

# Appraisal of Starch-Bonded Briquettes Utilization among User-Respondents in Port Harcourt, Rivers State, Nigeria

## ABSTRACT

The study appraised briquette users' opinions on the apparent properties and environment friendliness of the briquettes bonded by 30% and 40% starch composited saw dust collected from Marine and Illoabuchi Sawmills in Port Harcourt, Nigeria. Multistage sampling was used amongst 100 plantain (Bo-lae) roasters, meat barbecue (Suya), Garri (carbohydrate based food), and Akara (baked bean cake) respondents to elicit information on use of briquettes as an alternative source of energy on a 4-point Likert scale. The results showed that male user-respondents were 22 (88%) and 21 (84%) and female 3 (12%) from Marine and Illoabuchi sawmills, respectively. The 41-50 respondent age bracket were the most represented in both sawmills-Marine Base and Illoabuchi 12 (48%) and 11 (44%) respectively, followed by 31-40 (7: 28%) and 51-60 (4: 16%) in Illaboachi sawmill, while the 51-60 and 31-40 age groups were 6 (24%) and 5 (20%), respectively. Amongst the businesses run by respondents, users from Marine Base, plantain roasting was highest at 7 (28%), followed by fish barbecue and akara with 6 (24%), Suya had 5(20%), while at Illoabuchi, Suya grillers had 9 (36%), followed by plantain roasters 8 (32%). Garri stewards and Akara had the same 3 (12%). Environment friendliness and physical properties showed that briquettes smoked well with cut off Mark (M =3.04 and 3.80), smelled pleasantly (M=3.03 and 2.68), stuffy and choky smoke (M=0.4 and 1.00) and irritation of eyes had M=3.25 and 4.00 at Illaobuchi and Marine Base sawmills, respectively. Darkening pots, burning with dark smoke and being affected by water had their cut off marks at 1.33 and 1.40 (rejected), 2.63 and 2.50 (accepted) and 2.01 and 2.12 (rejected), portable, cheap and useful had M= 2.45 and 3.00, 3.60 and 3.60 and 3.40 and 3.09 from both mills respectively. This study recommends that briquetting of sawdust from sawmills be promoted via automation to maximize its utilization status.

**Keywords: Briquettes, environment friendliness user-respondents**

## INTRODUCTION

Africa is “still” at 1.2 billion (or 16% of global population) but it grows so fast and urban planning and infrastructure so slow in comparison that challenges like overcrowding, traffic congestion, pollution, and localized resource depletion are already worrying (Hafner, *et al.*, 2018). Booming

36 populations and urbanization, industrialization, and expansion of the middle class require more  
37 energy (Hafner, *et al.*, 2018).

38 There are multiple dimensions to the problem of energy access in Sub-Saharan Africa, where  
39 large shares of population lack a reliable supply of electricity and affordable modern cooking  
40 fuels: from insufficient power generation capacity, to difficulties in managing energy  
41 infrastructure and attract investments in the sector, to challenges in serving low-income users  
42 (Hafner, *et al.*, 2018). The demand for the use of fuel wood have been on the increase due to  
43 rural and urban poverty, low agricultural productivity, inequalities in land  
44 holding, rapid urbanization, sharp division in the socio- economic roles of men and women in  
45 some countries; rising costs of fossil fuel, kerosene, gas and electric cookers (Maurice, *et al.*,  
46 2015).

