SOLID FUEL FROM EMPTY FRUIT BUNCH FIBER AND WASTE PAPERS PART 3: ASH CONTENT FROM COMBUSTION TEST

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ABSTRACT

This research discussed on the results obtained for each sample that have been conducted to the solid fuel briquettes made of empty fruit bunch fiber and waste papers from view of ash content during combustion test. The results shows tremendous amount of ash content can be generated from these biomass compositions. Percentage of ash content in every composition is important to know how much ash produced every burning process because this is really related to environmental issues (human and equipment, i.e hygiene). Hence, the possibility result in this research is the development of solid fuel briquette by mixing the empty fruit bunch with a waste paper can be one sources of fuel energy. From the combustion analysis shows sample briquette of S/N 5 was found to be the best ratio as the amount of ash produced at the end of combustion process is the least compared to others researcher with a value of 1.11 percent.

Keywords: *Empty Fruit Bunch Fiber, Waste Papers, Ash Content.*

1.0 INTRODUCTION

Producing energy from renewable biomass is only one of the various ways of responding to the challenges of the energy crisis. Since the oil crisis in 1970's the use of biomass as a source of energy is a topic of growing interest and debate as agreed by Gómez-Loscos (2012), Tong and Li (2012), Arias (2011), Vaclav (2010), Fernando (2009), Kaygusuz and Keles (2008).

Corley and Tinker (2008) in their book discuss in detail about oil palm in Malaysia. In 2004, Malaysia had about 3.87 million hectares of land under oil palm cultivation. Currently, more than 80 percent of the oil palm produced is used for food applications like cooking oil, frying oil and many others. Oil palm is a perennial crop. It has an economic life span of about 25 years. Traditionally, oil palm is grown for its oil example like palm oil, palm kernel oil, and palm kernel cake as the community products. Besides palm oil and palm kernel, oil palm industry generates large quantity of biomass residue which is side products as stated before like fronds, trunks, EFB, palm oil mill effluent, palm fibre and shell that have not been fully commercially exploited.

Through concerted research and development efforts by many research organizations including Malaysian Oil Palm Board, this co – products from palm oil industry have been found to be good resources for many application such as palm oil fuel ash a biomass residue (Brown *et al.*, 2011), oil palm as a viable concrete pozzalanic material (Foo and Hameed, 2009), Oil palm ash as partial replacement of cement for solidification/stabilization of nickel hydroxide sludge (Chun *et al.*, 2008), oil palm ash in concrete (Tangchirapat *et al.*, 2007).There are many competitive uses of these materials. One of them is to utilize them as a fuel for energy production but in term of biodiesel fuel. In fact, Malaysian government has identified biomass as fifth fuel resource to compliment the petroleum, gas, coal, and hydro as energy resources, while palm biomass has been identified as a single most important energy source as stated by Sumiani (2006). On the other hands, the main sources of biomass in Malaysia are domestic wastes, agricultural wastes, effluent sludge and wood chips (Yuhazri *et al.*, 2011) and (Yuhazri *et al.*, 2010).

Biomass energy systems can be based on a wide range of feedstock like food and garden wastes (Romeela and Ackmez, 2012), solid wastes and sewage sludge (Despina *et al.*, 2012), cellulosic ethanol (Gonzalez, 2011), coal and cattle biomass (Carlin *et al.*, 2011) and many more. They use many different conversion technologies to produce solid, liquid, and gaseous fuels. These can then be used to provide heat, electricity and fuels to power vehicles; using burners, boilers, generators, internal combustion engines, turbine or fuel cells. Power can be generated by co – firing a small portion of biomass on existing power plant, burning biomass in conventional steam boilers, biomass gasification and anaerobic digestion.

Converting palm biomass into a uniform and solid fuel through briquetting process appears to be an attractive solution in upgrading its properties and add value as reported by (Sławomir, 2012), (De *et al.*, 2012), (Nasrin *et al.,* 2011), (Chuen-Shii, 2009). Biomass briquette is the process of converting low bulk density biomass into high density and energy concentrated fuel briquettes. Biomass briquette plant is of various sizes which converts biomass into a solid fuel. Briquettes are ready substitute of coal or wood in industrial boiler and brick kiln for thermal application. Biomass briquettes are non conventional source of energy, renewable in nature, eco – friendly, non polluting and economical. Process of converting biomass into solid fuel is non polluting process. It involves drying, cutting, grinding, and pressing with or without the aid of a binder.

