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An Evaluation of Briquettes from Sawdust and Corn Starch Binder

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Abstract:
The briquettes were produced mechanically with a hydraulic operated briquetting machine using sawdust and corn starch as binder. This was achieved by mixing 30ml, 40ml, 50ml of corn starch with 100g, 150g and 200g of sawdust with 75ml, 100ml, 125ml of water in different combinations for agglomeration to produce the briquettes. It was replicated ten times. The briquettes were further evaluated in terms calorific value, boiling time, fuel consumption rate, fuel efficiency and cooking efficiency. The data were analysed statistical using Microsoft Excel 2007. The results showed that as the volume of the binder increased there was a decrease in the boiling time and fuel consumption rate while there was an increase in calorific value, fuel efficiency and cooking efficiency. Of all the regression models tested only the polynomial model gave a perfect relationship with R^2 = 1. From these results it could be deduced that there was significance difference (p=5%) in the performance of the briquettes.

Keywords: *Briquettes, sawdust, corn starch, calorific value, fuel efficiency, cooking efficiency and fuel consumption rate*

1. Introduction

Briquetting is a technology for densification of agricultural residues/wastes to increase their bulk density, lower their moisture contents and make briquettes of uniform sizes and shapes for easy handling, transport and storage (www.fao.org/docept/T0275E). Briquettes can be defined as a product formed from physic-mechanical conversion of loose and tiny particle size materials with or without binder in different shapes and sizes.

Osarenwinda and Ihenyen (2012) stated that F.P Veshinakov (a Russian inventor) developed a method of producing briquettes from waste wood, charcoal and hard coal. Briquettes have high specific densities ranging from 1100-1200kg/m^3 and bulk densities of 800kg/m^3 as compared to lose agricultural residues which have bulk densities that range from 80kg/m^3 – 120kg/m^3 (Srivastra, 2009). This implies that briquetting can reduce the volume of materials by about 10 times. Briquettes are made using briquetting machine of either manual, screw and hydraulic types (Chinyere, 2014, Osarenwinda and Ihenyen, 2012 and Ramesh, 2005). Briquettes have high calorific value up to 60Mkal/kg depending on the material compared to loose materials (Chinyere, 2014).

In Nigeria, as in other developing countries, the prevelenceof sawdust hills around sawmills constitute an unsightedful problem to the local environment and a breeding ground for wood decaying organisms.But these sawdust hills could be compacted into briquettes for fuel energy supply.

Also, the direct burning of loose agro waste residues like rice husk, palm kernel shells, groundnut shells in conventional manner is associated with very low thermal efficiency, loss of fuel and widespread air pollution (Osarenwinda and Ihenyen, 2012). When compressed into briquettes, these problems are mitigated, transportation and storage cost are reduced and energy production by improving their net calorific value per unit is enhanced (Grover et al, 1996). This work is focussed on the Preliminary Production of Briquettes from sawdust and corn starch.

2. Materials And Method

2.1. Materials

The materials used in the production of briquettes include: sawdust, corn starch and water.

2.2. Production Method

The sawdust used for the briquette production was sieved to a particle size of 2mm, a measured quantity of corn starch (binder) for agglomeration and water were added and thoroughly mixed with a blender of 1000rpm. In the production, 30ml of corn starch (binder) was added separately to 100g, 150g, 200g of sawdust (Type A), 40ml of corn starch (binder) was added separately to 100g, 150g, 200g of sawdust(Type B) and 50ml of corn starch (binder) was added separately also to 100g, 150g, 200g of sawdust(Type C). 75ml, 100ml and 125ml of water was added respectively to each of the sawdust and binder and was thoroughly mixed for 60secs each. These were replicated ten (10) times each, to produce two hundred and seventy (270) briquettes in all.

