CHAPTER 2

Pyrolysis of Pineapple Wastes for Biofuels Production

Norazana Ibrahim, Izni Mariah Ibrahim, Vekes Balasundram, and Noraina Ibrahim

2.1 INTRODUCTION

Pineapple is one of the most popular crops planted in Malaysia and Sarawak, Selangor and Johor are among the highest producers and holding up the largest plantation area (Department of Agriculture [DOA], Malaysia, 2022). In 2021, the annual production of pineapple in Malaysia is approximately 525097 tonnes and according to Malaysia Pineapple Industry Board, the number is expected to increase to meet high demand in the local and foreign markets. With increasing production of pineapple, the waste generated is also increasing proportionally. Pineapple waste includes biomass created from the pineapple plantation from the pineapple leaves, crown, and the stem and also the waste produced from the canning process (pineapple peel, skin and pulp) (Mahamad et al., 2015). Pineapple waste as one of the sources of biomass is considered a potential feedstock that could be converted into biofuel through thermochemical processes such as pyrolysis. Pyrolysis stands out the most among other thermochemical processes for creating liquid fuels because it has higher flexibility as process conditions such as temperature, residence time and heating rate that can be optimized to increase the production of targeted products compared to other thermochemical routes (Osorio & Chejne, 2019). Mansor et al. (2018) has reported that pineapple biomass has similar characteristics with other biomass that has been used as a feedstock for biofuel and energy production.

Pyrolysis is a thermal decomposition process frequently carried out at temperature between 300-700 °C in either total or partial absence of oxygen. It is process that is presently considered one of the options within the utilize of agriculture or industrial waste due to the thermal conversion into biochar (solid), bio-oil (liquid fuel) and fuel gas (CO, CO_2, H_2, CH_4 and other hydrocarbons) (Rodriguez et al., 2020). The yield of each pyrolysis products (bio-oil, bio-char, and bio-gas) are incredibly influenced by the types of feedstocks utilized, temperature heating rates, pyrolysis reactor and others. Previously, other researchers focused on different parts of a pineapple mostly the peels and little on the leaves to be pyrolyzed and produced bio-oil as the main product/yield. Silva et al. (2019) has done energy potential and thermogravimetric study on pineapple crown leaves among other biomasses such as sugarcane bagasse, corn stover, ben pods, white cotton stalk and coloured cotton stalk. They highlighted that the research should be focused on the pineapple crown leave due to higher density (420.8 kg/m^3) and Higher Heating Value, (HHV) (18.93 MJ/kg) contained in this sample that could make it a possible feedstock for potential biofuel production (Silva et al., 2019). Previously, pineapple leaves, stem and crown had been used to produce activated carbon (bio-char) by pyrolysis as an adsorbent that can be utilized for dye removal in wastewater (Mahamad et al., 2015). Pineapple peels also has been shown to undergo pyrolysis to produce bio-char as the main product for several researches. For example, pineapple peels were pyrolyzed to produce bio-char (350-650 °C) as an alternative adsorbent for hexavalent chromium, Cr(VI) in wastewater treatment (Shakya & Agarwal, 2019).

Since pineapple production in Malaysia is increasing, thus the pineapple waste produced will also increase. The research on pineapple waste specifically peels and leaves in pyrolysis of biomass to produce bio-oil for biofuel production were not extensively covered. However, there a few research that has done on pyrolysis of pineapple waste biomass in Malaysia. Selvarajoo and Hanson (2014) has concluded that pineapple peels showed the potential to become a solid fuel resource by studying the effect of temperature, heating rate and residence time on bio-char yield. The char yield trend was reported to decrease (47.1-29.3 wt.%) with increasing pyrolysis temperature (300-700 °C). The optimum temperature for bio-char yield (39 wt.%) was obtained at 425 °C with HHV of 26.1 MJ/kg. Lower heating rate (5 °C/min) produces higher char yield and the optimum residence time for pineapple peels was found to be 1 hour (Selvarajoo & Hanson, 2014). A pyrolysis of pineapple leaves was done by Mahamad et al. (2015) at 500 °C for 1 hour to yield bio-char to be used as a source of activated carbon. There was no further explanation of pyrolysis product yield reported in his paper. In India, bio-char has been the main focus for the pyrolysis of pineapple peels to explore the effect of temperature on characteristics of bio-char and adsorption capability (Shakya & Agarwal, 2019). Shakya and Agarwal (2019) pyrolyzed the pineapple peels at different temperatures (350, 450, 550 and 650 °C) with 5 °C/min as the heating rate and holding time of 1 hour. The char yield was high (46.95 wt.%) at lower temperature (350 °C) and decrease with increasing pyrolysis temperatures. Bio-char derived from pyrolysis of pineapple peels in China was reported to be an efficient adsorbent in wastewater treatment (Fu et al., 2016). The