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EVALUATION OF THE PHYSICAL PROPERTIES OF SOME BIOMASS BRIQUETTES

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ABSTRACT
In many developing countries, the use of energy in the form of firewood, twigs and charcoal has been the major source of renewable energy due to the high cost of cooking gas and kerosene. This necessitated the use of agricultural and wood wastes in producing briquette as alternatives. In this work, the physical properties (compressed density, relaxed density, length expansion and swelling thickness) of some biomass briquettes of different sizes were evaluated. They are maize stalk (0.6, 1.0, 2.36, 4.75, 8.0, 9.5 and12.5mm), rice husks (0.6, 1.0, and 2.36mm), and sawdust (0.6, 1.0, 2.36, 4.75, 8.0, 9.5 and12.5mm. It was discovered that rice husk briquette of 0.6mm particle size showed better compressed and relaxed density than the other briquettes. Also, the briquettes produced from 0.6mm particle size for the three biomass materials showed better result for swelling thickness while rice husks of particle size of 0.6mm with 3% starch content showed better result for length expansion. It can therefore be concluded that the smaller the particle size of the briquette considered the better the physical properties evaluated. However, it is recommended that the production of good biomass briquettes should include moderate starch proportion or other good binder in order to influence the physical properties.

KEYWORDS: Briquettes, Starch content, Relaxed Density, Compressed Density, Length Expansion and Swelling Thickness.

INTRODUCTION
The availability of energy for domestic use in developing countries continues to pose a formidable challenge, especially with the high cost of cooking gas and kerosene, and the environmental problems associated with firewood. This has necessitated the need to improve on the use of agro and wood wastes such as maize stalk, rice husks, and sawdust as alternatives [1]. Traditionally, energy in the form of firewood, twigs and charcoal has been the major source of renewable energy for many developing countries [2].Many developing countries produce huge quantities of agro residues which are used inefficiently causing extensive pollution to the environment. The major residues are rice husk, coffee husk, coir pith, jute sticks, bagasse, groundnut shells, maize stalk, saw dust, mustard stalks and cotton stalks etc. [3]. Many waste materials from sawdust, rice husks and agricultural residue mentioned above can be turned into clean-burning, easy-to-handle fuels that cut waste and carbon emission [4]. These waste products can be recycled and used as supplement or substitute for cooking gas and Kerosene. Studies have shown that there is high energy potential and usability of agricultural wastes and residues like sawdust to generate heat for domestic and industrial cottage applications [5, 6]. According to Ahmad et. al., [7], agricultural wastes can contribute to solving the energy problem in developing country. Also, the burning of agricultural wastes is carbon neutral, since the amount of carbon dioxide emitted is 'matched by the amount assimilated during the plants' growth' [8, 9]. A recent study showed that agricultural residues are the most potential biomass considering their quantitative availability [10]. Also, biomass briquette are biofuel substitute to coal and charcoal which are mostly used in developing world where cooking fuels are not easily available [11]. Briquetting may be considered as a good idea to utilize these low grade combustible materials obtained from biomass sources [12]. Briquettes are easier to store and used for cooking than wood and charcoal because they are uniform in size and composition. They are cleaner to handle than charcoal or coal and produce less local air pollution. [3].

MATERIALS AND METHODS
In carrying out this research work the material used were maize stalk, rice husks, sawdust, paper pulp and starch (extract from cassava).

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Preparation of Briquettes

The maize stalks were collected from the farm and cut into small pieces, this was soaked for 7days in other to soften it; it was then pounded and dried for another 14 days due to the season. The dried maize stalks were grounded and rubbed over a sieve of sizes 0.6mm, 1mm, 2.36mm, 4.75mm, 8mm, 9.5mm, 12.5mm so as to obtain various sizes. Rice husks and sawdust were collected and dried for 14 days to reduce the moisture content and then sieved. The dried rice husks were sieved using sieve of sizes of 0.6mm, 1mm, 2.36mm through which three different particle size of the rice husks were obtained while the dried saw dust was sieved using sieve of sizes of 0.6mm, 1mm, 2.36mm, 4.75mm, 8mm, 9.5mm, 12.5mm from which seven particle sizes of sawdust were obtained.