The hydraulic operated briquetting machine fabricated was used in the production of briquettes mechanically. The cavity of the female moulds was filled with different quantities of the mixtures as explained above and was levelled off at the top to obtain smooth surface. Then the female mould filled with the mixture was placed under the ram fixed with the male mould. The ram was lowered via the control valve to compress the mixture to form the desired briquettes. The bolt and nut fitted on the female mould aided the ejection of already formed briquettes onto a flat surface/platform for sun and/or air drying which took 10 days to reduce the exiting moisture content to a minimum of 10% in the briquettes for efficient combustion and minimum or no smoking of the briquettes while cooking/heating. The mass of each dried briquettes are shown in Table 1 above.

Some of the dried briquettes are shown in Plate 1 below;

Plate 1 Dried briquette after production

2.3. Performance Evaluation of Briquettes Produced

After successful production the briquettes, a Hydrogen Bomb calorimeter was used to determine tha calorific value of each type of briquette. A further evaluation of their performance characteristics was carried out. Half litre of water was put in a kettle provided (0.5mm thickness) and placed on the stove (charcoal fired) and the briquettes were lighted for combustion. The initial temperature of water was gotten as 26^{0}C and the time it took each sample to boil water was recorded. The process was replicated 10 times using minimum of three briquettes in each. The amount of fuel burnt as well as the amount of water evaporated (0.01kg) were measured.

The above data was then used to estimate calorific value, fuel efficiency, cooking efficiency, boiling time and fuel consumption rate which served as a determinant for evaluating the performance of briquette samples.

2.3.1 Calorific Value

The calorific value of briquette is quantity of heat energy liberated by the fuel. This was determined by using equation 1 below;

$$H = \frac{\Delta\theta + (m_W + V_c)C_p}{M_f}.$$ ………………………………1 (Adegoke, 1999)

Where;

$\Delta\theta$ = Temperature rise of water (^{0}C) (100°C – 26°C = 74°C)

m_w = Mass of water (kg)

V_c = Volume of water equivalent of calorimeter (g), that is, water that fills the calorimeter

C_p = Specific heat capacity of water (4.2kJ/kg0C)

$\boldsymbol{M_f}$ = mass of fuel as shown in Table 1 above.

2.3.2 Fuel Efficiency

The fuel efficiency of briquette is the ratio of heat transferred to the cooking medium to the heat supplied by the fuel (briquettes). This was determined by using equation 2 below;

$$\eta_f = \frac{m_{w.i} \times c_{p.w} \times (t_e - t_i) + m_{w.evap} \times H_l}{m_f \times H_f}$$ ……… 2(Prasad et al, 1983)

Where;

$\eta_f = fuel\ efficiency$ (%).

$c_{p.w} = specific\ heat\ of\ water$ (4.2kJ/kg^{0}C

$m_{w.i} = initial\ amount\ of\ water\ in\ the\ kettle$(1litre)

$t_e = temperature\ of\ boiling\ water$(100^{0}C)

$t_i = initial\ temperature\ of\ water$(26^{0}C)

$m_{w.evap} = mass\ of$ Water evaporated during boiling (0.01kg)

$H_l = heat\ of\ evaporation\ of\ water\ at\ atmosp.pressure\ and$ 100^{0}(2260kJ/k)

$m_f = amount\ of\ fuel\ burnt(kg)$ (Difference between the mass of initial fuel and remaining fuel when water is boiled)

$H_f = conbustion\ value\ of\ fuel\ used \left(\frac{MJ}{kg}\right)$ $(calorific\ value\ of\ fuel\ used)$

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2.3.3 Cooking Efficiency

Cooking efficiency is the ratio of useful heat output (kJ/hr) to the heat input into the stove (kJ/hr) which was evaluated using equation 3 below:

$$\eta_c = \frac{m_w h_l}{m_f c_f} \ldots\ldots\ldots\ldots\ldots 3 \ (Danshehu\ et\ al, 1996)$$

