

## FUEL BRIQUETTE MADE OF BIOMASS MIXED WITH RESIDUAL BLEACHING EARTH FROM PALM OIL PLANT

Naruebodee SRISANG<sup>1</sup>, \*Siriwan PANNARAY<sup>1</sup>, Jiraporn THALARUM<sup>2</sup>, Tanawat PUAKNUT<sup>2</sup> and Watcharapong RODTHONGKEAW<sup>2</sup>

<sup>1</sup>Energy Engineering Division, King Mongkut's Institute of Technology Ladkrabang Prince of Chumphon Campus  
17/1, Moo 6, Pha thiew, Chumphon 86160, Thailand

<sup>1</sup>Department of Agricultural Engineering, King Mongkut's Institute of Technology Ladkrabang Prince of Chumphon Campus  
17/1, Moo 6, Pha thiew, Chumphon 86160, Thailand

Corresponding author: Naruebodee SRISANG. E-mail: oat\_2520@hotmail.com

### ABSTRACT

Much Oil quantities inside bleaching earth (B) could be recycled to use. Hence, the objective of this research was a study the fuel briquette (FB) production from B mixed with biomass. The properties of FB was studied, i.e., heating value (HV), ash, fixed carbon, volatile matter and moisture. The ratio of B: husk (H): the mixture of tapioca starch and torch (TST) was determined at 80:0:20, 70:20:10, 60:20:20 and 50:20:30. FB was dried by oven compared with the sun drying. Results showed the HV of FB increased with the increment of H quantity except at the H quantity of 30%. Both drying method could decrease moisture content of FB to the suitable level at 7-15% (d.b.). The suitable mixed ratio for FB production was 60:20:20. This mixed ratio gave the good fuel properties corresponded with the standard, excepting, the quantity of ash and fixed carbon.

**Keywords:** Fuel briquette; Bleaching earth; Heating value; Biomass

### INTRODUCTION

Currently, Biomass is wildly used and continuously growing as an energy source in domestic and industries [1, 2]. Many countries give to interest more and more recycling into renewable energy [3-6]. Major advantages of biomass fuel have cheap resource, reduction of biomass containing waste, low content of ash, carbon (C), nitro-gen (N) and trace elements[7]. Many current research studies on this area, Yumak et al.[8] exposed in different types of briquette product from soda weed to be used as a rural fuel source. Munawar et al. [9] studied in biomass pellet made from solid waste oil palm industry such as oil palm empty fruit bunch, oil palm frond, oil palm shell, and oil palm mesocarp. Saidur [7] reported in using biomass as a fuel for boilers in industries. Including, Othman et al.[10] supported evidence that could be recycled the plants to be reused as boiler. Addition, many agricultural residues such as crops, husk, durian peel, potato pulp, wood chips, palm shell and oil palm empty fruit bunch were recycled [11,12]. Shape of biomass can make in varieties formats such as pellets, cubes, cylindrical and briquette.

Briquette shaping is formed by extrusion for a dense, homogen-ous product because of good physical pro-perties, easy to feed and handle. Chumphon, Thailand has much palm oil plants that bring about a lot of residual materials for example palm shell, palm fiber, and palm empty fruit bunch. Bleaching Earth is one of the residual materials in palm oil production process. Bleaching Earth is clay that uses to filter palm oil step and inside bleaching earth consist of much oil quantities. Many researches [13,14] revealed informa-tion to applying bleaching earth into any function such as filter to reduce the amount of steryl glucosides in biodiesel and use to recyclable catalytic system for synthesis. Forming process composes of many factors such as press forcing and composition for mixing. In this study, composition for mixing consists of husk, bleaching earth and lubrication in various proportions before pressing. Tapioca starch and torch are lubricants that use in cold pressing methods. Hence, the objective of this study was investigated the fuel briquette production that it was made of bleaching earth mixed with biomass. Finally, we report and discuss in fuel

briquette that was investigated the properties of fuel, i.e., heat-ing value (HV), ash, fixed carbon, volatile matter and moisture.

