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Effect of Immersion Concentration in Salt Solution, Drying Time and Air Velocity on Drying Wet Noodles Using a Tray Dryer and Solar Assistance

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ABSTRACT

The noodles in the market are dry noodles with 8-10% water content. Dried noodles have a longer shelf life because they are less prone to mold growth. Drying noodles with the help of the sun and tray dryers are currently an option because they are efficient and do not require a lot of energy. Reduction of water content is also optimized by soaking wet noodles in salt water. This study aims to determine the effect of soaking noodles in salt water and the flow rate to decrease the water content of noodles. The study began with soaking wet noodles in a salt solution with a variation of 50-150 g/L, then dried for 1 hour using a hybrid method and tray dryer with a flow rate variation of 1.2-3.3 m/s. Observations were made at intervals of 0-1 hour. The results showed that the time and speed of the flow rate can reduce the humidity in the drying chamber of the tray dryer. The lowest water content reduction of up to 11% was obtained when soaking wet noodles in 150 g/L salt solution and at the highest flow rate of 3.3 m/s. The ANOVA results show that the drying method with tray dryer is more optimal than hybrid drying. Thus, this method can be a solution to optimize the noodle drying process quickly and efficiently.

***Keywords*:** Drying, hybrid, tray dryer, wet noodles.

1. INTRODUCTION

Noodles are one of the most consumed foods by most Indonesians [1]. A widely distributed noodles in the market are dry noodles with a longer shelf life [2]. According to the Indonesian Industrial Standard (SII) number 0178-90, dry noodles are noodles that have been dried until the water content reaches 8-10% [3]. The appropriate water content makes the noodles not easily overgrown with fungus so they can be stored longer [4], therefore drying the noodles is important [5,6]. Drying can also increase food stability and minimize physical and chemical changes during storage [7,8].

Drying is a complex process involving heat and the transfer of moisture in the product to the surface of the material and then to the surrounding medium [9]. Dry noodles can be produced using a controlled drying process in a room where the parameters of temperature, humidity and ventilation are regulated [10]. Some conventional drying methods that are widely used by the community are using the oven and sun drying (direct drying). However, this method can result in case hardening

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(hardened surface), takes a long time and other materials to evaporate [11]. While the noodle drying technology that is widely used in the industry is rotary or drum dryer. The disadvantages of this technology are that it can cause reduction due to erosion or breakdown, inconsistent characteristics of dry products, low energy efficiency, difficult equipment maintenance, and less safe to use to dry heat sensitive products [12]. Drying using a tray dryer is one of the more efficient methods and is suitable for drying noodles which are included in the type of heat sensitive material [13]. Tray dryers are efficient because they require less energy and the air temperature is not too high (70-80°C). Although it has not been widely used in large-scale industries, drying using tray dryers is usually used in home industries. Tray dryer uses a fan that is useful as a tool to regulate air circulation on the inside [14].

Several studies on drying wet noodles using a tray dryer have been previously reported. Purnamasari et al. [15] carried out drying of wet noodles using a tray dryer (temperature and time variations) with an initial moisture content of 38%. At a certain time, the moisture content is reduced to 9.3% which indicates that the time and temperature greatly affect the drying. According to Syahrul et al. [16] who conducted a study to determine the effect of variations in air velocity and material mass on the drying time of corn on a fluidized bed. The results showed that a large air velocity can accelerate drying. Hasanah et al. [17] also reported that drying foodstuffs with the salting method can speed up the process of removing water content. Osmosis reaction triggered by different salt concentrations results in decreased water content [18]. Although many researches on drying noodles have been carried out, from the literature there has never been done drying noodles using a hybrid method and salt water immersion.

Therefore, this study was conducted to analyze and compare the effectiveness of drying with hybrid methods (solar drying and tray dryer combination) and tray dryer using a variation of drying time, immersion salt solution concentration, and dryer air velocity to reduce the moisture content of noodles.

