Spouted Bed Drying of White Pepper (Piper nigrum L.) with Microwave Preheating Treatment

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Abstract. Drying is an important process in the production of high quality of white pepper commodities that have a high economic value. The objective of this study was to investigate the drying process and the quality of white pepper after spouted bed drying with microwave preheating treatment based on quality parameters of total oil content and microbial contamination. The results of the study indicated that the drying process of spouted bed was able to reduce the moisture content of pepper on average by 59.94% d.b. for 31 minutes on treatment of non-preheating, 60.38% d.b. for 37 minutes on treatment of preheating of 320 watts, and 59.35% d.b. for 32 minutes at treatment of preheating of 640 watts. The initial white pepper seeds that was boiling and soaking for 3 days had a total microbial contents of $2.5 \times 10^7$ CFU/g. Total microbial of white pepper after spouted bed drying process without preheating was $1.54 \times 10^4$ CFU/g, while the total microbes of white pepper with preheating treatment of 320 and 640 watts were $3.0 \times 10^4$ and $6.0 \times 10^3$ CFU/g, respectively. Oil content in all treatments was not significantly different. Oil content obtained in the treatment of non-preheating, preheating of 320 watts and preheating of 640 watts were 2.88%, 3.21% and 2.86%, respectively. It can be concluded that, in all treatments, the amount of moisture reduction and the drying time were relatively similar. However, preheating treatment can reduce microbial content to the IPC quality standard.

1. Introduction

Indonesia is the second largest pepper producing country after Vietnam with the total production of 75,000 Mt, comprises of 44,5000 Mt black pepper and 30,000 Mt white pepper. Export of white pepper of Indonesia amounted 21,000 Mt in valued of USD 19,500 was considered to be the largest one (IPC, 2016). As a high economic value commodity, the quality of white pepper should remain high and hence drying has an important role. Drying of white pepper is practically done after soaking 3-10 days, therefore the initial moisture content of pepper is quite high. High water content conditions are very susceptible to fungal growth if the drying process is slow, so that it can reduce the quality and even damage the pepper. The drying process at the farm level is carried out by sun drying, where it depends on the weather conditions, it can last 2-3 days until the moisture content reaches 15% w.b. Research conducted by Usmiati and Nurdjannah (2007) shows that sun drying of white pepper requires an average time of 13 hours for 2 days and mechanical drying with temperatures ranging from 40°-65°C lasts 4 - 4.5 hour. One method that can be developed in the mechanical drying process is the use of microwaves.

Microwaving in white pepper can be faster, better essential oils content and lower microbial contamination than hot air ovens (Hartulistiyoso and Sudarmaji 2005). In addition, microwaves were also developed in the pepper sanitation process (Emam et al. 1995) and evaluation results showed that the method still maintained the main aroma compounds of pepper (Plessi et al. 2002). However, the application of microwaves singly can cause uneven heating and inhomogeneous field distribution on
certain products, depending on the dielectric and thermo-physical properties. In addition, drying with a microwave oven singly can be very expensive, both in terms of equipment and operational costs. To overcome this problem, the application of microwaves can be combined with drying hot air. This will usually increase the efficiency and economic value of the drying process (Schiffmann 2006). Evaporating the free water content on the surface of the material is relatively efficient by using hot air, while to eliminate the free internal water content and the water content bound, microwaves provide an efficient way. Drying of hot air can be done through a spouted bed process, so that the drying process can be carried out in a relatively shorter time because of the high rate of loss of water content and ensure uniform heating of the material due to good particle movement. In this study, microwave treatment was carried out at the beginning before the drying process of spouted bed. By applying microwave treatment at the beginning of the drying process (preheating), it is expected to shorten the drying process and provide better quality results of drying white pepper.