## **MATERIALS AND METHODS**

### **Preparation of bleaching earth and husk**

Bleaching earth (B) used in this study was obtained from palm oil plant, Chumphon, Thailand. Most ingredients of B have waste oil about 40% by weight. This waste oil was adsorbed by soil. The husk (H) obtained from rice mill in Chumphon province. Both B and H may have the contaminations, e.g. pebbles, scraps of wood, leaves, which these contaminations were eliminated by visual inspection.

### **Preparation of the liquid mixture between paste tapioca starch and torch**

Paste tapioca starch was mixed with torch in ratio 1:1 and resulted in a liquid mixture of paste tapioca starch and torch (TST). TST was used to connect between the B and H for the strength of FB.

### **Preparation of FB sample**

Fig. 1 showed the component of mixing and forming FB machine. This device consisted of two main parts namely mixing unit and forming unit. Mixing unit had the function for stir and mixture. Aspect of mixing unit was rectangular tank at top region and cylindrical tank at bottom area. Rectan-gular tank had the width, length and height about 41.5, 49.5 and 18 cm, respectively. The radius and length of the cylindrical tank were 24 and 41.5 cm, respectively. Total volume of both tanks was 74505.78 cm<sup>3</sup>. The stir blades about 15 blades were installed inside cylindri-cal tank and were driven by 0.75 kW motor at the revolution velocity of 940 rpm. For forming unit, this unit constituted compres-sive screw and cylinder. The compressive screw was installed inside the compressive cylinder. The diameter of screw and cylinder were 4.3 and 4.5 cm, respectively. The length of screw and cylinder were 20 cm. A 0.75 kW motor was used to drive the compressive screw. The fuel compression used the revolution velocity of 20, 30, 40 and 50 rpm for the quest of a suitable revolution velocity. The appropriate velocity estimated from the length ratio of FB and the amount of FB production. The length ratio and number of FB received from five repetitions. In prepara-

tion of FB sample, the B, H and TST which obtained from previous process were mixed in determined ratio as followed 80:0:20, 70:20:10, 60:20:20 and 50:20:30 for the quantity of B, H and TST, respectively. All mixtures were stirred about 20 minutes. Then, all ingredients were formed into the FB by compression from compressive screw. After through the forming process, the FB had the outside and inside diameter about 4.5 and 1.2 cm, respectively. Then, this FB was cut to obtain the length of 10 cm that was the suitable length for testing fuel properties. This length referred from the ASTM standard [1,2]. Finally, the FB sample was dried from the initial moisture content of 27-29% (d.b.) until its moisture content remained about 8-15% (d.b.). Drying method in this study was compared with two methods namely sun drying for 8 hours and hot air drying (hot air oven) at 100°C for 6 hours. The moisture content of FB obtained from five repetitions. The FB sample after drying were inspected the properties of fuel.

### **Fuel properties measurement**

The FB <sup>sample</sup> was examined the properties of fuel by the examination method followed the standard of ASTM D7582 and D5865 [1,2]. The fuel properties analyzed in term of moisture content, the heating value (HV), ash, fixed carbon and volatile matter. All FB samples were sent to analyze at the Thailand Institute of Scientific and Technological Research (TISTR). Analysis result was shown by the average value of two repeti-tions.

## **RESULTS AND DISCUSSION**

### **Revolution velocity for fuel compression**

Fig. 2 showed that the effect of revolution velocity on the FB length ratio and the amount of FB production. The length ratio of FB increased with the revolution velocity and the amount of FB production for every the ratio of B:H:TST in this study. This changed length ratio caused from the increase of the velocity of compressive screw. The maximum and minimum FB length ratios were 29 and 65.2 cm/minute for the revolution velocity of 10 and 50 rpm, respectively.

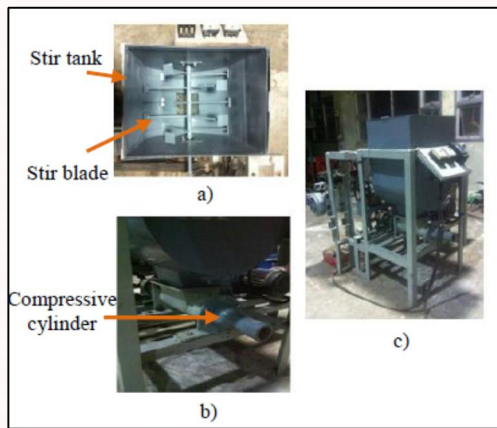


Fig. 1 Component of mixing and forming FB machine: a) mixing unit; b) forming unit; and c) overall mixing and forming FB machine.