The various sieved sizes of maize stalk, sawdust and rice husks were mixed with starch as binder and paper waste as additive in the proportion of 80% (Maize stalk, sawdust and Rice husks) to 20% paper pulp additive, while 3% and 4.5% of starch as binder were used for sawdust and rice husk that for maize stalk were 6.5% and 9% respectively. These mixtures were used to make the briquettes.

The Compressed Density Relaxed Densities, Length Expansion, and Swelling Thickness were then determined.

Compressed Density

The compressed density is the density of the briquettes obtained immediately after compression and this was calculated using the relation;

$$CD = \frac{CM}{CV} ----------------------(i)$$

where:

CD = Compressed Density (g/mm^3)

CM = Mass of briquette immediately after compression (g)

CV = Volume of briquette immediately after compression (mm^3)

Relaxed Density

The relaxed density was determined after the compressed briquette was allow to relax for some days until the weight becomes stable and measured in mass. The volume is also obtained by multiplying the length by the area. The relaxed density is determined by using the relation

$$RD = \frac{RM}{RV} ----------------------(ii)$$

where:

RD = Relaxed Density (g/mm^3)

RM = Mass of briquette after relaxation (g)

RV = Volume of briquette after relaxation (mm^3)

The equation for Compressed and Relaxed Density were derived from the equation,

$$Density = \frac{Mass}{Volume}$$ [13]

Length Expansion

Length expansion is the difference between the length of the briquette immediately after compression and the length of the briquette after it has relaxed for some time.

$$\Delta l = l_2 - l_1 ----------------------(iii)$$ [14]

where:

Δl = Length expansion

l_2 = length of the briquette after it has relaxed for some time

l_1 = length of the briquette immediately after compression

Swelling Thickness

The swelling thickness is the difference between the thickness or diameter of the briquette after relaxation and the thickness or diameter of the briquette immediately after compression.

$$st = t_2 - t_1 --------------------(iv)$$ [14]

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where:

St = Swelling Thickness

t_2 = Thickness or diameter of the briquette after relaxation

t_1 = Thickness or diameter of the briquette immediately after compression.

RESULT AND DISCUSSION

From the relaxed and compressed density table and chart below, maize stalk and rice husks briquettes of particle size of 0.6mm and 1.00mm have higher relaxed and compressed density than the other sizes between 2.36mm – 12.5mm. It is also observed that the relaxed density decreases as the particle sizes increases regardless of the starch proportion for all the briquettes tested.

Table 1: Compressed Density of the Briquettes for Different Composition

			PARTICLE SIZES (mm)						
Biomass Materials	**Starch Content**		**0.6**	**1**	**2.36**	**4.75**	**8**	**9.5**	**12.5**
Maize Stalk	**6.50%**	**CD**	0.76	0.59	0.35	0.56	0.52	0.57	0.56
	9%	**CD**	0.85	0.71	0.43	0.58	0.53	0.59	0.43
Rice Husk	**3%**	**CD**	0.95	0.85	0.65				
	4%	**CD**	0.91	0.83	0.65				
Saw dust	**3%**	**CD**	0.6	0.55	0.59	0.61	0.55	0.54	0.47
	4.50%	**CD**	0.66	0.54	0.79	0.62	0.58	0.6	0.6