Where; $\eta_c = cooking\ efficiency(\%)$
$m_w = mass\ of\ water\ evaporated\,(0.01kg)$
h_l = Heat evaporation of water at atmospheric pressure and 100^{0}C (2260kJ/kg)
$m_f = amount\ of\ fuel\ burnt(kg)$ (difference between the mass of initial fuel and remaining fuel when water is boiled)
c_f = heat value of fuel (MJ/kg) (calorific value of fuel used)

2.3.4. Boiling Time

The time to boil one (1) litre of water was determined using Equation 4 below;

$$T_s = \frac{T}{w_b} \ldots\ldots\ldots\ldots 4 \ (Danshehu\ et\ al., 1996)$$

Where; $T_s = boiling\ time\ (minutes/kg)$
$T = total\ time\ spent\ in\ boiling\ water(minutes)$
$w_b = total\ weight\ of\ boiled\ water(kg)$

2.3.5 Fuel Consumption Rate

The rate which briquettes of various fuel samples were burnt was determined using equation 5 below;

$$m_f = \frac{w_i - w_f}{t} \ldots\ldots\ldots\ldots\ldots 5 \ (Danshehu\ et\ al, 1996)$$

Where; $m_f = fuel\ consumption\ rate\ (kg/hr)$
$w_i = initial\ mass\ of\ fuel\ before\ consumption(kg)$
$W_f = final\ mass\ of\ fuel\ after\ consumption(kg)$
t= total cooking or boiling time (minutes)

3. Results And Discussion

Table 1 below shown the average values of the parameters used and obtained during the evaluation using equation 1 -5.

Binder (Corn Starch)	**30ml**									**40ml**									**50ml**								
Sawdust(g)	**100**			**150**			**200**			**100**			**150**			**200**			**100**			**150**			**200**		
Water (ml)	75	100	125	75	100	125	75	100	125	75	100	125	75	100	125	75	100	125	75	100	125	75	100	125	75	100	125
Mass of briquettes (g)	100.7	101.0	100.9	150.7	150.8	151.1	200.8	200.4	201.2	100.7	101.3	101.2	150.0	151.6	151.2	201.5	201.2	200.3	101.6	101.8	101.9	151.7	151.6	151.9	201.6	201.7	201.9
Calorific value (MJ/kg)	38.30	38.12	38.18	39.83	39.77	38.80	40.30	40.52	40.44	41.21	41.16	41.18	41.88	42.45	42.66	43.45	43.31	43.38	44.90	44.82	44.88	44.95	46.03	45.54	46.80	47.05	46.93

Boiling time (mins)	17.20	17.00	17.08	16.09	15.98	16.00	16.17	15.86	15.80	16.27	16.15	16.10	15.41	15.10	15.00	15.22	15.0	15.10	15.44	15.32	15.20	14.45	14.32	14.35	14.33	14.35	14.28
Fuel consumption rate (g/hr)	34	33.2	32.6	31.4	30.7	30.0	30.5	29.8	29.0	32.8	31.7	31.8	29.3	28.0	28.7	28.5	27.9	28.0	31.6	30.9	31.0	28.2	27.8	27.5	27.4	26.9	27.0
Fuel efficiency (%)	46.4	45.8	45.90	46.64	46.65	46.70	47.50	47.57	47.58	47.67	48.14	48.00	48.77	48.98	48.60	49.12	49.23	49.25	50.45	50.40	50.48	50.68	50.49	50.53	50.75	50.70	50.92
Cooking efficiency (%)	29.5	30.3	31.3	40.4	40.8	41.6	61.2	61.9	62.0	32.5	32.51	33.0	46.4	45.9	46.0	66.3	66.8	67.1	36.4	36.5	38.2	47.3	47.7	46.2	68.8	69.0	69.4

Table 1: Average values of parameters used and obtained in the evaluation of the briquettes at constant deformation force of 4KN

3.1. Briquettes Performance Evaluation Results

The data obtained during the evaluation of briquettes were analyzed statistically with two factor analysis of variance. It was also analyzed graphically to determine the regression models. These are shown in Tables 2 – 6 and Figure 1 – 5**.** The statistical tool used in the analysis of this work was Microsoft Excel 2007.

