Production of biochar from Bitter Melon Seeds Waste by Pyrolysis Method

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Abstract. The rejection rate of seeds at a seed company is approximately 5\% of total sorted seeds. Rejected seeds is difficult to treat and caused the problem in the environment. This research aims to produce carbon or biochar from rejected bitter melon seeds by pyrolysis method. The functional groups on the carbon formed was observed using Fourier Transform Infrared Spectroscopy (FTIR). The pyrolysis was carried out at temperature variations of 350\°C, 400\°C, and 450\°C for 60 minutes. The yield of carbon using pyrolysis at temperature of 350\°C, 400\°C, and 450\°C were 34.65\%, 26.09\%, and 24.22\%, respectively. The results of FTIR spectrophotometer analysis on pyrolyzed carbon contain several functional groups of O–H, C= C, and C–O. This produced char can be recycled back to agriculture land as biochar for soil improvement.

Keywords: Biochar, pyrolysis, yield, functional groups

1. Introduction
Bitter melon plant belongs to Cucurbitaceae family, it spreads across China, India, and Southeast Asia [1]. In Indonesia, the bitter melon plant has been used for food and medicine. The bitter melon seeds can treat skin diseases because of the presence of secondary metabolites such as alkaloids, saponins, and monoterpenes [2,3]. Ewindo or East West Seed Indonesia is one of the large seed companies that produce various horticulture seeds including bitter melon. In the process of seed quality control collected seed from farmers is sieved to get quite similar seed size before packaging. The undersize and oversize seed will be rejected and it counts about 5\% of the total processed seed. This rejected seed is difficult to be utilized for instance by composting since it is very hard and difficult to be decomposed.

Char is a porous solid containing 85-95\% carbon, produced from carbonaceous materials by heating at high temperatures under inert or low oxygen atmosphere [4,5] in the temperature range 350 to 800\°C[6]. The raw materials are types of wood, rice husks, animal bones, coal, coconut shells, coffee bean skins [7,8]. The char can be considered as biochar if it is applied to improve soil fertility. Biochar in agriculture acts as soil ameliorant that able to increase fertilizer efficiency for plant [9,10], enhance soil carbon absorption[11,12,13] and improve soil quality [14,15]. Furthermore, the application of biochar triggers the increase of biomass and soil microorganism composition associated with crop production [16,17]. In addition, biochar provides suitable conditions that support the development of mycorrhizal [18,19,20].

In this study, biochar is produced from bitter melon seed waste from the seed industry by using pyrolysis. The temperature of pyrolysis was varied to observe its impact on the char yield and functional group on the surface. It is expected that the seed waste can be recycled into char and can be put back to the soil to improve its fertility.
2. Method

In this research, the sample of bitter melon seeds was collected from EWINDO Company. Activated carbon from bitter melon seeds was prepared by pyrolysis method at a temperature of 350°C, 400°C and 450°C for 60 minutes. The results of pyrolysis were calculated as the char yield as shown in eq. (1).

\[
\text{char yield} = \left( \frac{\text{mass of char}}{\text{mass of initial seeds}} \right) \times 100
\]  

(1)

To determine changes of the functional group on the char due to temperature increases in pyrolysis, Fourier transform infra-red (FTIR) was utilized.

3. Result and discussion

The yield and porosity of char from various pyrolysis temperature is shown in Table 1. In general, higher pyrolysis temperature will lower the solid yield. Higher temperature during pyrolysis will remove further volatile materials. This is due to the acceleration of the reaction rate following the kinetics theory where the higher the reaction temperature is used, the faster the reaction rate will be [21, 22]. In terms of porosity, char from seed has low relatively low surface area and pore volume. For application the char for adsorbent is not yet suitable. It needs further activation to increase the porosity to become activated carbon. For biochar application, since biochar will be digested by soil microbial in a long period of time so that the initial porosity already sufficient.

| Pyrolysis Temp. (°C) | Yield (%) | Surface area (m²/g) | Total pore volume (cc/g) |
|----------------------|-----------|---------------------|-------------------------|
| 350                  | 34.65     | 2.89                | 0.029                   |
| 400                  | 26.09     | 4.34                | 0.034                   |
| 450                  | 24.22     | 6.57                | 0.098                   |

Meanwhile, FTIR analysis is used to identify the types of functional groups present on the char surfaces that is presented in Fig.1.
**Figure 1. FTIR spectrum of pyrolysis product**

The resulting spectrum pattern is the result of vibration absorption from all constituents in the cell [23]. The identification results of functional groups on the char from the bitter melon seeds indicated that the char by pyrolysis method contained O–H, C–H, C=C, and C–O. The FTIR spectrum exhibited adsorptions band for O–H (alcohol) stretching at 3431 cm\(^{-1}\), C–H (alkane) stretching at 2916 cm\(^{-1}\), C=C (aromatic ring) stretching at 1600 cm\(^{-1}\), and C–O (primary alcohol) stretching at 1097 cm\(^{-1}\). The signed wavenumber to specific functional group is summarized in Table 2.

**Table 2. Functional group list on the char surface**

| Wavenumber, cm\(^{-1}\) | Functional group     |
|-------------------------|----------------------|
| 3431                    | O–H                  |
| 2916                    | C–H                  |
| 1605                    | C=C                  |
| 1375                    | C–H                  |
| 1097                    | C–O                  |

The increase of pyrolysis temperature in general reduced the peak of FTIR spectrogram. There is no new peak appear by the temperature change instead of reduction of existing peaks intensity. The reduction of peaks is an indicator of the increase of carbonization level of the char. It is also attributed to acceleration in dehydration reaction of biomass [24]. Higher temperature will also further remove the volatile matter [25] that will also reduce the appearance of related functional groups on the FTIR spectra.

**4. Conclusion**

Waste seed can be recycled to agriculture land as biochar by pyrolysis. The higher temperature of pyrolysis will enhance the porosity and volatile content in the char and reduce the functional groups attached. Meanwhile, the maximum yield was achieved by the lowest temperature (350°C) while the highest porosity was achieved by the highest treatment temperature (450°C).

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