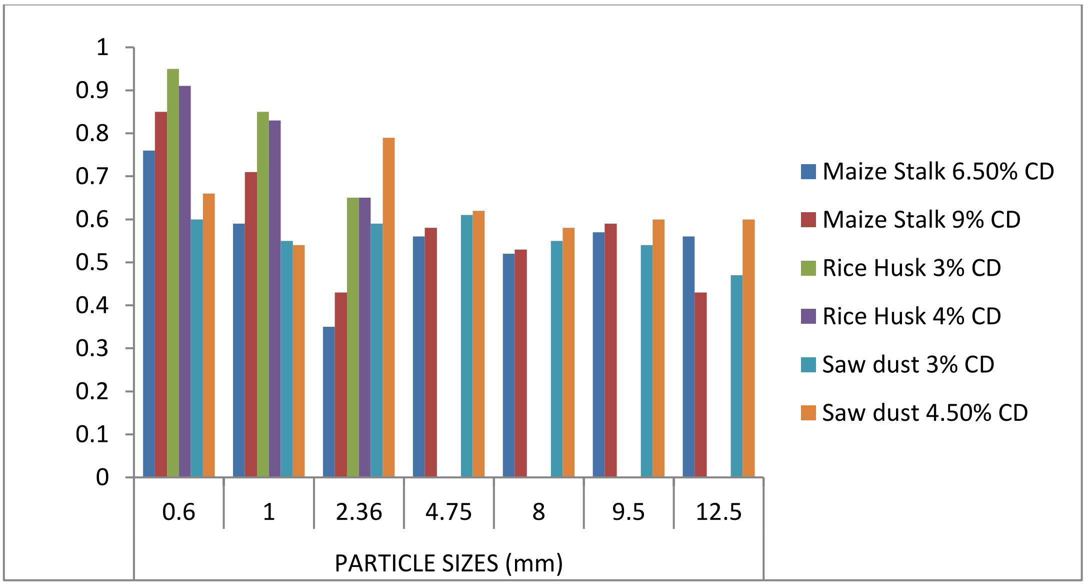

Fig 1: Chart showing the Compressed Density of the Briquettes immediately after Compression for the Different Composition

Table 2: Relaxed Density of the Briquettes for Different Composition

			PARTICLE SIZES (mm)						
Biomass Materials	**Starch Content**		**0.6**	**1**	**2.36**	**4.75**	**8**	**9.5**	**12.5**

Maize Stalk	**6.50%**	**RD**	0.407	0.291	0.185	0.246	0.233	0.268	0.313
	9%	**RD**	0.447	0.394	0.218	0.273	0.258	0.288	0.21
Rice Husk	**3%**	**RD**	0.628	0.444	0.383				
	4%	**RD**	0.636	0.41	0.376				
Saw dust	**3%**	**RD**	0.319	0.279	0.315	0.31	0.333	0.281	0.255
	4.50%	**RD**	0.332	0.264	0.466	0.305	0.346	0.343	0.334