2. RESEARCH METHODS

2.1. MATERIALS

The materials used in this study were 1.5 kg of wet noodles, distilled water, NaCl, cotton, oil paper, and aluminum foil to maintain the sterility of the material when placed in the oven. The wonton noodles used are still in a semi-finished state. The NaCl was dissolved with 800 ml of distilled water, with different doses of NaCl, namely 10 g, 20 g, and 30 g.

2.2. EXPERIMENTAL DEVICE

The main apparatus used in this study is a tray dryer as shown in Figure 1 [8,19]. The description of the tool in Figure 1 is as follows; Heater power button (1), Temperature controller (2), Fan power button (3), Fan speed control button (4), Temperature control button (T1-T4) (5), Temperature sensor (T1-T4) (6), Sensor of dry bulb temperature before rack (7), Wet bulb temperature sensor before rack (8), Dry bulb temperature sensor after rack (9), Wet bulb temperature sensor after rack (10), Analytical balance (11), and Material rack (12). Tray dryer is a plate-shaped dryer equipped with shelves that are used to dry solid materials. In addition, the tray dryer is also equipped with a thermometer as well as a temperature controller, a fan and a fan speed controller, temperature display screens for T1, T2, T3, and T4, and a scale. The tray dryer used has a capacity of 42 m^3/min, type SF-25H with a frequency of 50 Hz, a power of 190 W, a voltage of 220-240 V, a size of 250 mm, and a speed of 2800 r/min. In addition to the tray dryer, the supporting tools for this research are the GSF G-4405 analytical balance, basin, stainless steel knife, oven, sieve, blender, HoldPeak HP-866B anemometer which is used to measure the drying air rate, stopwatch, and measuring cup.

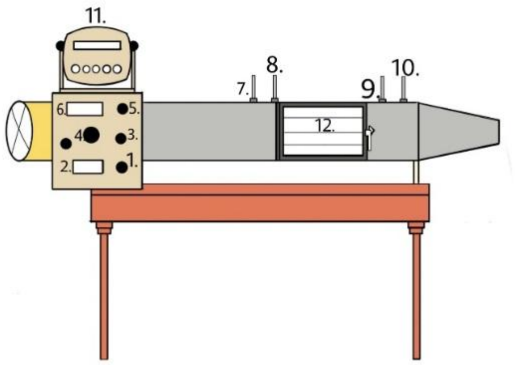

Figure 1. Schematic diagram of Tray Dryer

2.3. EXPERIMENTAL PROCEDURE

In this experiment, two methods were applied: tray drying and hybrid. Hybrid drying combines the drying process using solar energy and a tray dryer. The hybrid method begins with soaking the noodles for 30 minutes in salt solution with concentrations of 50, 100 and 150 g/L, then immediately dried in the sun for 30 minutes. After that, it is put into the tray dryer using 3 variations of wind speed, namely 1.2; 2.3; and 3.3 m/s for 30 minutes. So that, in this hybrid method 9 samples were produced and observations were made every 10 minutes. The procedure carried out in the direct method is noodles that have been soaked for 30 minutes in salt solution with concentrations of 50, 100 and 150 g/L, then immediately dried in a tray using varying fan speeds, namely 1.2; 2.3; and 3.3 m/s. This method also produces 9 samples, drying lasts for 1 hour and observations are made every 15 minutes.

2.4. EXPERIMENTAL ANALYSIS

The analytical method used in this experiment is to calculate the humidity from temperature of the dry bulb and wet bulb. Calculation of water content using a wet basis calculation.

$$Water\ content\ (wet\ basis) = \frac{[W-(W1-W2)]}{W} \quad (1)$$

Where W is the sample mass before dried (g), W_1 is the sample mass after dried + measuring cup (g), and W_2 is the measuring cup (g).

In this experiment, statistical methods were also carried out using the analysis of variance or ANOVA (Analysis of Variance) method which aims to determine the significant effect of the variables used, the software used for ANOVA analysis is IBM SPSS Statistics 20 [20–22].