2. Material and Method

2.1. Sample Preparation and experimental procedure
Pepper was obtained from community plantations in the Enrekang district of South Sulawesi province with an age of approximately 8-9 months after flowering. The drying process was carried out on white pepper seeds after the immersion process for 3 days. After the process of soaking and washing the white pepper seeds, the pepper was left on top of the filter so that the water that attaches to the surface of the seeds that can be released by gravity decreases. The wet white pepper was then weighed to get 400 grams of white pepper and put into a spouted bed drying room for non-preheating treatment, while for preheating treatment pepper was stored in a container. The preheating process was done using a microwave oven which has a working frequency of around 2450 Hz. The power used was 320 watts for 2 minutes and 640 watts for 2 minutes. The temperature before and after the preheating was measured, then the preheating pepper was transferred to the spouted bed drying room and the convection drying process was carried out. During the drying process, several parameters for drying analysis are measured and the quality of white pepper is measured after the drying process was complete.

2.2. Measurement and Data Analysis
The final moisture content of the material is determined using the distillation method. This method is a water content test method for white pepper based on SNI 0004: 2013. This method was used because the ingredients (pepper seeds) contain volatile compounds. Total microbes were calculated using the scatter count method (Hadioetomo 1993). This method was based on the assumption that every cell that can live will develop into a single colony. The number of living organisms contained in the sample was based on the total colonies that appear on the cup. Total microbes were determined by taking a sample of 1 gram of pepper.

The desired drying air flow was generated from the blower then passes through the electric heating element which was placed on the air flow path before entering the drying chamber. An electric heater heated the air that passes through it and the resulting air temperature was maintained at temperatures ranging from 40-65°C with a thermostat. Measurement of material mass includes the initial mass, mass during the drying period and the final mass. The mass measurement of the material was carried out every two minutes during the drying process and the drying process is stopped when it reaches the desired moisture content (about 10% bb). When retrieving mass data, the blow dryer air was turned off for a moment, then the pepper and drying chamber are weighed with digital scales (accuracy of 0.01 gram). Pepper mass was obtained by subtracting the data from the mass of the drying chamber. Temperature measurements were carried out on the air entering and exiting the drying room, the ambient air temperature, and the temperature of the material during the drying process every 2 minutes. In the flow of air in and out, the temperature measured was the temperature of the wet ball and the temperature of the dry ball. The measurement of the temperature of the material was done by stopping the air flow for a moment Temperature measurement using a T-type thermocouple connected to a hybrid recorder to display temperature data.
Drying time was the total time used to dry the material from the initial water content to the desired final moisture content. The time used for measuring the mass of the material does not count as drying time.

Determination of essential oil content was based on the SNI 0004: 2013 test method carried out by distillation using water as its solvent.

3. Results and Discussion

3.1. Temperature in the Drying Process

As shown in Figure 2, the temperature of the material with non-preheating and preheating treatment has increased gradually to reach a relatively constant temperature of around 50 °C in the range of the 20th minute drying process. It shows that the temperature of the drying air at 40 to 65°C did not significantly affect the temperature of the material. The initial temperature of pepper seeds on non-preheating drying was around 28.1°C. In the treatment of preheating with 320 watts of power for 2 minutes, the pepper temperature was increased to 41.1 °C, while at 640 watts for 2 minutes, the pepper temperature increased to 63.8 °C. The rapid increase of the temperature was caused by the principle of microwave heating which vibrated polar compounds (water) found in pepper seeds.

After the preheating process in a microwave oven, the pepper was transferred into a spouted bed drying chamber and convective drying was carried out. Since the water content of the material was still high, the temperature tend to decrease at the beginning of the process to the wet bulb temperature.

It was seen that in the second minute drying with a preheating of 320 and 640 watts, the pepper temperature was only in the range of 33.1 and 31.2 °C respectively (Figures 2b and 2c).

The outlet air temperature has a value that was not much different from the temperature of pepper seeds as shown in Figure 16. This can indicate that the interaction between the inlet hot air and the material enabled even heat transfer from the air to the pepper seeds.