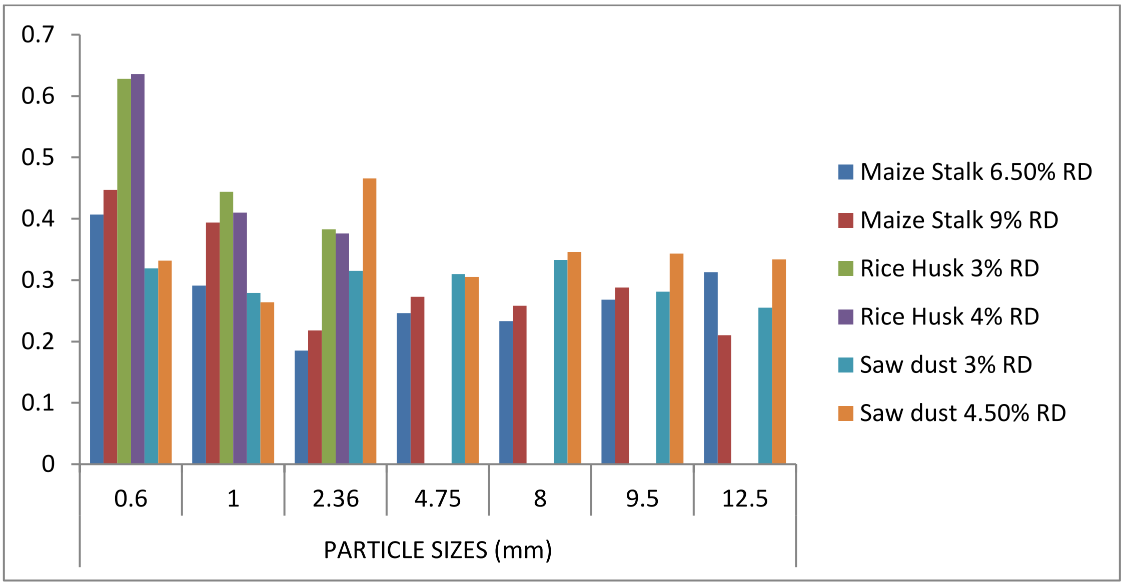

Fig 2: Chart showing the Relaxed Density of the Briquettes after Relaxation for the Different Composition

From table 3, the length expansion was more rapid within the first 60 minutes after compression with the best result 6.5% starch content, 8mm particle size for sawdust briquettes and least in 3% starch content, 2.36mm particle size for rice husk although there were no significant changes after seven days of compression for the rice husk. It was also discovered that all the briquettes later became stable.

Table 3: Length Expansion of the Briquettes at various Time intervals

			PARTICLE SIZES (MM)						
	Biomass Materials	**Starch Content**	**0.6**	**1.0**	**2.36**	**4.75**	**8.0**	**9.5**	**12.5**
30 Minutes	**Maize Stalk**	**6.5%**	15	15	8	16	18	15	14
		9%	12	12	9	14	16	13	13
	Rice Husk	**3%**	8	12	5	Size not applicable			
		4%	8	12	12				
	Saw dust	**3%**	16	14	14	9	9	15	16
		4.5%	16	13	14	13	13	14	15
60 Minutes	**Maize Stalk**	**6.5%**	23	25	13	27	29	24	20
		9%	22	23	14	28	28	25	20
	Rice Husk	**3%**	12	27	7	Size not applicable			
		4%	13	26	18				
	Saw dust	**3%**	25	26	22	21	14	27	25
		4.5%	27	24	21	22	16	21	20
1440 Minutes	**Maize Stalk**	**6.5%**	25	27	14	33	31	26	22
		9%	27	24	18	31	30	29	21
	Rice Husk	**3%**	14	31	8	Size not applicable			

		4%	17	30	20				
	Saw dust	**3%**	28	29	25	25	16	32	26
		4.5%	30	27	23	25	18	23	21
10,080 Minutes	**Maize Stalk**	**6.5%**	26	27	14	34	31	26	22
		9%	29	24	20	34	31	31.5	23
	Rice Husk	**3%**	15	32	8				
		4%	18	32	20				
	Saw dust	**3%**	28	29	25	27	16	33	26
		4.5%	31	29	23	27.5	19	23	22