47 The Energy Commission of Nigeria asserted a 92.2% consumption of fuel wood as a primary  
48 alternative energy source in the country (ECN, 2019). This is corroborated by Aju and Uwalaka  
49 (2010) that fuel wood is a primary energy source accounting for over 90% of the total energy  
50 used for domestic purposes in Nigeria. The demand for fuel wood is expected to rise to about  
51  $213.4 \times 10^3$  metric tonnes, while the supply is expected to decrease to about  $28.4 \times 10$  metric  
52 tonnes by the year 2030 (Hafner, *et al.*, 2018 ). Fuel wood energy used is consumed mostly by  
53 the low and lower-middle income urban households as well as by owners of cottage and small  
54 scale industries and to augment commercial enterprises' sources such as pottery (David-  
55 Sarogoro, *et al.*, 2019), hotels (David-Sarogoro, *et al.*, 2019), schools (David-Sarogoro, *et al.*,  
56 2019), banks (David-Sarogoro, *et al.*, 2019) and hospitals (David-Sarogoro, *et al.*, 2019). In  
57 Ogoniland and other parts of Rivers State (Nigeria), wood and even twigs and leaflets of woody  
58 species are garnered and scavenged from newly exploited and cultivated riparian and mangrove  
59 forests as well as polluted oil sites for fuel (David-Sarogoro, *et al.*, 2019). Rural dwellers troop in  
60 groups to forests with axes, machetes, ropes and basins trekking long distances in search of these  
61 resources (David-Sarogoro, *et al.*, 2019). The high cost conventional sources of energy have  
62 changed the paradigm to wood as an energy source for livelihood sustenance and as an income  
63 source (David-Sarogoro, *et al.*, 2019). For this reason, a transition to a sustainable energy system  
64 is urgently needed in developing country like Nigeria to augment the monoculture-fossil energy  
65 source (petroleum).

66 One of such energy source is wood waste or sawmill residue. Sawdust constitutes one of the  
67 most abundant waste or residue in wood industries. The inefficient wood conversion and low  
68 biomass recovery from the Nigerian timber industry have led to sawdust hills around sawmills,  
69 constituting a visual blight on the local environment and a breeding ground for wood decaying  
70 organisms (Emerhi, 2011). Sawdust hills could be compacted into briquettes as a source of fuel  
71 energy (Wilaipon, 2007). Briquettes made from sawdust can possibly reduce forest degradation  
72 and deforestation to mitigate these problems.

73 Briquetting, which is aggregation of micro- or minute-wood waste, costs little or no money  
74 compared to other wastes such as newspaper or partially decomposed plant waste. Sawdust can  
75 be an alternate source of domestic and industrial energy to charcoal, firewood, gas, coal and  
76 electricity. Briquettes made from charcoal and sawdust is a desirable fuel because it produces a  
77 hot, long-lasting and virtually smokeless fire, and is produced when charcoal and sawdust are  
78 combined with other materials, and it is formed into uniform chunks (Emerhi, 2011). Thus far  
79 nothing has been stated about Starch-bonded briquettes. Starch-bonded briquettes is an organic

80 amalgam of pulverised saw dusts in various particulate sizes and bonded by starch as binding  
81 agent natural or synthetic. Globally, the overdependence by humans on fossil fuel has led to  
82 environmental degradation. Briquette as an energy alternative to costly fossil fuel that is cheap  
83 and readily available dotting the sawmills located near the coastal part of Port Harcourt. Wood  
84 logs are transported to these sawmills by water. Thus there is a need for a sustainable,  
85 inexpensive alternative energy source such as, wood micro waste (sawdust). Therefore, this  
86 study aimed at appraising briquette users' opinion on the apparent properties and environmental  
87 friendliness of the briquettes bonded by starch after usage. The duo of rapid deforestation and  
88 environmental pollution constitute smog and polluted air inhaled by the coastal area dwellers of  
89 Port Harcourt where heaps of sawdust ubiquitous at sawmills briquetted will provide clean and  
90 alternative source to fuel wood use by these poor and low income earners.

