Fluidized bed drying of stingless bees pot-pollen: performance of swirling distributor

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Abstract. Pot-pollen is pollen collected by stingless bees, that is mixed with honey and bee secretion, and then stored in cerumen pots. Raw pot-pollen contains high moisture content which can lead to excessive fermentation and spoilage. Drying of pot-pollen is needed to preserve them. Typically, elevated temperature can increase the drying performance. However, as pot-pollen is heat sensitive, heating above 40 °C is not preferable. Hence, the objective of this study is to investigate the drying performance of fluidized bed dryer with swirling distributor. The experiment was conducted using three different distributors, a perforated distributor, 45° and 67° swirling distributor, at 1.0 m/s and 1.5 m/s superficial air velocities. Drying experiment was conducted at ambient conditions, with no heating being applied to the pot-pollen samples. It was found that 67° swirling distributor at 1.5 m/s superficial air velocity had the highest improvement in terms of drying performance, able to reduce the moisture content from 30.5 % to 18 % within 30 minutes drying time. Hence, using swirling distributor is a suitable enhancement to fluidized bed drying especially for heat sensitive food materials.

1. Introduction

Stingless bees are native to Malaysia and locally known as “kelulut”. They are important pollinator especially in tropical region such as Malaysia [1]. As stingless bees are usually kept for its honey, meliponiculture or beekeeping tend to neglect other bee products. Similar to honey bees, stingless bees collect pollen from variety of plant species [2]. The pollen is mixed with honey and bee secretion before stored in cerumen pots, coining the term pot-pollen. Often used interchangeably with bee bread (which refer to honey bee stored pollen), the term pot-pollen exclusively refer to pollen stored in stingless bees nest [3]. Pot pollen has high nutrition content as it contain high level of proteins, carbohydrates, lipids, vitamins and phenolic compounds [4]. Besides, pot pollen has been shown to have therapeutic, and medicinal benefits [5–10].

Raw pot-pollen are not usually harvested by farmers due to difficulty in preserving and storing them. This is due to its high moisture content which can lead to excessive fermentation and spoilage [11]. Thus, drying of pot-pollen is needed to preserve and store them. Dried pot-pollen can then be consumed or processed further into various products. One of the method is using fluidized bed dryer.

Fluidized Bed Dryer (FBD) employs the concept of fluidization to dry solid particles. FBD is currently considered as the most effective and practical method to dry solid particles [12]. In terms of technology, FBD is the fourth and latest generation of dehydration technology. FBD are widely used for drying of wet particles and grains owing to their advantages over conventional drying techniques. This is because of its advantages as compared to the conventional drying techniques.

Meliponiculture or stingless bees farming as an industry is growing steadily in Malaysia. Hence, some technological development is needed in order to develop them further. At present, only a few research were reported on the on technical and engineering application for meliponiculture especially in Malaysia. The research focuses more on hive temperature regulation [13,14], honey processing [15,16] as well as engineering economic analysis for stingless bees keeping [17]. However, there is little study done on pot-pollen drying. This is critical in order to increase the value of pot-pollen through a suitable drying method.

In a fluidized bed, drying temperature is the most significant parameter towards drying rate [18–20]. However, pot-pollen is a heat sensitive food material. Drying temperature for pot-pollen is to be kept below 40°C to retain its nutritional properties [21]. A swirling flow in a fluidized bed dryer can improve particulate mixing, increase mass and heat transfer [22,23]. This can be done without applying heating to the bed material. However, there is no study reported on the drying of pot-pollen by fluidized bed drying with swirling distributor.

Thus, the objective of this paper is to investigate the performance of swirling distributor as compared to the perforated distributor for fluidized bed drying of stingless bees pot-pollen.

2. Methodology

The drying experiments were carried out at the Meliponini Engineering Laboratory (MePEL), Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang (UMP). Stingless bees pot-pollen sample used is sourced from a local stingless bees farm. Prior to experiment, the pot-pollen sample was cleaned and stored at -10°C.

