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Performance Evaluation of Continuous Vibrating Fluidized Bed Dryer on Green Tea Production

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This paper presents the experimental work and performance evaluation of continuous vibrated fluidized bed dryer on green tea production. In order to maintain high catechin content, drying is a significant process in green tea production. Tea leaves after steaming process which has 75–80% moisture content was dried in different temperature (50°, 60° and 70°) and air inlet velocity (0.71 m/s, 0.94 m/s, 1.09 m/s). The result shows that the temperature distribution along the bed is uniform. Temperature and air velocity have a significant effect on drying temperature. Shortest drying time was achieved at the temperature of 70 °C with an air velocity of 1,09 m/s.

Keywords: Drying, Green Tea, Moisture Content, Vibrating Dryer, Fluidized Bed Dryer.

1. INTRODUCTION

Green tea has a high popularity because it has many benefits for human health.[1–3] The processing of green tea includes steaming/panning, rolling, roll breaking, drying and sorting. Drying of a post harvested leaves is an important stage in the production process because it determines the flavor and natural substances.[4,5] In green tea production, drying process can determine the quality of green tea, because excessive drying times and drying temperatures can cause thermal degradation and epimerization of catechins. Epimerization of catechin will turn catechin into non catechin isomer.[6,7]

The moisture content in fresh tea leaves are usually 75–80% and the maximum moisture content of tea to be preserved without degradation of quality is 6%.[8,9] Based on the Indonesian National Standard, SNI 01-3945-1995, the maximum allowable water content in green tea is 8%.[10]

Fluidized bed dryer is a kind of new efficient dryer.[11] Fluidized bed dryer has several advantages such as a good solid mixing, high rate heat and mass transfer and easy to transport materials.[12] The higher heat and mass transfer will reduce drying time without damaging heat-sensitive materials.[13] Research on fluidized bed dryer has been done on apple,[14] carrot cubes,[15] corn and pistachio[16] paddy,[17] tea,[18] etc. The application of fluidized bed dryer on the moist, sticky and large size of the material will result in higher minimum fluidization velocity. Fresh tea leaves with high moisture content require higher air velocity.[18]

The addition of the vibration system to fluidized bed dryer will add benefits: improve the fluidization quality of moist and sticky materials,[19] increased the bed uniformity because it preventing bubbles in the bed,[20] helps to overcome inter particle forces,[21] increased efficiency of gas-solid contact, reduced minimum fluidization velocity and fluidization pressure drops and increased homogeneity and stability of the fluidized bed layers.[22]

2. EXPERIMENTAL DETAILS

2.1. Materials

2.1.1. Sample Preparation

The tea leaves are taken from tea plantation at Medini, Kendal, Central Java.

2.1.2. Drying Equipment

The main equipment use in this research was a square continuous vibrating fluidized bed dryer with 2000 × 200 mm drying area (Fig. 1). The hot air generated by the LPG burner mixed with ambient air which was sucked by the centrifugal blower. Another equipment used in this research were analitical balance (OHAUS Pioneer TM PA2102C), digital thermometer, anemometer (Lutron-AM 4205A), inverter and multimeter.

2.2. Method

First, LPG burner lit, followed by setting the blower in accordance with the desired air flow rate by adjusting the frequency of the blower motor. The thermostat was set at the desired temperature variation of 50°, 60° and 70 °C. The air flow rate was varied by varying the frequency of the electric motor on the blower using Siemens inverters TCN4S-24R. Frequency was

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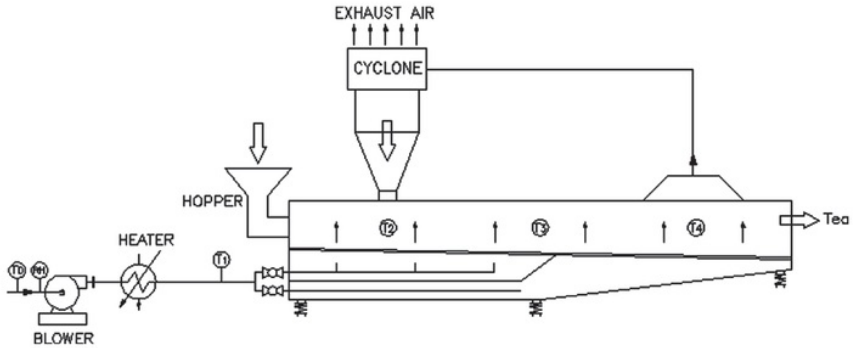

Fig. 1. Continuous vibro fluidized bed dryer schematic.

varied at 30, 40 and 50 Hz. Tea leaves that have been plucked then weighed in 1000 gr, steamed, rolled and cut to a width about 7 mm. The tea leaves began inserted into the dryer after the desirable temperature and air velocity on drying area were reached. After the tea leaves came out of the drying area (15 minutes), then weighed and put into the feeder again repeatedly until a constant weight was reached.