## 91 **METHODOLOGY**

92 Study area

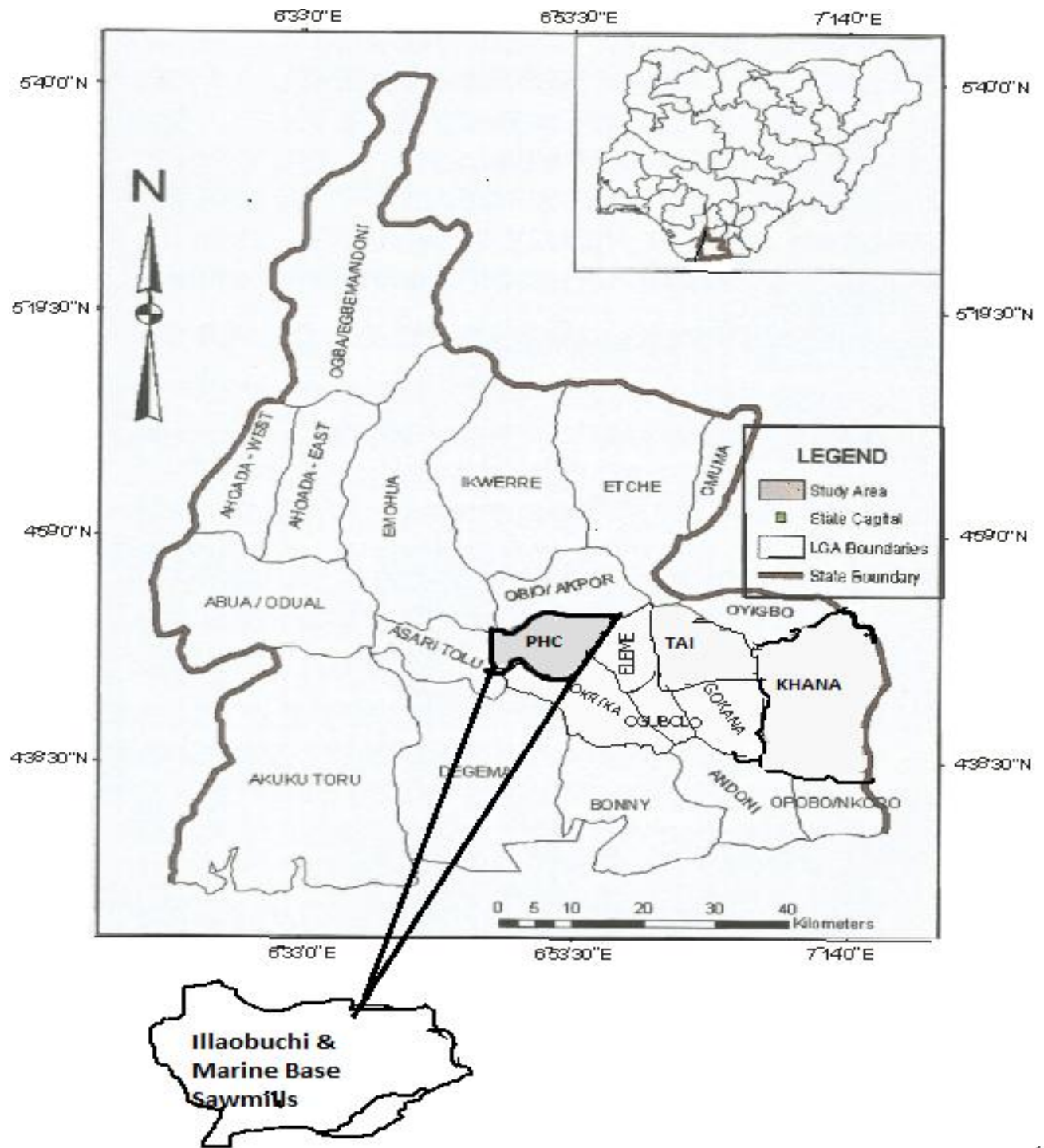
93 Sawdust was sourced from Marine and Illoauchi sawmills in Port Harcourt, Rivers State, Nigeria  
94 on Latitude 4.51°N, and Longitude 7.01°E (Figure 1).

95 The socio-economic conditions of the populations around Marine and Illoauchi sawmills are  
96 coastal areas of Port Harcourt where dwellers are usually low, medium income earners and some  
97 even unemployed with standard of living poor below \$1 per day and expenditure on fossil fuel is  
98 minimum in most cases none. They depended on fossil fuel alternatives like fuel wood and  
99 sawdust briquettes for cooking where heaps of sawdust ubiquitous at sawmills.