Malaysia has involved in palm oil industry over the last four decades and since then it has generated vast quantities of palm biomass, mainly from milling and crushing palm kernel. Empty fruit bunch is the main solid waste from oil palm obtained from milling process. This biomass can be used as an alternative energy for combustion purposes especially in industry. Unfortunately, due to its poor physical properties EFB is not normally utilized as fuel. However, it can be use in optimise by upgrading and treating its properties. The method that can be used is the briquetting technique. Briquetting is the alternative method in upgrading biomass into a useful solid fuel that can be done through various technologies. In this research, EFB material will be mixed up with the recycled papers and it will be turned into solid briquette through the briquetting process. The used of recycle papers in this research is to utilized the abundant papers into something useful, thus helps in reducing the number of municipal wastes generated every year. Papers are selected as a material to be used compared to the other types of recycled wastes such as glass and plastic because it is known to be a good material for a combustion ignition. As for plastics, it may be compatible to papers to be used as ignition material in combustion, but it will spread a toxic gas while it is burn.

The scope of this research is mainly focusing on the mixing of the empty fruit bunch, EFB and the recycled papers. All these palm oil mills is to be obtained, mixed up and to be develop as a fuel briquette at a certain ratio or percentage with the EFB as the major element. This fuel briquette is to be carried out with the performance tests and comparison tests in terms of its calorific values (Yuhazri *et al.,* 2012a), gas emission (Yuhazri *et al.,* 2012b), stability and durability, proximate, ultimate, immerse and crack, but in this paper (part 3) only discuss on ash content produced after combustion test.

2.0 MATERIALS AND METHODS

Empty Fruit Bunch (EFB) supplied by Malaysian Palm Oil Board (MPOB) from one of plantation in Malaysia was used as reinforced material in this green composites fabrication. The EFB used in the composites was in a chopped strand form. The EFB type used was shown in the Figure 1(a) and the Table 1 is the basic properties of EFB used for the fabrication of the composites based on study done by (Nasrin *et al.*, 2008).

(a) **(b)**

Figure 1: **(a)** EFB in fibrous form, **(b)** Shredded paper in shredder machine.

Recycled papers are use as a matrix material in the solid fuel briquette fabrication. The reason to choose papers as recycled waste in this research is because due to the properties of papers which can provide good properties for combustion. Furthermore, it can act as a binder during the blending of papers and EFB during fabrication stage. The papers are obtained from waste papers of the paper shredder machine. This is because the crushing papers have a standard size and dimension after is shredded inside the crushing machine. The standard size and dimension helps to ensure that the blending of papers and EFB is uniform.

Table 1: Properties of EFB as raw materials. (Nasrin *et al.*, 2008)

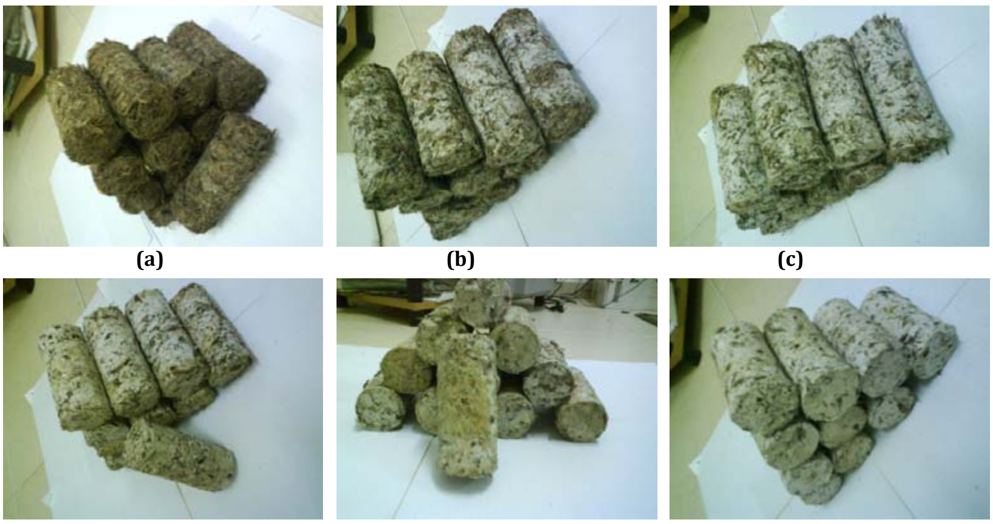
Raw Material	Average size of Materials	Calorific Value kJ/kg	Moisture Content %	Ash Content %
Pulverized EFB	<212μm	17000	12.0	2.41
EFB Fibre	3 cm	16641	16.0	4.70
EFB Fibre	2.5 mm	16641	14.0	4.60

The dimension of sample briquette produced during sample preparation is 40 mm in diameter and 73 mm in length with average weight about 67.64 grams. The ratio of briquette produced is presented in Table 2 and Figure 2 is actual specimens.