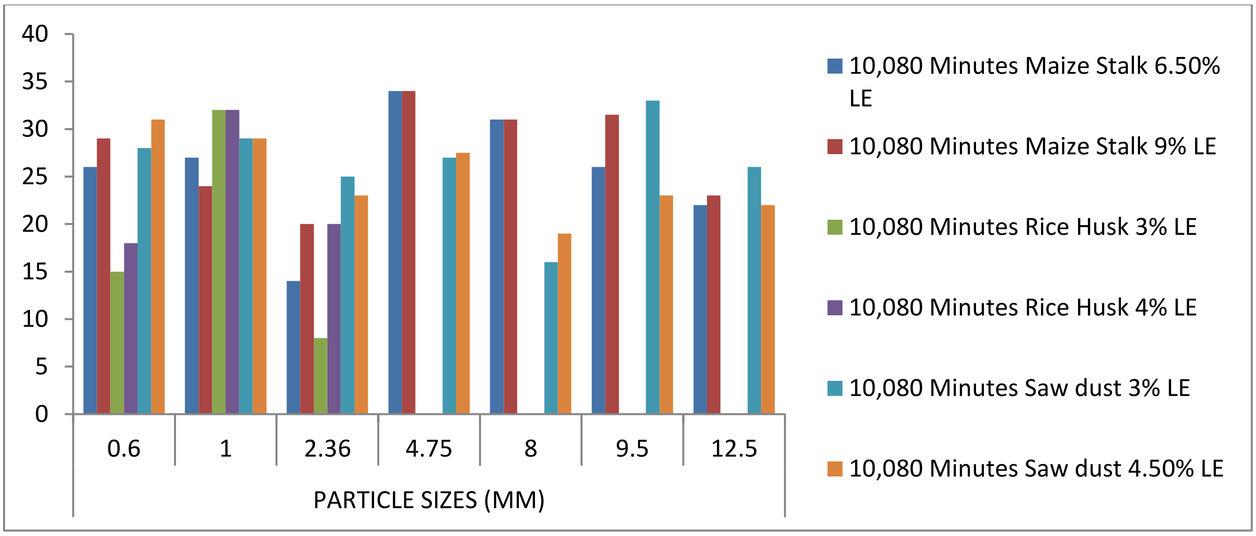

Fig 3: Chart showing the Length Expansion of the Briquettes after 10,080 minutes (7 days) for the Different Composition.

The chart showing the swelling thickness revealed that all briquettes produced from 0.6mm particle size have uniform swelling thickness. Also briquettes produced from other particle sizes between 1.00mm – 12.50mm have swelling thickness that is a little higher than that of 0.6mm particle size except for sawdust of 3% starch content, sawdust briquette of 4.5% starch content, maize stalk briquettes of 6.5% starch content that possess uniform swelling thickness while rice husks briquettes of 3% starch content have the highest swelling thickness of all the briquettes tested.

Table 4: Swelling Thickness of the Briquettes for Different Composition

			PARTICLE SIZES (mm)						
Biomass Materials	**Starch Content**		**0.6**	**1**	**2.36**	**4.75**	**8**	**9.5**	**12.5**
Maize Stalk	**6.50%**	**St**	1	1	1	4	4	2	1
	9%	**St**	1	1	1	2	1	3	3
Rice Husk	**3%**	**St**	1	1	5				
	4%	**St**	1.2	2	1.5				
Saw dust	**3%**	**St**	1	1.5	2	2	4	3	4
	4.50%	**St**	1	3	1	2	1	1	1

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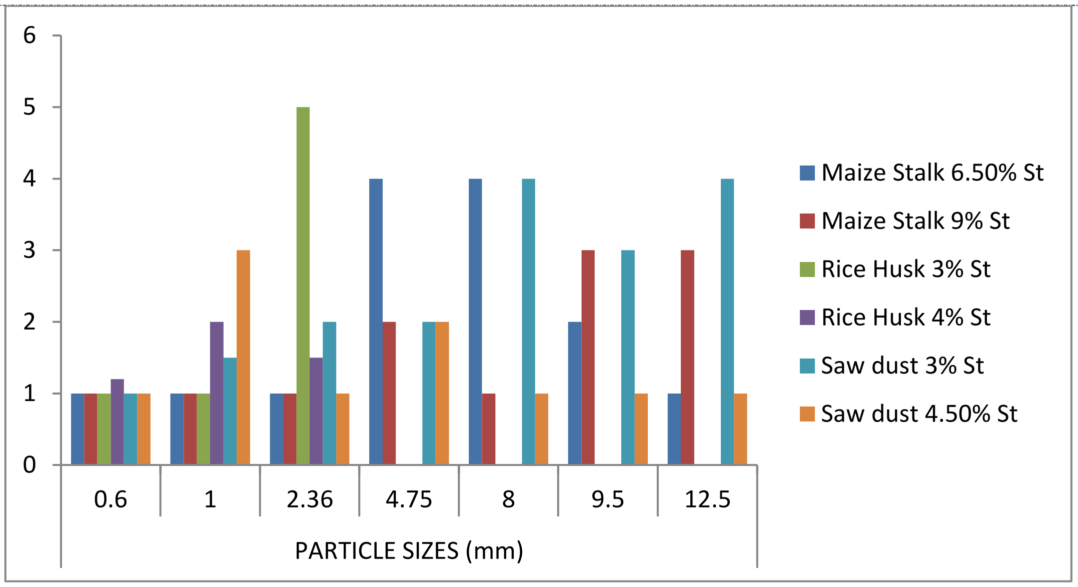