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102 *Figure 1: Remove this figure*



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105 **Figure 1: Source: Rivers State Ministry of Environment, July, 2019**

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107 **Research design**

108 Multistage sampling method ([www.researchgate.net](http://www.researchgate.net)) was used in the identification of target  
109 respondents and their locations were purposively selected: the respondents' businesses were  
110 identified by identifying their various locations (5 at each sawmill where briquettes were  
111 produced). Fifty questionnaires (50) were administered directly amongst energy-using  
112 respondents-plantain and fisher roasting or barbecue otherwise known as bo-lae, meat barbecue  
113 (suya), garri (carbohydrate based food) and akara (baked bean cake) respondents. 10 per business  
114 category in both sawmills-Marine and Illoabuchi. Sample size of 25 each at each mill-2  
115 locations.

116 **Data collection**

117 Data were collected between July, 2019 and September, 2019 using a semi-structured  
118 questionnaire designed to capture the following information: (i) biographical data of respondents,  
119 (ii) Users assessment of briquettes, and (iii) Assessment of problems associated with briquettes  
120 utilization.  
121

122 **Data analysis**

123 ~~Multistage sampling method (2019) ([www.researchgate.net](http://www.researchgate.net)) was employed and obtained data~~  
124 ~~were subjected to descriptive statistics and a 4 point Likert scale which ranged from strongly~~  
125 ~~agreed=4, agree=3, disagree=2 to and strongly disagree=1. The data obtained were analyzed MS~~  
126 ~~Excel Window 16.~~

127  
128 *Environment friendliness and physical properties showed that briquettes smoked well with cut off*  
129 *Mark (M =3.04 and 3.80), smelled pleasantly (M=3.03 and 2.68), stuffy and choky smoke*  
130 *(M=0.4 and 1.00) and irritation of eyes had M=3.25, and 4.00 at Illaobuchi and Marine Base*  
131 *sawmills, respectively. Darkening pots, burning with dark smoke and being affected by water*  
132 *had their cut off marks at 1.33 and 1.40 (rejected), 2.63 and 2.50 (accepted) and 2.01 and 2.12*  
133 *(rejected), portable, cheap and useful had M= 2.45 and 3.00, 3.60 and 3.60 and 3.40 and 3.09*  
134 *from both mills respectively.*

135 The product of Likert scale is divided by the sum of set of raw data: if the product of Likert scale  
136 option is 4 for strongly agreed, 3 for agreed, 2 for strongly disagreed and 1 for disagreed, then  
137 for instance outcome of an option of an opinion in the questionnaire is 10, this means  $10 \times 4 = 40$ .  
138 This is repeated across the column of strongly agreed. Similarly, this will be repeated for others-  
139 agreed, strongly disagreed and disagreed on the 4-point Likert scale. At the end, their sums will  
140 be added up as grand total say 79. Still on the Likert scale table, across the row total will be

141 taken and use as the divisor say 29 therefore  $M=79/29=2.71$  (2decimal places). One accepts an  
142 opinion if the cut off mark (M) is equal or above the quotient of  $10/4=2.50$  and rejects that  
143 opinion if the quotient is below 2.50.

#### 144 **Ethical considerations**

145 The participants of the research were duly informed and consulted orally before the  
146 questionnaires copies were administered on them with an appeal of consent letter (See appendix  
147 1) from me. The letter introduced the intent of the Researcher and the reason of the research, in  
148 all no antagonistic response was received.

### 149 **RESULTS AND DISCUSSION**

#### 150 **Biographical characteristics of participants**

151 Results showed that across different enterprises males were dominant 22 (88%) and 21 (84%)  
152 and 3(12%), male and female at Marine and Illoabuchi sawmills respectively (Table 1).

153 The age of respondents that used the briquettes showed that 41-50 age bracket had the highest in  
154 both sawmills-Marine Base and Illoabuchi 12 (48%) and 11 (44%) respectively followed by 31-  
155 40 (7:28%) and 51-60 (4:16%) in Illoabuchi sawmill while 51-60 and 31-40 were 6(24%) and 5  
156 (20%) respectively (Table 1).

157

158 The businesses were dominated by the married briquettes users 11 (44%) from Marine Base  
159 sawmill but at Illoabuchi married and single users had the same frequency and percentage with  
160 10 (40%) while separated users had the lowest (1:4% and 3: 12%, MB and IB sawmills  
161 respectively (Table 1).