The schematics of the FBD used is shown in Figure 1:

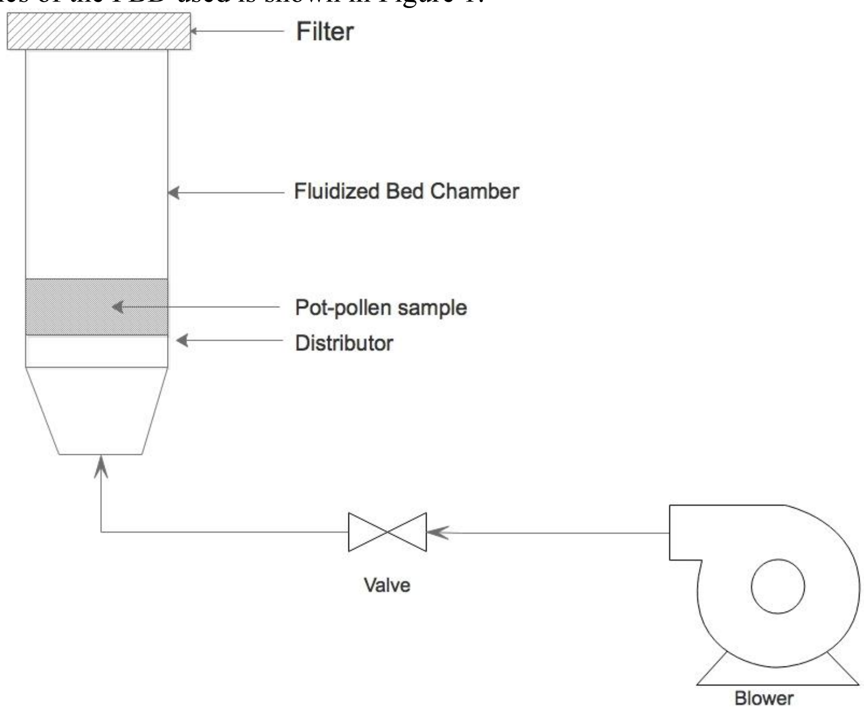

Figure 1: Schematic of fluidized bed dryer for pot pollen drying

Three different distributor types were tested in this experiment. First, a perforated distributor, followed by 45° swirling distributor, and 67° swirling distributor.

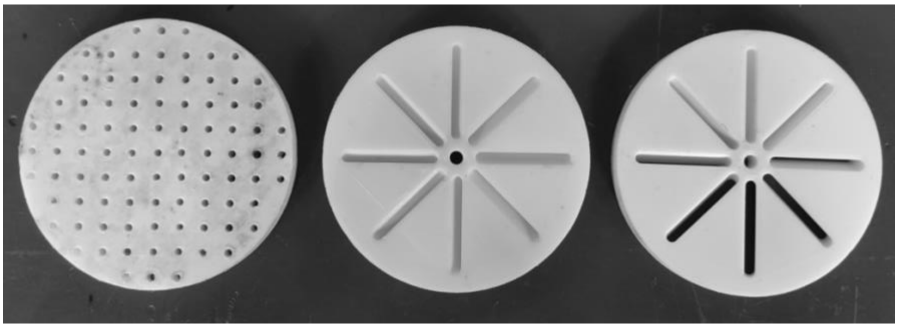

Figure 2: From left, perforated distributor, 45° swirling distributor, and 67° swirling distributor

For each experiment, 50 g of raw pot-pollen was weighed using a mass balance (EL-02H). The pot-pollen then was dried for 30 minutes at superficial air velocity of 1.0 m/s. Air velocity was measured using a hot air anemometer (YK-2400AH). The experiment was repeated for all three different types of distributor, and at two levels of superficial air velocities, 1.0 m/s and 1.5 m/s.

The moisture content of raw pot-pollen and dried pot-pollen samples were determined using hot air oven method. Each pot-pollen sample was weighed to 2 g before put in hot air oven (DZF-6050) at 100 °C for 24 h. The moisture content level is the difference of the initial mass and the dried mass as shown in equation 1 [24].

$$Moisture\ content, MC\ [\%] = \frac{A - B}{B} \times 100 \quad (1)$$

where A is the initial mass in g of pot-pollen sample before oven drying and B is the final mass of pot-pollen after dried in the oven.

3. Results and discussion

Figure 3 and **Figure 4** shows the moisture content level of stingless bees pot-pollen dried at 1.0 m/s and 1.5 m/s, respectively. The reduction in moisture content represents the drying rate for each drying conditions.