Fig. 3 presented that the FB length after compression at the revolution velocity of 10, 20, 30 40 and 50 rpm. Before testing fuel properties, the FB was cut to obtain the suitable length at 10 cm. Aforementioned FB length, the revolution velocity of 10 and 50 rpm gave the least and maximum amount of FB production about 180 and 391 pieces per hour, respectively. However, the lowest revolution velocity could adequately produce the number of FB for testing fuel properties. Thus, the revolution velocity of 10 rpm was suitable for producing FB sample.

Fig. 4 showed that the FB sample before drying and after drying. The FB sample before drying was black color as shown in Fig. 4a. Sun drying and hot air drying was used in this study to compare the effect of different drying method on fuel properties. Sun and hot air drying spent the drying time of 6 and 8 hours for the moisture content reduction of FB in the range of 8-15% (d.b.) [17,18,19]. The color of FB changed from black to gray for both drying method as shown in Fig. 4b.

### Fuel properties

Fig. 5 represented that the moisture content of FB for each mixed ratio after drying by hot air and sun drying. The FB had the initial moisture content about 40-45% (d.b.). The hot air drying could remove the moisture of FB more than sun drying. Because of hot air drying in oven Stir tank Compressive cylinder Stir blade

could easily control the drying condition, i.e., drying temperature and air velocity, while those drying condition in sun drying hardly controlled. The moisture transfer from FB

decreased with the increase of H quantity. The mixed ratio of 50:20:30 had the highest moisture content about 10-15% (d.b.) after drying because there was the highest husk quantity which was obstacle the movement of moisture. The FB at mixed ratio of 60:20:20 had the lowest moisture content about 6-9% (d.b.) after drying.

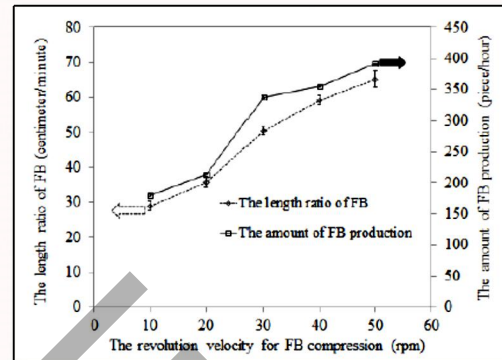


Fig. 2 The effect of the revolution velocity on the length ratio of FB and the amount of FB production.

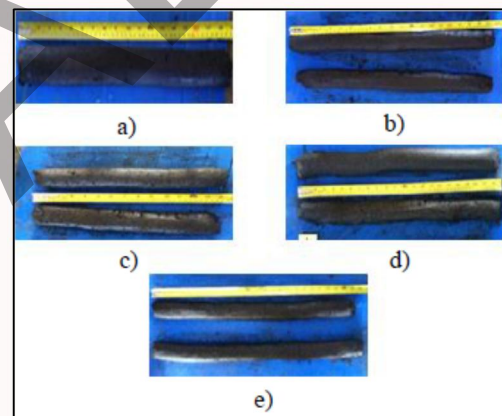


Fig. 3 The length of FB after compression each revolution velocity: a) 10 rpm; b) 20 rpm; c) 30 rpm; d) 40 rpm; and e) 50 rpm.



However, both drying process could decrease the FB moisture content to appropriate a range at around 8-15% (d.b.) [17,18,19]. Damirbas [17] reported that the moisture content of FB obtained the effect from the pressure of fuel compression. The moisture could be removed from FB during compres-

sion process. The appropriate moisture content in FB will facilitate for fuel compression.