162 The result on education status of briquettes users showed that secondary leavers were almost the  
163 same at both MB and Illoabuchi sawmills with 12 (48%) and 11 (44%) respectively, followed by  
164 those without education with 7 (28%) and 5 (20%) and lowest was primary school leavers. Even  
165 university graduates were involved in this petty entrepreneurial business with 5 (20%) for both  
166 sawmill (Table 1).

167 The year of experience of respondent users matters as 11-12 years had the highest (12:48%)  
168 followed by 1-10 years with 10 (40%) at MB while 1-10years was the highest with 9 (36%)  
169 followed by 11-20years with 8 (32%) and 21-30years with 4 (16%) (Table 1).

170 Amongst the businesses carried out by respondents, users of briquettes from Marine Base, Port  
171 Harcourt, plantain roasting was highest of 7 (28%) followed by fish barbecue and akara with 6  
172 (24%), meat barbecue had 5(20%) while at Illoabuchi, meat barbecue had 9 (36%) followed by  
173 plantain had 8 (32%) and garri and akara had the same 3 (12%) (Table 1).

#### 174 **Table 1: Biographical characteristics of briquette users.**

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Marine Base Sawmill	Illoabuchi Sawmill
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Socio-economic Characteristics		Frequency	Percentage	Frequency	Percentage
<b>Gender:</b>	Male	22	88	21	84
	Female	3	12	3	12
<b>Age in years</b>	31-40	5	20	7	28
	41-50	12	48	11	44
	51-60	6	24	4	16
	61-70	2	8	3	12
<b>Marital Status</b>	Married	11	44	10	40
	Single	9	36	10	40
	Divorced	3	12	1	4
	Separated	1	4	3	12
	Tertiary				
<b>Education Status</b>	education	5	20	5	20
	Secondary school	12	48	11	44
	Primary school	2	8	3	12
	No Education	7	28	5	20
<b>Year of Experience</b>	1-10	10	40	9	36
	11-20	12	48	8	32
	21-30	1	4	4	16
	31-40	2	8	2	8
	41-50	0	0	1	4
<b>Kinds of Business:</b>	Plantain Roasting	7	28	8	32
	Meat Barbecue	5	20	9	36
	Fish Barbecue	6	24	2	8
	Garri	1	4	3	12
	Akara	6	24	3	12

175 **Field Survey, 2019**

176 **Users Assessment of Briquettes from Illaobuchi and Marine Base Sawmills**

177 The result on the use of briquettes from both sawmills in terms their environment friendliness  
178 and physical properties showed that briquettes smoked well (M=3.04 and 3.80), smelled  
179 pleasantly (M=3.03 and 2.68) Illaobuchi and Marine Base respectively, but contrariwise the  
180 briquettes smoke was stuffy and choky smoke (M=0.4 and 1.00) and irritation of eyes had  
181 M=3.25 and 4.00 respectively (Table 2). This finding provides energy solution to user  
182 respondents which agrees with Ogunsanwo (2001) that application of briquetting technology of  
183 saw dust is promising solution to the problems of unutilized agricultural residues. The  
184 environment friendliness properties of briquettes also agrees with Yaman *et al.*, (2000) and  
185 Olorunnisola (2004) reported that greater heat intensity, cleanliness, convenience in use, and  
186 relatively smaller space requirement for storage are notable merits of briquettes. The use of  
187 briquettes from sawdust ubiquitous at sawmills in urban, towns, villages and other rural dwellers  
188 living close to them may reduce the energy, time and danger trekking to the forests to harvest  
189 fuel wood which a pragmatic paradigm shift to exploration of alternative source of energy. This  
190 agrees with Barrow *et al.*, (2007) who reported that restoration of woodland around the

191 communities reduced the time taken to collect fuel wood by up to four hours and this has  
 192 potential to free up time for women to engage in other productive activities that can improve  
 193 gender empowerment, equity and sustainability of woodland. Applying this concept to  
 194 availability of briquettes, the time would be less than four hours, the limitation of briquetting is  
 195 the manual production method used.