Hypotheses:

Null hypothesis (H_o) = there is no difference in the mean of the average calorific value, boiling time, fuel consumption rate, fuel efficiency and cooking efficiency.

Alternative hypothesis (H_1) = there is a difference in the mean of the average calorific value, boiling time, fuel consumption rate, fuel efficiency and cooking efficiency.

3.1.1. Performance evaluation for calorific value of the briquettes

In the evaluation of the briquettes, the water levels were not considered because water were dried off in the process of drying the briquettes.

It could be seen in Table 1, as the volume of binder increased with the mass of sawdust the calorific value increased. This could be because of the ratio of binder volume to mass of sawdust. This also shown in the ANOVA Table 2 below;

SV	DF	SS	MS	F – cal	F – tab	P-value 5%	Significance 5%
Binder	2	48.88	25.44	12.08	8.91	0.01	**
Sawdust	2	1412.31	704.53	543.19	6.32	1.42E-05	**
Error	4	4.897	2.02				
Total	8	1358.90					

Table 2: Analysis of variance (ANOVA) for calorific value
Where SV = source of variation, DF = degree of freedom, SS = Sum of square, MS = mean sum of square,
*** highly significant.*

Inference:

From Table 2 above, For Factor A, F-calculated > F- tabulated (12.08 > 8.91), it means there is a significant difference (binder) effect on the calorific value of briquettes. For Factor B, F-calculated > F- tabulated also (543.19 > 6.32), it means that there is a significant difference (sawdust) effect on the calorific value of briquettes. Hence, the Null hypothesis (H_o) is rejected and the alternative Hypothesis (H_1) is accepted. It means also that both sawdust and corn starch have different effects on the calorific value of the briquettes. This could be compared with rice husk and sawdust briquettes with cow dung as binder which also gave a significant difference in the calorific value (Bhatacharya, 2003).

The combine effect of sawdust and binder on calorific value was further evaluated graphically as shown in Fig. 1 below;

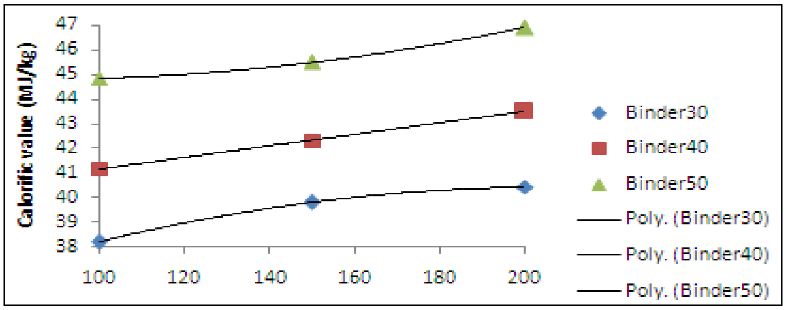

Figure 1: Effect of sawdust mass on calorific value for different volumes of binder
Sawdust (g)

From Fig 1, it could be observed that as the mass of sawdust increased from 100g to 200g with the same volume of binder the calorific value increased, that is 100g:30ml = 38.20MJ/kg, 150g:30ml = 39.80MJ/kg, 200g:30ml = 40.42MJ/kg etc. Also, as the volume of the binder increased from 30ml to 50ml with the same mass of sawdust the calorific value increased, that is 100g:30ml = 38.20MJ/kg, 100g:40ml = 41.17MJ/kg, 100g:50ml = 44.87MJ/kg etc. This may be because of the heat value in the sawdust and binder added to the briquettes. As both the sawdust and binder increased, there is a significant increased in the calorific value of the briquettes. The regression models of the graphs shown that logarithmic model gave a bit good relationship while the polynomial gave a perfect relationship both in equation and coefficient of determination (R^2 =1). A T-test was applied but there was not a significant difference between the models. Therefore, logarithmic model is recommended to be used as shown in Table 3 below;