The value of basis moisture content was determined by, $MC = (w_c - w_n/w_c)$ in which MC is moisture content, w_t is the weight of tea leave after t minute, w_n is the weight of tea leave at constant weight.

3. RESULTS AND DISCUSSION

3.1. Effect of the air Flow Rate on Moisture Rate

Temperatures throughout the drying area is quite stable and there was no significant difference. The relationship between the moisture content and the drying time can be seen in Figure 2. The higher the air flow rate, the heat content in the air is higher, so the time required for drying will be lesser. The drying of green tea leaves start from the initial moisture content of solid entering the dryer equipment and finish when there is no longer change of the solid weight. This condition shows that the final moisture content have approached the equilibrium of moisture content. During drying process, the heat transferred from the internal of tea leaves by conduction and following the molecular convection to the surface of tea leaves. This heat is used to evaporate the water inside the tea leaves. Therefore, the water can be migrated from leave into the air and brought to the outside of the drying chamber.[8]

Drying time will be shorter if the air flow rate is increased. In this research, the maximum flow rate was designed at 1.09 m/s, based on the minimum flow rate for fluidization tea leaves which is 0.35 to 1.2 m/s, when moisture content is higher, then the minimum flow rate is also higher.[9] The addition of the air flow rate is of course followed by an increase of blower capacity and energy consumption.

3.2. Effect of Temperature on Moisture Rate

Figure 3 shows the relationship between temperature and the moisture rate. The higher the temperature, the decrease on moisture content will be higher, because the heat content of air is increase.

Based on the Indonesian National Standard, the maximum moisture content in green tea is 8%. The time needed to reach the water content below 8% is at least 60 minutes (air flow rate 1.09 m/s at a temperature of 50 °C, and 3.51% of water content). At the temperature of 70 °C with an air flow rate of 1,09 m/s, a moisture content of 4,12% has been reached in 45 minute. Drying time will be shorter if the air temperature is raised, however a careful consideration must be taken into account the limit temperature at which catechin thermal degradation occurs. Thermal degradation will reduce the amount of green tea catechins, which means a decrease in quality.

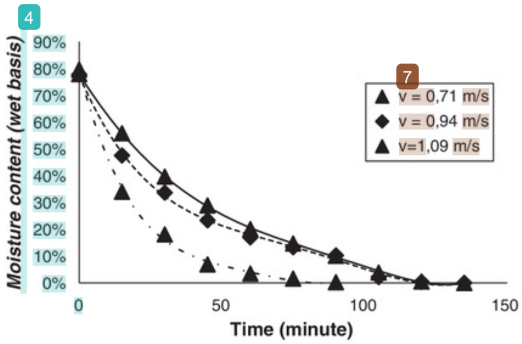

Fig. 2. Effect of air flow rate on moisture content.

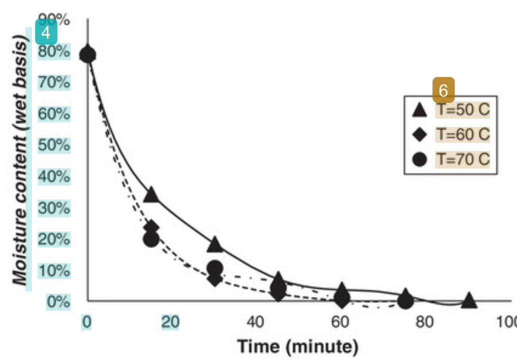

Fig. 3. Effect of temperature on drying rate.

4. CONCLUSION

Green tea drying with a vibrating fluidized bed dryer showed that the shortest drying time is achieved at 70 °C and air flow rate of 1.09 m/s which is 45 minutes. The moisture content decreases more rapidly with increasing temperature and air flow rate. Temperatures throughout the drying area are relatively stable, but the mixing chamber temperature outlet increases with increase in drying time at setting temperature of 70 °C.

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