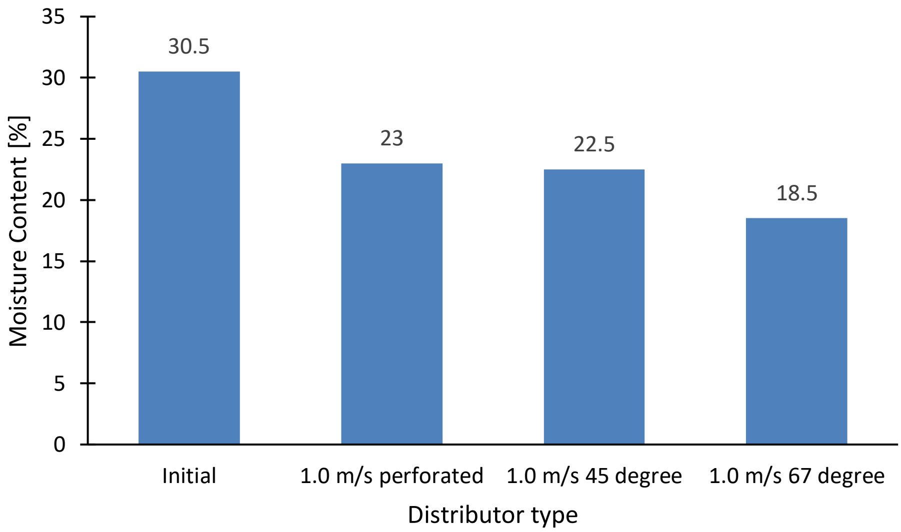

Figure 3: Moisture content for pot-pollen dried at 1.0 m/s

The moisture content for the raw pot-pollen used for the drying experiment has been determined to be at 30.5%. This is common range of moisture content for stingless bees pot-pollen [3,25–27].

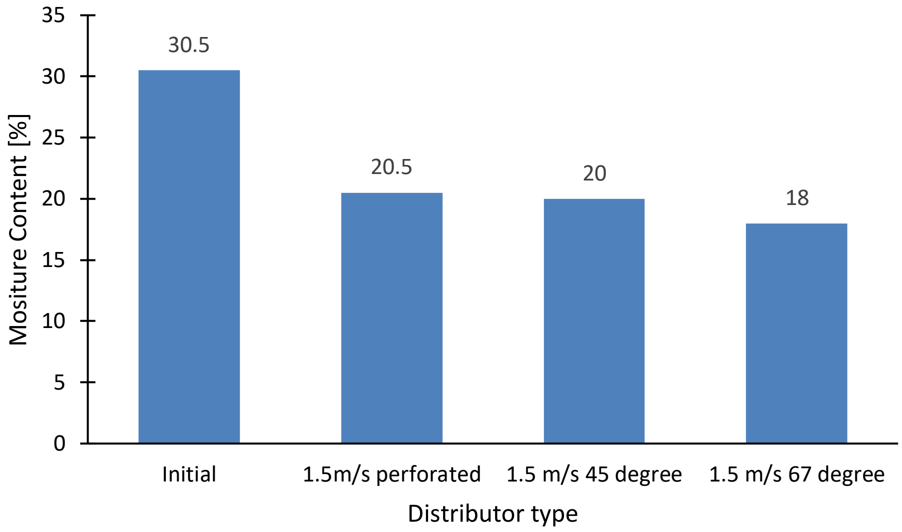

Figure 4: Moisture content for pot-pollen dried at 1.5 m/s

The moisture content for the raw pot-pollen used for the drying experiment has been determined to be at 30.5%. This is common range of moisture content for stingless bees pot-pollen [3,25–27]. The drying rate is represented by the final moisture content level of dried pot-pollen sample. All the conditions tested reduced the moisture content level. At both air velocities tested, 67° swirling distributor had the best drying performance, followed by 45° swirling distributor and perforated distributor. This is because the swirling flow enhance the mass and heat transfer during drying, especially at 67° inclination angle.

Increasing superficial air velocity also improved the drying rate for all distributor types. For perforated distributor, increasing air velocity resulted in additional 2.5% decrease in moisture content. In contrast, the effect was less significant with the 67° swirling distributor where only 0.5% difference increased. Such result can be attributed to the pot-pollen has reached the region of falling drying rate [28,29].

The most significant reduction was from the 67° swirling distributor at 1.5 m/s, where the moisture content had been reduced by a staggering 12.5 %. Considering drying is done for only 30 minutes, this is considered as rapid process. In contrast, perforated distributor at 1.0 m/s has the least reduction, at 7.5% lower than initial moisture content. Hence, 67° swirling distributor had the best performance across the three distributor types tested. Thus, it is possible to enhance the drying performance of fluidized bed dryer without heating by using the swirling distributor.

4. Conclusion

50 g of stingless bees pot pollen sample is dried using fluidized bed dryer for 30 minutes using three different distributor types and at two levels of superficial air velocities. From the three types of distributor tested, it was found that 67° swirling distributor has the best drying performance, where it managed to reduce the moisture content of raw pot-pollen sample from 30.5 % to 18.5 % and 18.0 % at 1.0 m/s and 1.5 m/s, respectively. Hence, for heat sensitive food material such as stingless bees pot-pollen, drying rate can be improved by using swirling distributor in the fluidized bed dryer.

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