Regression	Model	R^2
Logarithmic	Cv_{30} = 1.5572ln(s) + 33.227	0.991
	Cv_{40} = 0.7058ln(s) + 36.638	0.999
	Cv_{50} = 1.4904ln(s) + 34.014	0.999

Table 3: Regression models for Fig 1
Where Cv = calorific value, s = sawdust; 30, 40, 50ml are binder volumes

3.1.2. Performance evaluation for boiling time of the briquettes

It could be seen in Table 1 that as the volume of binder increased with the mass of sawdust the boiling time decreased. This could be because of the ratio of binder volume to mass of sawdust. This also shown in the ANOVA Table 4 below;

SV	DF	SS	MS	F – cal	F – tab	P-value	Significance 5%
Binder	2	4.04	2.02	548.99	6.94	1.32E-05	**
Sawdust	2	2.10	1.05	285.99	6.94	4.82E-05	**
Error	4	0.004					
Total	8	6.16					

Table 4: Analysis of variance (ANOVA) of data of boiling time
*Where SV = source of variation, DF = degree of freedom, SS = Sum of square, MS = mean sum of square, ** highly significant*

Inference:

From Table 4 above, For Factor A, F-calculated > F- tabulated at both level probability (548.99 > 6.94), it means there is a significant difference (binder) effect on the boiling time of briquettes. For Factor B, F-calculated > F- tabulated also (285.99 > 6.94), it means that there is a significant difference (sawdust) effect on the boiling time of briquettes. Hence, the Null hypothesis (H_o) is rejected and the alternative Hypothesis (H_1) is accepted. It means also that both sawdust and corn starch have different effects on the boiling time of the briquettes. This could be compared with groundnut shell and maize cob briquettes with corn starch as binder which as also gave a significant difference (Bello, 2006)

The combine effect of both sawdust and binder on boiling time was further analyzed graphically as shown in Fig 2 below;

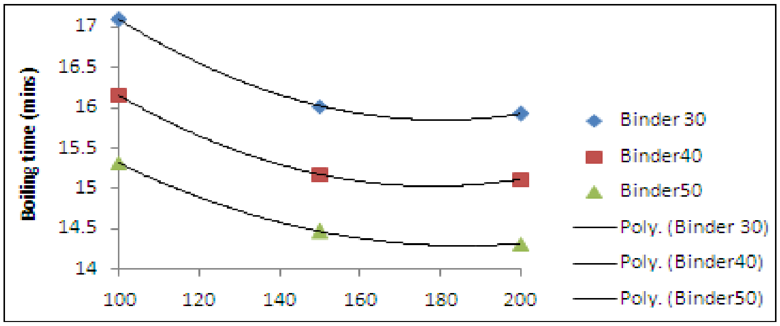

Figure 2: Effect of sawdust mass on boiling time for different volume of binder
Sawdust (g)

From Fig 2 above, it was observed that as the mass of sawdust increased from 100g to 200g with the same volume of binder, the boiling time decreased, that is 100g:30ml = 17.09mins, 150g:30ml = 16.02mins, 200g:30ml = 15.92mins etc. Also, as the volume of binder increased from 30ml to 50ml with the same mass of sawdust the boiling time decreased, that is, 100g:30ml = 17.09mins, 100g:40ml = 16.16mins, 100g:50ml = 15.32mins etc. This may be because of the calorific values of both sawdust and binder added to the briquettes. The regression models of the graphs shows that the power model gave a bit good relationship but it is the polynomial model that gave a perfect relationship both in the equation and the coefficient of determination (R^2=1). A T-test shown that there is a significant difference between the models. So, power model is recommended to used as shown in Table 5 below;

Regression	Model	R^2
Power	$B_{30} = 24.19s^{-0.1}$	0.922
	$B_{40} = 25.53s^{-0.1}$	0.867
	$B_{50} = 27.42s^{-0.1}$	0.885

