up of Cassava starch and Gum Arabic (from cashew) were used as binding agents. Hydraulic press machine, Water, Fabricated Rocket stove and Matches, Glass Mercury Thermometer, Weighing balance, Meter rule etc were prepared and sterilize for the laboratory experiments. The manual briquetting machine used for this study has four major assembling units which comprises of the housing frame, the mould unit, the jack and ram and the Pressure cap. It is made up of a pair of 4mm thick angle bar of a total height of 49cm, the two angle bar were welded together to produce a rectangular shaped box of total width of 16.5cm. Another angle bar was welded to the top of the frame, two holes were drilled so as to drive a bolt and nut to frame, this bolt and nut will hold the mould to the frame so as to avoid the mould from shaking while the briquetting process is taking place.

Fig 1: The frame

The mould is the part of the press that receives the samples for compaction; it is made up of a pair of cylindrical steel pipe of 120mm with a diameter of 50mm. An angle bar of 10mm thick holding the two cylindrical moulds are fastened to the frame of the press by two 13 bolts and nuts; this is just to ensure that the mould is firm while the compaction is going on. After compaction, the samples is been removed while the separator helps in providing shorter briquettes.

Fig 2 - The Fabricated mould

In other to achieve proper briquette compaction, a pressure cap is introduced on top of the briquetting. While compaction process is being carried out, the pressure cap stops the samples from escaping the top of the mould. It is made up of a thick 4mm steel plate which is slide into its sitting at the upper part of the briquetting machine. A gap was created between the frame and pressure cap so as to help water escape from the samples while compaction is being carried out.

The jack is the only device that produces the pressure for compaction to take place, it is a 3 tons jack that uses upward force to carry out the compaction and removal of the sample briquettes. The jack is being placed inside the frame; it also carries the Ram and piston press as the default arrangement of the briquetting machine. In other to achieve proper briquette compaction, a ram is introduced as a press with the help of the jack (3 tons).

Briquetting process for rice husk with starch and gum arabic

The collected rice husk sample was screened from stones and other impurities that might inhibit proper briquette formation. The heating mantle was switched on and water was poured into the pot and placed on the heating mantle. After boiling, the hot water was then mixed with the starch until a sticky gel was produced. The rice husk was individually wetted with water so as to enhance uniform mixing with the binding agent (Starch). The binder (starch) was then mixed with the wetted samples in the proper binder-mix ratio. This mixture was then poured into the mould of the briquette machine. With the combined effect of the compression and the ejection stroke, the briquettes were formed. The produced briquettes were sun dried for efficient moisture removal. After the drying process, the briquettes were removed from the sun and a solid mass was formed capable of being used as a substitute for wood fuel.

Fig 3: produced rice husk sample

Gum Arabic was soaked in water at average temperature for up to one hour, then the stone-like material fully dissolved in water to produce a binder, the binder is mixed with the Rice husk to produce the mixture.

Briquetting process for Saw dust with starch and gum arabic

The collected saw dust sample was screened from stones and other impurities that might inhibit proper briquette formation. The heating mantle was switched on and water was poured into the pot and placed on the heating mantle. The saw dust was individually wetted with water so as to enhance uniform mixing with Starch. The binder was mixed with the wetted samples in the proper binder-mix ratio. This mixture was poured into the mould of the briquette machine. The produced briquettes were sun dried for efficient moisture removal. Same process was carried out for gum - Arabic, only that gum - Arabic does not require hot water when forming the gel like binder. Gum Arabic was soaked in water at average temperature for up to one hour, to produce a reddish liquid material as a binder. This sample is being poured into the mould of the briquetting machine. The compaction and ejection was carried out and the briquettes were formed.

Briquetting process for mixture of 50:50 ratios for rice husk and Saw dust using starch and gum arabic as binder.

The mixture of rice husk and saw dust sample was screened from stones and other impurities that might inhibit proper briquette formation. The heating mantle was switched on and water was poured into the pot and placed on the heating mantle. After boiling, the hot water was then mixed with the starch until a sticky gel was produced. The mixture was individually wetted with water so as to enhance uniform mixing with the binding agent (Starch). The binder (starch) was then mixed with the wetted samples in the 50:50 binder-mix ratios.