Fig. 6 showed that the volatile matter content of FB for each mixed ratio after drying by hot air and sun drying. The quantity of volatile matter increased with the decrease of B and the increase of TST. The incremental volatile matter content may cause from the increase of torch quantity that was ingredient in TST. Torch was a material which could easily enkindle. The different drying method did not significantly affect with the volatile matter quantity, excepting, at the mixed ratio of 80:0:20 for sun drying that showed the lower volatile matter quantity. The volatile matter quantity of FB for both drying method was in the range of 40-54%. This volatile matter quantity was similar with the other biomass [20]. In general, FB or biomass desired the high quantity of volatile matter because the high volatile matter content affected the increase of heating value.

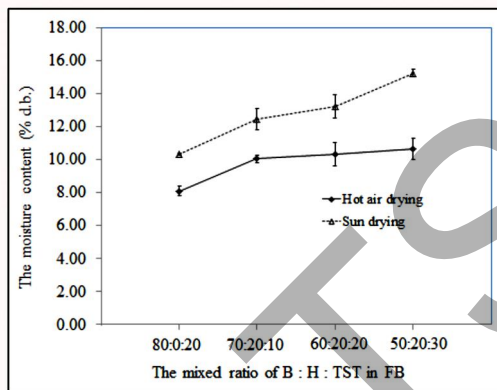


Fig. 5 The moisture content of FB for each mixed ratio after drying by hot air and sun drying.

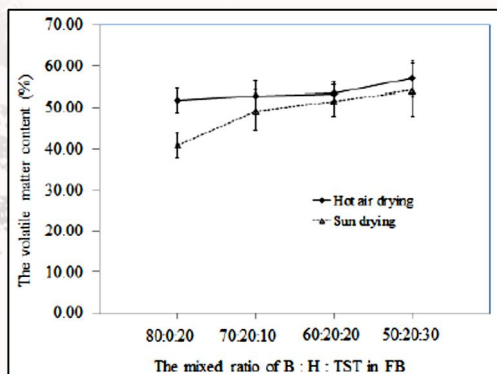


Fig. 6 The volatile matter content of FB for each mixed ratio after drying by hot air and sun drying.

Fig. 7 presented that the fixed carbon content of FB for each mixed ratio after drying

by hot air and sun drying. The content of fixed carbon did not significantly

difference for both drying method. The fixed carbon content did not obviously change with the mixed ratio of FB by the fixed carbon content in both drying method had increased trend when the TST quantity increased to 30%. In good fuel should has the high fixed carbon content which it implied the fuel could burn for long duration. FB in this study had the low fixed carbon about 4-8.4% when compare with the standard (not less than 15%) [21] and the other biomass, e.g., cane trash, rice husk and rice straw [20]. The lowest fixed carbon content found at the mixed ratio of B about 80%.

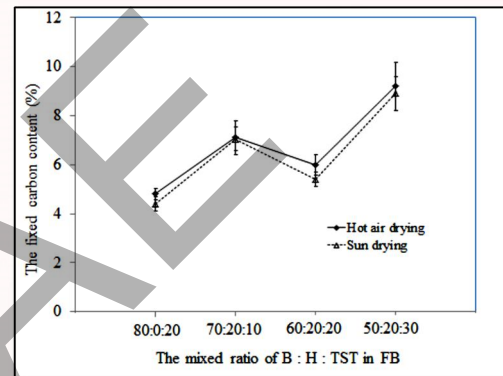


Fig. 7 The fixed carbon content of FB for each mixed ratio after drying by hot air and sun drying. Fig. 8 represented that the ash content of FB for each mixed ratio after drying by hot air and sun drying. The quantity of ash decreased with the reduction of B quantity in fuel. This result showed that the B was poor fuel. The increment of the quantity of H and TST could increase to burn the FB and resulted in the ash content diminished. The ash content of FB was in the range of 27-48%. This result corresponded with the research of Suhartini et al. [22]. Their result showed that the ash content about 34-40%. However, FB in this study had still the ash content lower than the criterion (not more than 20%) [21]. The different drying method did not significantly influence with the ash quantity, excepting, at the mixed ratio of 80:0:20 for hot air drying that showed the higher ash quantity.