Fig 4: Chart showing the Swelling Thickness of the Briquettes for the Different Composition

CONCLUSION

From the compressed and relaxed density result, rice husk briquettes of 0.6mm particle size showed better compressed and relaxed density than the other briquettes.

Also, the briquettes produced from 0.6mm particle size for the three biomass materials showed better result for length expansion and swelling thickness. The starch content of the briquettes has greatly influences all the physical properties of the briquettes evaluated.

It can however be concluded that briquettes produced from 0.6mm particle size showed better result than other sizes. When considering briquettes that offered considerable length expansion it is recommended that the briquettes should be produced from rice husks of particle size of 0.6mm with 3% starch content. It can however be recommended that the production of good biomass briquettes should include moderate starch proportion in order to influence the physical properties.

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REFERENCE

[1] O. P. Fapetu, " Production of Charcoal from Tropical Biomass for Industrial and Metallurgical Process", Nigerian Journal of Engineering Management, 1(2), pp 34-37, 2000.
[2] Y. V. Omojogberun, "Assessment of the Effect of Particle Size and Briquette Type on the Bulk Density and Resistance to Humidity of Some Solid Biomass Briquettes", International Journal of Engineering Science and Research Technology, 5 (11), pp 234 – 238, 2016.
[3] Ashden, " Biomass Briqutties and Pellets", 2016. http://www.ashden.org/briqutties.
[4] O. P Fapetu, "Management of Energy from Biomass", Nigerian Journal of Engineering Management, 1(1), pp 14-19, 2000.
[5] R. Maninder, K. Singh and G. Sonia, " Using Agricultural Residues as a Biomass Briquetting: An Alternative Source of Energy", IOSR Journal of Electrical and Electronics Engineering, 1(5),pp 11-15,2012. www.iosrjournal.org.
[6] K. E. Ugwu, and K. F. Agbo, "Briquetting of Palm Kernel Shell", Journal of Applied Science and Environmental Management, 15 (3), pp447 – 450, 2011.
[7] M. M. Ahmad, M. F. Aziz , A. Inayat and S. Yusup., "Heat Integration Study on Biomass Gasification for Hydrogen Production", Journal of Applied Science, 11(21), pp 3600-3606, 2011.
[8] C. Y. Sing,. and M. S. Aris, "A Study of Biomass Fuel Briquettes from Oil Palm Residues", Asian Journal of Science and Research, 6(3), pp 537-545, 2013.

[9] M. S. Khardimar, K. D. Anil, D. M Mahalle, and S. Kumar, "Study on the Physical Properties of Crop Residues Briquette for gasification", International Journal of Renewable Energy Technology Research, 2(1), 2013. http://ijretr.org.

[10] E. A., Emerhu, "Physical and Combustion properties of Briquettes produced from Sawdust of three hardwood Species and different organic binders", Advances in Applied Sciences Research, 2(6), pp 236-246, 2011.

[11] Wikipedia **, "**Biomass Briquettes", 2011, https;//en.m.wikipedia.org/…/Biomass.

[12] A. Dermibas ,"Physical Properties of briquettes from waste paper and wheat straw mixture", Energy Conversion and Management,40(4), pp437-445, 1999. www.sciencedirect.com/.../

[13] R. K Rajput, "A Textbook of Fluid Mechanics", S. Chand and Company limited, New Delhi. pp5, 2008.

[14] R. S Khurmi, "Strength of Materials", S. Chand and Company limited, New Delhi. pp 15, 2010.