Table 2: Sample ratio and its serial number

Ratio of EFB to Paper	Serial Number
90:10	S/N 1
80:20	S/N 2
70:30	S/N 3
60:40	S/N 4
50:50	S/N 5
40:60	S/N 6

There are several steps involved in producing a single briquette according to its ratio. Firstly, the waste papers need to be immersed in water for 24 hours and then it is blended using a blender to mash up the waste papers. Then, the blended papers it weighed again to get the weight of mashed papers with water. After dividing the EFB and shredded papers according to their ratios, the EFB fiber is mixed up with the shredded paper. Then, the compacting step takes place by compacting the mixing of EFB and waste paper into a solid briquette by using hydraulic press machine and cylinder mold. The size of the mold is 100 mm in length and 40 mm in diameter. The mixing is compressed into the mold until it gets to the desired length which is 73 mm. The amount of pressure applied during compacting process is 3 bars. Finally, the solid briquette is placed inside a drying oven at temperature 100 °C for 24 hours to remove the water obtained during the compacting process.



(a) **(b)** **(c)** **(d)** **(e)** **(f)**

Figure 2: Samples of solid briquettes in different ratios; **(a)** S/N 1, **(b)** S/N 2, **(c)** S/N 3 **(d)** S/N 4, **(e)** S/N 5 and **(f)** S/N 6.

3.0 RESULTS AND DISCUSSION

From the combustion test, the amount of ash produced from the combustion of each briquette can be obtained. It can be done by taking the residue from the sample that has burnt completely and weighed it using a digital weight scale. The percentage of ash content produce for each briquette can be calculated. The percentage of ash content of solid briquette for each ratio is represented in a Table 3.

Table 3: Ash content and percentage of ash for sample briquettes

Ratio of EFB to paper	Mass of Briquette (g)	Ash content (g)	Percentage of Ash (%)
S/N 1	135.28	4.8	3.55
S/N 2	135.28	2.0	1.48
S/N 3	135.28	6.0	4.44
S/N 4	135.28	2.1	1.55
S/N 5	135.28	1.5	1.11
S/N 6	135.28	2.4	1.77

The sample briquette S/N 5 produced the least amount of ash as a result of the combustion process test. This is followed by a sample briquette S/N 2 with percentage of ash content is 1.48 %. Sample briquette S/N 3 produced the largest amount of ash content which is 4.44 % and followed by sample briquette S/N 1 with percentage of 3.55 %. This value can be further represent by a graphical form in Figure 3.

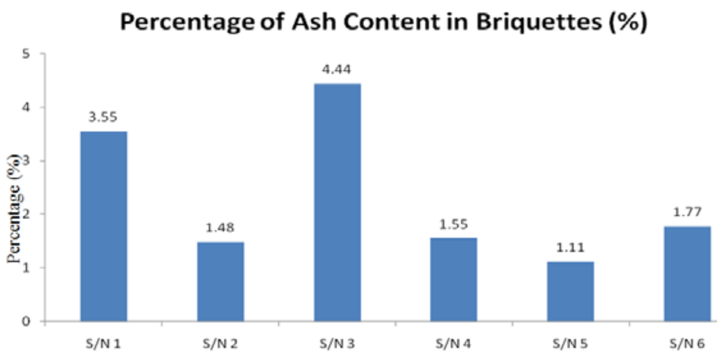


Figure 3: Percentage of ash in briquettes.

Figure 3 shows the gap between briquettes with the highest ash content with a briquette with the lowest ash content is 3.33 percent. A good and quality briquette in terms of combustion efficiency is the least amount of ash content produced after combustion process. This shown that the briquette is burning effectively causing the ash produced at the end of the combustion process is small. From the experiment, the higher amount of waste paper in the ratio, the smaller the amount of ash produced at the end of the combustion process. This is because, paper will get burnt easily and it will burn completely first leaving the EFB that sustained the burning of the briquettes. Briquettes with the largest amount of EFB will produce greater amount of ash at the end of the combustion process. This is proven by the experimental work conducted which shown that S/N 3 and S/N 1 produced the highest amount of ash content compared to others. Similar to the combustion analysis conducted by Nasrin *et al*., (2008), 100 % EFB briquette produced the highest amount of ash content compared to other briquettes tested. The authors also discussed on the comparison of the ash content produced by the EFB in two different conditions which one is in fibre form and the other one is in powder form. It is shown that EFB in fibre form will produce greater ash content compared to EFB in powder form at the end of combustion process. Obernberger and Thek (2004), also stated that in order to maintain a high operating comfort for end users in the residential heating sector, a high ash content must be avoided. This is due to the possibility of increasing danger of slag and deposit formation in the furnace as well as the rising of dust emission. High percentage of ash content implied that fiber could only burnt satisfactorily in a limited range of coal appliances for example step furnace. High ash content is likely to reduce the ignitability of fuel briquettes which in contrast to fuel property that should be combustible and easy to ignite. Mass losses over specific temperature ranges in a specific atmosphere provide a compositional analysis of that substance. Figure 4 illustrated the comparison of ash content on sample briquettes S/N 5 and S/N 6 with a sample briquette conducted by Nasrin *et al*., (2008) based on the same ratio.