196 **Table 2: Assessment of Environmental Friendliness and Physical Properties of Briquettes**

	Illaobuchi	Marine Base	
<b>Physical Properties</b>	Mean	Mean	Remarks
Friability and Easily Breaks	1.78	2.00	Reject
Weighty and Heavy	1.71	2.00	Reject
Smokes well	3.04	3.80	Accept
Smell Pleasantly	3.03	2.68	Accept
Stuffy and Choky Smoke	0.4	1.00	Reject
Smoke Irritates Eyes	3.25	4.00	Accept

197 **Cut off Marks (M): Accept if  $M \geq 2.50$ , Reject if  $M \leq 0.05$**

198 **Assessment of Problems Associated with Briquettes Utilization**

199 The results of respondents users problems like darkening pots, burning with dark smoke and  
 200 being affected by water had their cut off mark (M) ranged from 1.33 and 1.40 (rejected), 2.63  
 201 and 2.50 (accepted) and 2.01 and 2.12 (rejected) from Illaobuchi and Marine Base respectively  
 202 (Table 3). The briquettes were portable, cheap and useful had  $M = 2.45$  and  $3.00$ ,  $3.60$  and  $3.60$   
 203 and  $3.40$  and  $3.09$  from Illaobuchi and Marine Base sawmills respectively (Table 3). In terms of  
 204 cost and ease of use, it agrees with Hafner, *et al.*, (2018) that greater heat intensity, cleanliness,  
 205 convenience in use, and relatively smaller space requirement for storage are notable merits of  
 206 briquettes. According to Hafner, *et al.*, (2018) scenario of universal access to clean cooking,  
 207 efficient and advanced cook stoves (biomass improved) plays a major role in Sub Sahara  
 208 Africa and likely remain the only feasible upgrading from the status quo for many—especially  
 209 in rural areas—and, in terms of fuel, charcoal will play an increasingly important role  
 210 compared to fuel wood and other solid biomass (e.g. agricultural residues).

211 Wood briquette use provides alternative to fuel wood utilization that impinges on deforestation  
 212 and forest degradation which corroborates with Hafner, *et al.*, (2018) that benefits of  
 213 achieving universal access to clean cooking would be immense and would include  
 214 improvement of health conditions, local job creation, gender empowerment, and reduced forest  
 215 degradation (and in turn improved climate mitigation at global level).

216 **Table 3: Assessment of Problems Associated with Briquettes Utilization**

	Illaobuchi	Marine Base	
Problems	Mean	Mean	Remarks
Darkness or Blackens pots	1.33	1.40	Reject
Lack of other Alternatives	2.44	2.20	Reject



Burns with Smoke	2.63	2.50	Accept
It is Cheap	3.60	3.60	Accept
Affected by water	2.01	2.12	Reject
Portability	2.45	3.00	Accept
Smokes well	3.01	4.00	Accept
It is Useful	3.40	3.09	Accept

217 **Cut off Marks (M): Accept if  $M \geq 2.50$ , Reject if  $M \leq 0.05$**

## 218 **Conclusion**

219 The properties of briquettes analyzed and appraised by product users showed that the produce  
 220 briquettes had positive environment qualities, though some properties were not all that useful and  
 221 friendly but the overall use of the briquettes were promising as an alternative to conventional  
 222 fossil energy sources. Briquetting of sawdust from sawmills is recommended in order to reduce  
 223 deforestation, degradation and environmental hazards caused by the use of other sources of  
 224 energies especially petroleum products. There should be automation of production of briquettes  
 225 in order to maximize its utilization status.

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278 **Appendix 1**

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Faculty of Agriculture  
Rivers State University,  
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20<sup>th</sup> July, 2019

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**Dear Respondent,**

This questionnaire is designed to extract information from you (respondent) on the utilization and environmental friendliness of the information required shall be used solely and mainly for academic purposes of which the result of this survey shall assist the policy makers in the wood energy sectors to formulate sustainable ways in providing alternatives to conventional energy use briquette. You are therefore asked to provide me with the real information as possible as this shall be strictly treated with confidence.

Please, tick the appropriate option that matches with your original opinion about each of the following question.

Thanks for your co-operation.

**Yours sincerely,**

Dr. David-Sarogoro, N.