Table 5: Regression models for Fig 2
Where B = boiling time, s = sawdust; 30ml, 40ml, 50ml are binder volume

3.1.3. Performance evaluation for fuel consumption rate of the briquettes

It could be seen in Table 1 that as the volume of binder increased with the mass of sawdust fuel consumption rate decreased. This could be because of the ratio of binder volume to mass of sawdust. This also shown in the ANOVA Table 6 below;

SV	DF	SS	MS	F – cal	F – tab	P-value	Significance 5%
Binder	2	7.68	3.84	13.50	6.94	0.02	**
Sawdust	2	34.08	17.04	59.91	6.94	0.001	**
Error	4	1.14	0.28				
Total	8	42.90					

Table 6: Analysis of variance (ANOVA) for fuel consumption rate

Where SV = source of variation, DF = degree of freedom, SS = Sum of square, MS = mean sum of square, ** highly significant.

Inference:

From Table 6 above, For Factor A, F-calculated > F- tabulated at both level probability (13.50 > 6.94), it means there is a significant difference (binder) effect on the fuel consumption rate of briquettes. For Factor B, F-calculated > F- tabulated also (59.91 > 6.94), meaning also that there is a significant difference (sawdust) effect on the fuel consumption rate of briquettes. Hence, the Null hypothesis (H_o) is rejected and the alternative Hypothesis (H_1) is accepted. It also, shown that the interaction of both sawdust and binder gave a significant different effect on the fuel consumption rate of the briquettes.

The combine effect of sawdust and binder on fuel consumption rate was further analyzed graphically as shown in Fig 3 below;

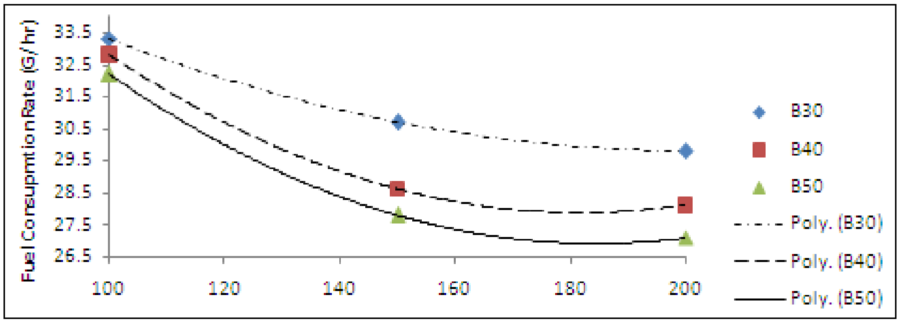

Figure 3: Effect of sawdust mass on the Fuel Consumption Rate for different volume of binder Sawdust (g)

From Fig 3, it could be observed that as the mass of sawdust increased from 100g to 200g with the same volume of binder the fuel consumption rate decreased (100g:30ml = 33.30g/mins, 150g:30ml = 30.7g/mins, 200g:30ml = 29.8g/mins etc). Also as the volume of binder increased from 30ml to 50ml the boiling time decreased (30ml: 100g = 33.3g/mins, 40ml: 100g = 32.80g/mins, 50ml:100g = 32.20g/mins etc) . This may be because of the heat values of both sawdust and binder added to the briquettes. The higher the heat content, the lower the fuel consumption rate. The regression models of the graphs, shown that power model gave a bit good relationship but it is the polynomial model that gave a perfect relationship both in the equation and the coefficient of determination (R^2=1). But a T-test shown that there was no significant difference between the models. Therefore, power is recommended to be used. as shown in Table 7 below;

Regression	**Model**	**R^2**
Power	$Fc_{30} = 70.17s^{-0.16}$	0.973
	$Fc_{40} = 93.68s^{-0.23}$	0.900
	$Fc_{50} = 103.4s^{-0.25}$	0.919