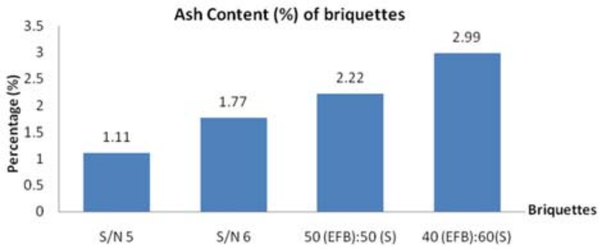


Figure 4: Percentage of ash in sample briquettes

Based on the Figure 4, it is proven that the ash content of the fuel briquette form S/N 5 and S/N 6 are relatively lower compared to the sample briquettes produced by the author at the same ratio. The author is conducting a sample briquette of EFB and sawdust at several ratios. The different between the ash content from S/N 5 with the author sample briquette of 50 (EFB):50(S) is 1.11 percent whereby the different in percentage of ash produced for sample briquette S/N 6 with sample briquette of 40(EFB):60(S) is 1.22 percent. This has clearly shown that the sample briquette S/N 5 and S/N 6 produced are better compared to the sample briquettes produced by the author. Another comparison can be made with the other researchers that have conducted the study on the same field which is production of solid briquettes by referring the Table 4.

Table 4: Comparison of ash content (%)

No	Authors	Title of study	Ash content (%)
1	Husain *et al.* (2002)	Briquetting of palm fiber and shell.	5.8
2	Demirbas and Sahin (1997)	Briquetting of waste paper and wheat straw	13.6
3	Yaman *et al.* (2000)	Production of briquettes form olive refuse and paper mill waste	5.0
4	Nik Farah Nik Zulkifli (2006)	Development of fuel briquettes from Oil Palm Trunk	1.8

Table 4 shows the percentage of ash content in fuel briquette for several researches on biomass briquettes. Based from the table, the least amount of ash obtained from the briquettes from those researchers is higher compared to the palm briquettes that have been studied now. The comparison for the ash content of the sample briquettes produced with the other researchers can be further represented by Figure 5.

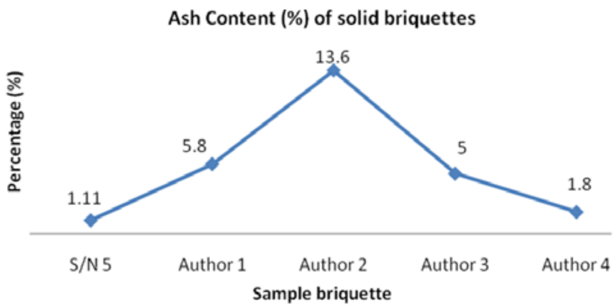


Figure 5: Comparison of briquette S/N 5 with other journal

Referring to Figure 5, it is shown that sample briquette S/N 5 gives a better percentage of ash content compared to other briquettes from other researchers. The difference may be due to the mass and density of the briquettes produced which vary with the other researchers. Sample briquettes that gives the second best percentage of ash content is from the author 4 which studied on the development of fuel briquette form oil palm trunk (OPT). The different if ash content for this author and S/N 5 is 0.69 percent. The difference is smaller compared to the different of percentage of ash content of sample S/N 5 with author 2 which is 12.49 %. The reason for the large gap may be due to the compositional of the raw material used for the briquettes.

4.0 CONCLUSION

The experiment carried out, it was generally found out that the characteristics of palm biomass briquettes produced from compaction of EFB and waste paper were satisfactory and compatible with the other researches that involved the palm briquettes. From combustion (heat released) analysis, it can be concluded that S/N 6 gives the best properties in terms of burning time of the briquette and sample S/N 4 is the best ratio as it released the highest value of heat released from the combustion process with a value of 162.77 kJ. As for the ash content, sample S/N 5 was found to be the best ratio as the amount of ash produced at the end of combustion process is the least compared to others with a value of 1.11 percent. In the nutshells it can be summarized that all samples briquettes have their own strength and weakness when they were subjected to different types of testing, but still all the briquettes were compatible with each others and it is suitable to be commercialized as a new solid fuel sources that can be utilized in many application such as camping, barbeque and for residence utilization energy. The blending of EFB fiber with waste paper can improve its physical, mechanical, and combustion properties.

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