Fig 4: produced sample of rice husk and saw dust in 50:50 ratio

This mixture was then poured into the mould of the briquette machine. With the combined effect of the compression and the ejection stroke, the briquettes were formed as shown in plate. The produced briquettes were sun dried for efficient moisture removal. After the drying process, the briquettes were removed from the sun and a solid mass was formed capable of being used as a substitute for wood fuel. The moisture contents of the briquettes were determined based on the fresh and dry weights of the briquettes as described below:

$$\%\ moisture = \frac{X_1 - X_2}{X_1} \times 100 \qquad \text{.......1}$$

$$where\ X_1 = wet\ weight\ of\ briquette$$

$$X_2 = Dry\ weight\ of\ dried\ briquette$$

Briquettes burning rate were determined by recording the briquettes weight before combustion and after the briquettes were completely burnt, the rate at which fire consume the briquette samples were calculated using equation.

$$Burning\ rate = \frac{mass\ of\ total\ fuel\ consumed\ (Kg)}{total\ time\ taken\ (min)} \qquad \text{.......2}$$

RESULTS AND DISCUSSION.

Wet samples of all briquettes have the same colour as the original raw materials. And sun dried briquettes produced from rice husk and sawdust using cassava starch and gum arabic as binders and their various colours. Briquettes produced using sawdust & cassava starch as binder are reddish brown in colour while briquettes produced using saw dust with gum arabic are dark brown in colour. Rice husk samples of cassava starch and gum arabic produced a similar light brown color only that Rice husk & cassava starch is more whitish than the other rice husk & gum arabic.

Fig 5: Rice husk and cassava starch.

Fig 6: Rice husk with gum arabic.

Fig 7: Saw dust with gum arabic.

Fig 8: Mixture of rice husk and saw dust 50:50 ratio using gum Arabic as binder.

The result for moisture content which describes the samples that carries more moisture at maximum weight, table 1 shows that saw dust with cassava starch had the highest moisture content while rice husk with cassava starch had the least moisture content. The density of the relaxed mass indicated that saw dust with cassava starch had the highest values of density while rice husk & gum arabic had the least value at relaxed weight.

Samples	Diameter (cm)	Height (cm)	Fresh weight (g)	Dry weight (g)	Moisture content (%)	Volume (cm^2)	Dry Density (gcm^{-2})
Rice husk & cassava starch	5.00	4.94	65.00	52.00	20.00	97.00	0.5361
Rice husk & gum Arabic	5.00	5.04	63.00	50.00	20.63	98.96	0.5053
Saw dust &cassava starch	5.00	4.93	78.00	59.00	24.36	96.80	0.6095
Saw dust & gum Arabic	5.00	5.03	74.00	57.00	23.00	98.76	0.5772

Both samples & cassava Starch	5.00	4.95	71.50	56.00	21.30	97.19	0.5762
Both samples & gum Arabic	5.00	5.07	69.00	54.00	21.70	99.55	0.5424

Table 1 shows the variation of height, weight, moisture content, volume and density of products.

Table 2 below shows that the rice husk briquette with cassava starch attained a temperature of 40^{o}C in 3 minutes while rice husk briquette with gum arabic attained a temperature of 54^{o}C at the same time interval. In 6 minutes, the temperature of the water for rice husk - starch briquette rose to 53^{o}C, followed by 85^{O}C in 9 minutes, 90^{O}C in 12 minutes and finally 100^{O}C in 15 minutes. Compared to rice husk & gum arabic which burns from 54^{o}C in 6 minutes, 67^{o}C in 9 minutes, 78^{o}C in 12 minutes, and finally 100^{o}C in 15 minutes. From the result obtained it can be seen that the water heated with rice husk & cassava starch and rice husk with gum arabic briquettes both took 15 minutes to boil 1 litres of water.

Rice husk & cassava starch		Rice husk & gum Arabic	
Time (min)	Temperature (^{o}C)	Time (min)	Temperature (^{o}C)
0	28	0	28
3	40	3	54
6	53	6	67
9	85	9	78
12	90	12	89
15	100	15	100

Table 2 boiling point test for rice husk briquette (cassava starch and gum arabic).

Table 3 shows the variation of temperature with time for both Saw dust starch and gum Arabic both from initial temperature of 28^{o}C, it is seen from this table that the saw dust - starch briquette attained a temperature of 58^{o}C in 3 minutes while saw dust gum arabic attained a temperature of 60^{o}C at the same time interval. In 6 minutes, the temperature of the water for Saw dust – starch briquette rose to 70^{0}C, followed by 81^{o}C in 9 minutes, finally 100^{o}C in 12 minutes, compared to saw dust which burns from 76^{o}C in 6 minutes, 85^{o}C in 9 minutes, and finally 100^{o}C in 12 minutes.