Table 7: Regression models for Fig 3
Where Fc = fuel consumption rate, s = sawdust, 30ml, 40ml, 50ml are binder volumes

3.1.4. Performance evaluation for fuel efficiency of the briquettes
It could be seen in Table 1 that as the volume of binder increased with the mass of sawdust fuel efficiency increased. This could be because of the ratio of binder volume to mass of sawdust. This also shown in the ANOVA Table 8 below;

SV	DF	SS	MS	F – cal	F – tab	P-value 5%	Significance 5%
Binder	2	0.12	0.06	62.58	6.94	0.001	**
Sawdust	2	5.57	2.79	2901.24	6.94	4.75E-07	**
Error	4	0.004	0.001				
Total	8	5.70					

Table 8: Analysis of variance (ANOVA) of data of fuel efficiency

Where SV = source of variation, DF = degree of freedom, SS = Sum of square, MS = mean sum of square, ** highly significant.
Inference:
From Table 8 above, for Factor A, F-calculated > F- tabulated at both level probability (62.58 > 6.94), it means there is a significant difference (binder) effect on the fuel efficiency of briquettes. For Factor B, F-calculated > F- tabulated also (2901.24 > 6.94), meaning also that there is a significant difference (sawdust) effect on the fuel consumption of briquettes. Hence, the Null hypothesis (H_o) is rejected and the alternative Hypothesis (H_1) is accepted. This clearly shown that both sawdust and binder have a significant effect on the quality of the briquettes. This could be compared with rice husk and sawdust briquettes with cow dung as binder which also gave a significant difference (Bhathacharya, 2003)
The combine effect of both sawdust and binder on fuel efficiency was further analyzed graphically as shown in Fig 4 below;

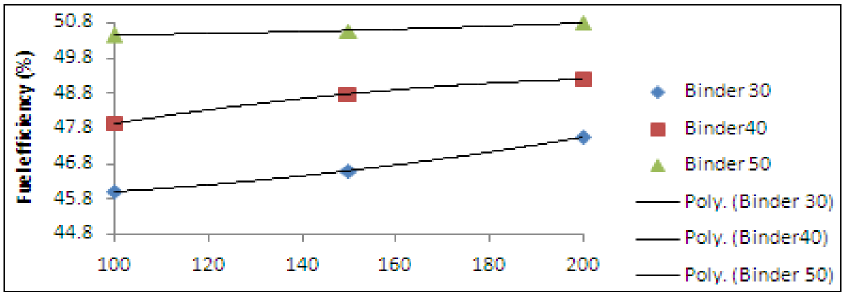

Figure 4: Effect of sawdut mass (g) on the fuel efficiency for different volume of binder(ml)
Sawdust (g)

From Fig 4, it was observed that as the mass of sawdust increased from 100g to 200g with the same volume of binder the fuel efficiency increases (100g:30ml = 46%, 150g:30ml = 46.6%, 200g:30ml = 47.55%). Also, it was observed that as the volume of binder increased from 30ml to 50ml with the same mass of sawdust the fuel efficiency increased (30ml:100g = 46%, 40ml:100g = 47.93%, 50ml:100g = 50.44%). The heat values of both sawdust and binder added to the briquettes could be the reason. As the heat content increased, fuel efficiency is also improved. The regression models of the graphs show that the linear and logarithmic model gave a bit good relationship but it is the polynomial model that gave a perfect relationship both in the equation and the coefficient of determination (R^2). But a T-test shown that there was no significant difference between the models. Therefore, linear model is recommended to be used as shown in Table 9 below;

Regression	Model	R^2
Linear	$Fe_{30} = 0.019s - 0.23$	0.998
	$Fe_{40} = 0.019s – 0.451$	0.992
	$Fe_{50} = 0.019s – 0.57$	0.992

Table 9: Regression models for Fig 3
Where Fe = Fuel efficiency, s = sawdust; 30, 40, 50ml are binder volumes