Fig. 9 showed that the HV of FB for each mixed ratio after drying by hot air and sun drying. The distinct drying method did not significantly affect with the HV, excepting, at the mixed ratio of 80:0:20 for sun drying that showed the lowest HV about 2,910 kcal/kg.

The HV of FB increased with the increase of H quantity due to the HV of H higher than B and TST. Furthermore, this increment of HV corresponded with the increase of volatile matter content. The maximum HV was 3,800 kcal/kg at the mixed ratio of 60:20:20 for hot air drying. However, the HV of FB decreased at mixed ratio of 50:20:30. The decreased result of HV indicated the B quantity should not less than 60%. Moreover, the decrease of HV may be explained the moisture content in FB. Beker [23] accounted that the decrease of the calorific values of briquette due to the increase of moisture content within briquette. The HV of FB in this study was higher than the criterion (not less than 3,000 kcal/kg) [21], excepting, at the mixed ratio of 80:0:20 for sun drying.

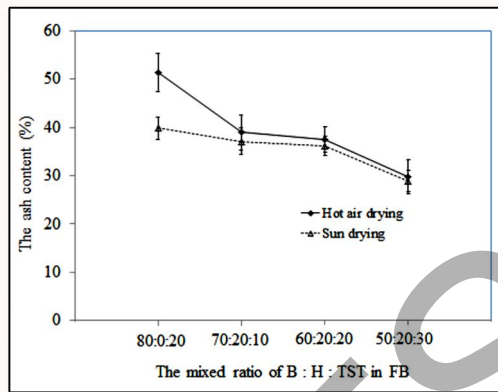


Fig. 8 The ash content of FB for each mixed ratio after drying by hot air and sun drying.

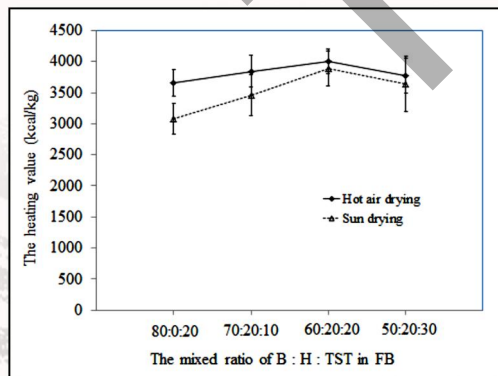


Fig. 9 The heating value of FB for each mixed ratio after drying by hot air and sun drying.

## CONCLUSIONS

The Bleaching earth could be used the mixture for producing FB. The FB was produced by the mixing and forming FB machine. In forming process, the suitable revolution velocity for compression was 10 rpm which the machine could produce the

amount of FB about 180 pieces per hour. The suitable mixed ratio of fuel briquette was 60:20:20 for the quantity of B, H and TST, respectively. This mixed ratio gave the maximum HV, the high quantity of volatile matter and the low quantity of ash. However, the other properties should be improved, i.e., the moisture content should be decreased, the fixed carbon quantity should be increased.

## ACKNOWLEDGMENTS

The authors would like to express their appreciation to the National Science and Technology Development

Agency (NSTDA) and the King Mongkut's Institute of Technology Ladkraj-bang Prince of Chumphon Campus for supporting the finance in this research.