Table 3 boiling point test for saw dust briquette (cassava starch and gum arabic).

Saw dust & cassava starch		Saw dust & gum Arabic	
Time (min)	Temperature (^{o}C)	Time (min)	Temperature (^{o}C)
0	28	0	28
3	58	3	60
6	70	6	76
9	81	9	85
12	100	12	100

Table 4 shows the mixture of 50:50 ratio of rice husk with saw dust briquette using cassava starch as binder attained a temperature of 49^{o}C in 3 minutes while mixture of 50:50 ratio of rice husk with saw dust briquette using gum arabic as binder attained a temperature of 57oC at the same time interval. In 6 minutes, the temperature of the water for mixture of 50:50 ratio of rice husk with saw dust briquette using starch as binder rose to 61oC, followed by 83^{O}C in 9 minutes, and finally 100^{O}C in 12 minutes. Compared to mixture of 50:50 ratio of rice husk with saw dust briquette using gum arabic which burns from 77^{o}C in 6 minutes, 87oC in 9 minutes, 95^{o}C in 12 minutes, and finally 100oC in 15 minutes. From the result obtained it can be seen that the water heated with mixture of 50:50 ratio of rice husk with saw dust briquette using starch boiled in 12 minutes while mixture of 50:50 ratio of rice husk with saw dust briquette using gum Arabic took 15 minutes to boil the same quantity of water.

Mixture of both samples with starch		Mixture of both samples with gum arabic	
Time (min)	Temperature (^{o}C)	Time (min)	Temperature (^{o}C)

0	28	0	28
3	49	3	57
6	61	6	77
9	83	9	87
12	100	12	95
15		15	100

Table 4 boiling point test for 50:50 ratios for rice husk with saw dust briquettes (cassava starch and gum arabic)

The table below indicates that Saw Dust Starch and Gum Arabic, and mixture of rice husk with saw dust in 50:50 ratio had the highest burning rate 0.694 compared to rice husk samples which has the lowest value 0.556, it also show that the mixture of rice husk samples and mixture of rice husk with saw dust in 50:50 ratio has the lowest value of 0.556. Result shows that saw dust has higher burning rate and thermal efficiency than rice husk. From the results, starch is more combustible than gum arabic

Samples	Mass of burnt samples (g)	Time taken (min)	Time taken (sec)	Burning Rate (g/sec)
Rice Husk & starch	500	15	900	0.556
Rice Husk & Gum Arabic	500	15	900	0.556
Saw Dust & Starch	500	12	720	0.694
Saw dust & Gum Arabic	500	12	720	0.694

Mixture of both samples & starch	500	12	720	0.556
Mixture of both samples & gum Arabic	500	15	900	0.694

Table 5 shows the combustion rate of rice husk briquettes

From table 5, we can see that rice husk & gum Arabic had the highest percentage of ash 21%, while saw dust & cassava starch had the least ash content. This shows that saw dust with cassava starch and saw dust with gum arabic burns more efficiently than rice husk with cassava starch and rice husk with gum arabic.

Fuel briquettes	Weight of fuel (g)	Weight of ash (g)	Percentage ash content %
Rice husk & cassava starch	500	90	18
Rice husk & gum Arabic	500	105	21
Saw dust &cassava starch	500	45	9
Saw dust & gum Arabic	500	55	11
Mixture of both & cassava starch	500	68	13.6
Mixture of both & gum arabic	500	80	16

Table 6 shows the ash content of the four samples.

CONCLUSION AND RECOMMENDATION

The finding of this study shows that, sawdust briquette (cassava starch) had the highest moisture content 24.36 while rice husk (cassava starch) had the lowest 20.00. Also the value for sun-dried briquettes indicates that saw dust (cassava starch) had the highest value for density 0.6095 while rice husk (gum arabic) has the lowest value of density 0.5053. Rice husk with gum arabic recorded the highest percentage value of ash content at 21% while saw dust with cassava starch recorded the lowest value at 9%. From the result it was observed that briquettes produced from rice husk and saw dust makes a good biomass fuel. However, conclusion can be drawn that briquettes produced from saw dust had more efficiency of biomass fuel than rice husk briquette. And briquettes produced from rice husk and saw dusts are of good quality. It is therefore recommended that fast compaction and automated production designs of a more effective and motorized briquetting press should be carried out. A mixture of combined samples of rice husk and saw dust combined with other residues should be made into briquettes and studied for better performances. The shape and size of briquettes should be modified and produced for better stability. An alternative high quality binder should be sourced for.

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