3.1.5. Performance evaluation for cooking efficiency of the briquettes

It could be seen in Table .1 that as the volume of binder increased with the mass of sawdust cooking efficiency increased. This could be because of the ratio of binder volume to mass of sawdust. This also shown in the ANOVA Table 10 below;

SV	DF	SS	MS	F – cal	F – tab	P-value 5%	Significance 5%
Binder	2	46.78	23.39	19.18	6.94	0.01	**
Sawdust	2	1307.24	653.62	535.99	6.94	1.38E-05	**
Error	4	4.887	1.22				
Total	8	1358.90					

Table 10: Analysis of variance (ANOVA) for cooking efficiency
*Where SV = source of variation, DF = degree of freedom, SS = Sum of square, MS = mean sum of square, ** highly significant*

Inference:

From Table 10 above, for Factor A, F-calculated > F- tabulated (19.18 > 6.94), it means there is a significant difference (binder) effect on the cooking efficiency of briquettes. For Factor B, F-calculated > F- tabulated also (535.99 > 6.94), it means that there is a significant difference (sawdust) effect on the cooking efficiency of briquettes. Hence, the Null hypothesis (H_o) is rejected and the alternative Hypothesis (H_1) is accepted. This could be compared with ground shell and maize cob briquettes with corn starch as binder which also gave a significant difference

The combine effect of both sawdust and binder oncooking efficiency was further evaluated graphically as shown in Fig. 5 below;

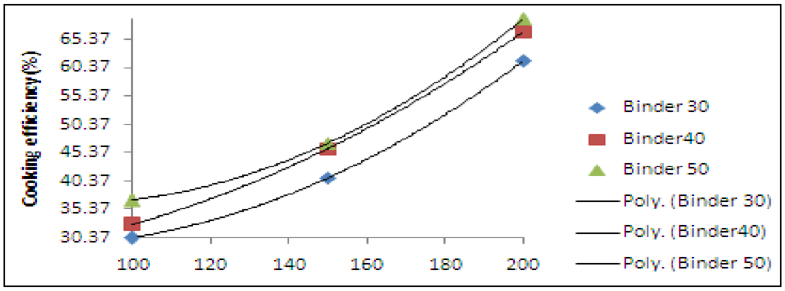

Figure 5: Effect of sawdust mass (g) on cooking efficiency (%) for different volume of binder (ml) sawdust (g)

From Fig 5, it is observed that as the mass of sawdust increased from 100g to 200g with the same volume binder the cooking efficiency increased (100g:30ml = 30.37%, 150g:30ml = 40.93%, 200g:30ml = 61.7% etc). Also as the volume of binder increased from 30ml to 50ml with the same mass of sawdust the cooking efficiency increased (30ml:100g = 30.37%, 40ml:100g = 32.67%, 50ml:100g = 37.03% etc). The calorific values of both sawdust and binder could be the cogent reason for the increase in cooking efficiency of the briquettes produced. The regression models of the graphs shows that the exponential model gave a bit good relationship but it is the polynomial model that gave a perfect relationship both in the equations and the coefficient of determination (R^2). A T-test shown that there was no significant difference between the models. Therefore, exponential model is recommended to be used as shown in Table 11 below;

Regression	Model	R^2
Exponential	$Ce_{30} = 14.78e^{0.007s}$	0.990
	$Ce_{40} = 13.55e^{0.007s}$	0.981
	$Ce_{50} = 13.29e^{0.007s}$	0.986

Table 11: Regression models for Fig 5
Where Ce = cooking efficiency, s = sawdust; 30, 40, 50ml are binder volumes

4. Conclusion

The preliminary production of briquettes from sawdust and corn starch has been achieved. From the results of the parameters evaluated, it could deduced that as the volume of binder (corn starch) increased with the same mass of sawdust there is an increase in the performance of the briquettes. This shows that corn starch is a good binder and recommended for the processing of other agro residues into briquettes.

5. References

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