## REFERENCES

- [1] Liu, Z., Quek, A. and Balasubramanian, R. Preparation and characterization of fuel pellets from woody biomass, agro-residues and their corresponding hydrochars. *Applied Energy*. 113: 1315–1322 (2014)
- [2] Kaliyan, N. and More, R.V. Factors affecting strength and durability of densified biomass products. *Biomass and Bioenergy*, 33: 337–359 (2009)
- [3] Arranz, J.I., Miranda, M.T., Montero, I., Sepúlveda, F.J. and Rojas, C.V. Characterization and combustion behaviour of commercial and experimental wood pellets in South West Europe. *Fuel*. 142: 199–207 (2015)
- [4] Chiew, Y.L. and Shimada, S. Current state and environmental impact assessment for utilizing oil palm empty fruit bunches for fuel, fiber and fertilizer: A case study of Malaysia. *Biomass and Bioenergy*. 51: 109–124 (2013)
- [5] Felfli, F.F., Mesa, J.M., Rocha, J.D., Filippetto, D., Luengo, C.A. and Pippo, W.A. Biomass briquetting and its perspectives in Brazil. *Biomass and Bioenergy*. 35: 236–242 (2011)
- [6] Chen, L., Xing, L. and Han, L. Renewable energy from agro-residues in China: Solid biofuels and biomass briquetting technology. *Renewable and Sustainable Energy Reviews*. 13: 2689–2695 (2009)
- [7] Saidur, R., Abdelaziz, E.A., Demirbas, A., Hossain, M.S. and Mekhilef, S. A review on biomass as a fuel for boilers. *Renewable and Sustainable Energy Reviews*. 15: 2262–2289 (2011)
- [8] Yumak, H., Ucar, T. and Seyidbekiroglu, N. Briquetting soda weed (*Salsola tragus*) to be used

- as a rural fuel source. *Biomass and Bioenergy*. 34: 630–636 (2010)
- [9] Munawar, S.S. and Subiyanto, B. Characterization of Biomass Pellet made from Solid Waste Oil Palm industry. *Procedia Environmental Sciences*. 20: 336-341 (2014)
- [10] Othman, M.R., Hassan, M.A., Shirai, Y., Baharuddin, A.S., Ali, A.A.M. and Idris, J. Treatment of effluents from palm oil mill process to achieve river water quality for reuse as recycled water in a zero emission system. *Journal of Cleaner Production*. 67: 58-61 (2014)
- [11] Nuriana, W. and Martana, N.A. Synthesis Preliminary Studies Durian Peel Bio Briquettes as an Alternative Fuels. *Energy Procedia*. 47: 295-302 (2014)
- [12] Obidziński, S. Analysis of usability of potato pulp as solid fuel. *Fuel Processing Technology*. 94: 67–74 (2012)
- [13] Na-Ranong, D., Laungthaleongpong, P. and Khambung, S. Removal of steryl glucosides in palm oil based biodiesel using magnesium silicate and bleaching earth. *Fuel*. 143: 229-235 (2015)
- [14] Mogle, P.P., Kamble, R.D., Hese, S.V. and Dawane, B.S. Bleaching earth clay (pH 12.5)/PEG-400: an efficient recyclable catalytic system for synthesis of 5, 6, 7, 8 tetrahydroquinoline-3-carbonitrile derivatives. *Research on Chemical Intermediates*. (2014) 15. ASTM D7582-12, Standard test methods for proximate analysis of coal and coke by macro thermogravimetric analysis, ASTM International, West Conshohocken, PA. (2012) 16. ASTM D5865-13, Standard test method for gross calorific value of coal and coke, ASTM International, West Conshohocken, PA. (2013)
- [15] Damirbas, A. Physical properties of briquettes from waste paper and wheat straw mixtures. *Energy Conversion & Management*. 40: 437-445 (1999)
- [16] Yaman, S., Sahan, M., Haykiri-acma, H., Sesen, K. and Kucukbayrak, S. Production of fuel briquettes from olive refuse and paper mill waste. *Fuel Processing Technology*. 68: 23-31 (2000)
- [17] Olorunnisola, A. Production of fuel briquettes from waste paper and coconut husk admixtures. *Agricultural Engineering International: CIGR e-journal*. 9: 1-11 (2007)
- [18] Laohalidanond, K., Heil, J. and Wirtgen, C. The production of synthetic diesel from biomass. *KMITL Science and Technology Journal*. 6: 35-45 (2006)
- [19] Industrial waste management bureau, pp. 1-83, Handbook of the way and criterion of waste properties for transformation into fuel pellets and interlocking brick, Department of industrial works, Thailand (2012)
- [20] Suhartini, A., Hidayat, N. and Wijaya, B. Physical properties characterization of fuel briquette made from spent bleaching earth. *Biomass and Bioenergy*. 35: 4209-4214 (2011)
- [21] Beker, U.G. Briquetting of Afsin-Elbistan lignite of Turkey using different waste material. *Fuel Processing Technology*. 51: 137-144 (1997)