3.2. Drying Process

The drying process of spouted bed reduced pepper water content by an average of 59.94% d.b. for 31 minutes in the non-preheating treatment, 60.38% d.b. for 37 minutes on the 320 watt preheating treatment, and 59.35% d.b. for 32 minutes on the 640 watt preheating treatment. The decrease in water content occurred quickly because the high air flow rate, which was around 15 ms⁻¹. The circulation of pepper seeds in the drying room enabled good contact between the air and pepper seeds. A good circulation of pepper seeds increased the surface area of the material exposed to hot air, so that the heat transfer from the air to the material take place well and at the end it increased the drying rate of the material. A fast air flow bring water vapor to the environment air quickly, thus eliminating air humidity faster, increasing the gradient of water vapor pressure and ultimately increasing the rate of drying (Fellows 2009). Mujumdar (2006) explained that external factors that influence the release of water as steam from the surface of the material are temperature, humidity and air flow, surface area, and pressure.
To compare the drying characteristics of various treatments, it can be done by reviewing the graph of the ratio of water content \( \frac{M_t}{M_0} \) to the drying time (Figure 3). The moisture content ratio is the ratio between the seed moisture content at the specific drying time and the initial moisture content of the seed. The graph shows that, the preheating treatment does not adequately affect changes in the moisture content of the material during the drying process. These results are different from those described by Schiffmann (2006) that preheating will cause the drying curve to be steeper. This difference can be occurred due to its short preheating process, which was applied to avoid material damage caused by high temperature. It indicated that the drying characteristic of the seeds was relatively the same in all treatments, which formed an exponential pattern as the case for drying of cork stoppers (Magalhães and Pinho 2007).

**Figure 2.** Temperature of air and material during drying process: (a) non-preheating; (b) preheating 320 watt; (c) preheating 640 watt. ---□—air inlet temperature, --Δ—air outlet temperature, --○—material temperature, --◊—ambient temperature.
3.3. Microbial Content
The microbiological test was important to determine the effect of the preheating and drying process on total microbes on white pepper seeds. White pepper seeds from 3 days of soaking have total microbes (TPC) of $2.5 \times 10^7$ CFU/g. This result was as explained by Usmiati and Nurdjannah (2007) that the value of TPC pepper at the end of immersion was very high, ranging from $10^7$ to $10^8$ CFU/g. They further explained that, high microbes could be the result of enzymatic processes that allow decay by microbes that may be present in soaking water or fresh pepper seeds. The results showed that the preheating treatment was able to provide a positive influence on total microbes after the drying process, namely by reducing the total microbial content. The total microbes with the preheating treatment were significantly different from those in the treatment without preheating, while in the preheating of 320 and 640 watts, the total value of microbes was not significantly different. Total white pepper microbes after spouted bed drying without preheating was averaged $1.54 \times 10^5$ CFU/g, whereas total microbes in white pepper with the treatment of preheating of 320 and 640 watts were averaged $3.00 \times 10^4$ and $6.00 \times 10^3$ CFU/g respectively. The results showed that white pepper through a preheating process and then continued by drying spouted beds at an average temperature of around $55^\circ$C had met the International Pepper Community (IPC) total microbial quality standards, which was $5 \times 10^4$ CFU/g.

3.4. Essential Oil Content
Essential oils have an important role in the distinctive aroma of white pepper. The essential oil content in all treatments was not significantly different at the test level of 5%. Essential oil content obtained from the treatment of non-preheating, 320 watt preheating, and 640 watt preheating was in average of 2.88%, 3.21%, and 2.86% respectively. In all of these treatments, the essential oil content was above the minimum limit of ISO quality requirements, which was 1%. In addition, the essential oil content obtained was not much different from the level of essential oils produced by traditional methods of 2.49% and the results of mechanical processing of 3.11% (Nurdjannah 2005). Thus, the drying process with a spouted bed both non-preheating and preheating still maintains essential oils on white pepper. Essential oils can evaporate together with water when the drying process takes place. The essential content can be maintained at the drying temperature of below $70^\circ$C (Hidayat et al. 2009).

4. Conclusion
The two minutes treatment of 320 and 640 W microwave in preheating of spouted beds drying of white pepper seeds did not affect its drying characteristics. The spouted bed drying reduced the water content considerably in the range of 57-64% d.b. in a short time of about 30 minutes. Preheating treatment with microwave was able to reduce microbes’ content of white pepper better than drying
without preheating and meet the IPC standard of below $5.00 \times 10^4$ CFU/g. The essential oil content of the dried pepper was in all treatments was not significantly different and higher than the ISO standard.

5. References

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