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Title(English)	Low-potassium Content Pellet Fuel Production from Palm Empty Fruit Bunch by Hydrothermal and Washing Co-treatment
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論 文 要 旨

THESIS SUMMARY

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要旨（英文800語程度）
Thesis Summary（approx.800 English Words ）

In Southeast Asia, one kind of biomass that being considered as the most potential for energy production is empty fruit bunch (EFB), a byproduct of palm oil industry. This byproduct is poorly utilized yet causing many problems associated with the improper disposal practices of EFB. Hence, the utilization of EFB as a source of renewable energy is considered to be crucial. Despite of the abundant resource of EFB, as like other biomass, it also faces several limitations in its use. The bulk density is low and the moisture content of fresh EFB is approximately 65%. It also contains high ash and potassium content that promotes slagging and fouling problems in boilers. Currently, several different approaches have been considered to improve the fuel properties of biomass. In this study, the combination of hydrothermal treatment (HTT), washing pre-treatment and pelletization were employed in order to mitigate the issues.

The lab scale investigation on HTT of waste EFB was performed in order to upgrade the fuel qualities of the biomass into value added solid fuel. The HTT experiments were conducted using a batch type autoclave reactor. Four reaction temperatures were investigated at 100, 150, 180, and 220°C with the holding time of 30 minutes. The results indicated that the fuel qualities of the product was improved after HTT; such as a higher carbon content, a higher energy density, a lower O/C and H/C ratios compared with the raw feedstock. The calorific value of the EFB was increased from 17 MJ/kg to approximately 20 MJ/kg after HTT, which is equal to low-grade sub-bituminous coal. The mechanism of HTT was also investigated by the Van Krevelen diagram and the FTIR analysis. The main reaction pathways that might occur during the HTT process at a mild temperature were the dehydration and the hydrolysis. Considering the energy consumption and fuel property, HTT at 180°C is found to be most favorable for large-scale production of solid fuel from EFB.

High potassium content in EFB leads to the high slagging and fouling tendency in furnaces. Hence, the removal of the potassium content by combination of HTT and the water washing is also investigated. After HTT, the treated product was subjected to water washing experiments that were conducted using a batch-washing system. The samples were mixed with the ratios of 1:5, 1:8, 1:10, 1:20 and 1:50 of distilled

water at the washing temperature of 60°C for 15 min. The results indicated that the major removal of potassium was attributed to the HTT process, with 92% potassium removal can be obtained after HTT combined with the water washing. The combination also lowered the ash content and the chlorine content of EFB down to averagely 0.9% and 0.19%, respectively. According to the results, it was found that 180°C was the optimum HTT temperature for the effective potassium removal. Combination of HTT and the water washing improved the slagging and fouling indices, exhibiting positive results in the term of the deposition tendency, thus clarified that the removal of potassium may lead to the lower deposition tendency.

The comparison of the pellets produced from raw EFB, and the hydrothermally treated EFB (hydrochar) as well as the washed hydrochar were investigated. Pelletization of biomass has been practiced widely to produce homogenous products with a high density. However, the study on the pelletization of the washed hydrothermally treated biomass is currently limited. The pelletization was conducted using a single pellet making device and performed in the room temperature and the pressure of 150 MPa with the holding time of 30 s. From the results, washed HTT-EFB pellets showed a high mechanical strength, and high durability compared to HTT-EFB and raw EFB pellets. The pellets also showed the hydrophobic nature against the moisture exposure. However, washed HTT EFB pellets required higher energy for making pellet. From the analysis, it was found that the changes in the composition of EFB biomass by HTT and the washing process regulate the pelletization behavior and affect the bonding mechanism during the pelletization.

The possibility to use the leachate from the washing process of HTT-EFB for the agricultural purpose was studied. The analysis of the properties of the leachate and the phytotoxicity test were performed to decide the safety approach when applying the leachate back to the palm oil plantation. Considering the macronutrients amount, the leachate could not be used as an universal fertilizer, but primarily as an organic nutrient supplement. A proper dilution factor was found to reduce the phytotoxicity effect of the leachates to the plant growth.

Overall, the combination of the pelletization, HTT, and the washing co-treatment is promising for upgrading abundant EFB biomass into clean, energy dense, homogenous, friable, durable, and hydrophobic solid fuel that is ready for domestic and international markets, while dealing with the waste EFB problem in the plantation.