3. RESULTS AND DISCUSSION

3.1. HUMIDITY IN THE CHAMBER OF TRAY DRYER

Humidity in the drying chamber affects the effectiveness of drying. If a wet solid sample is contacted with air whose humidity is lower than the sample's water content, the wet sample will release some of its water content and dry until it balances with the air. Figure 2 shows the lower the humidity inside drying chamber, the greater the ability of the sample to release its water content, thus resulting in lower moisture content in the sample. This phenomenon is because dry air requires a certain amount of water content to reach equilibrium.

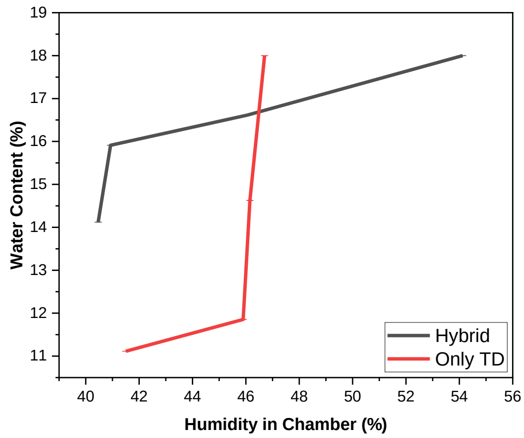

Figure 2. Effect of humidity inside drying chamber on water content (%)

Figure 3 shows the humidity in the drying chamber during the noodle drying process with a tray dryer and a hybrid at various air flow rates. It can be seen that the drying time and the flow rate can reduce the humidity in the chamber significantly. If the time changes, the humidity will also change. This is because the longer the drying time causes the contact with the heating air to be longer so that the water in the material and the drying chamber can be evaporated even greater [15,23]. The longer drying time will cause precipitation (condensation) of water molecules contained in the air so that the water content in the air decreases [24]. Based on Figure 3, it can be seen that at the largest flow rate variation of 3.3 m/s, the tray dryer method is more optimal than the hybrid method to reduce humidity up to 22%. This can be compared with the results of studies previously reported that the humidity with hybrid is the highest and the humidity with the tray dryer is the lowest [25].

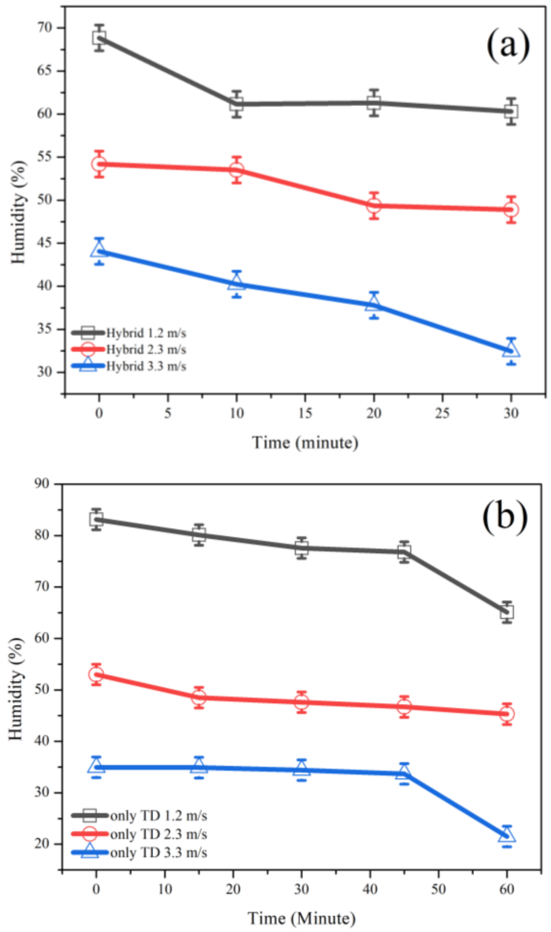

Figure 3. Humidity in the chamber using the hybrid (a) and tray dryer (b) method

3.2. EFFECT OF SALT CONCENTRATION

Figure 4 shows the effect of various salt concentrations for soaking wet noodles on the final moisture content after drying using the hybrid method and tray dryer. Based on the graph, it can be seen that the best treatment was obtained when the wet noodle sample was immersed in 150 g/L salt solution. The higher the salt concentration, the less water content after drying (drying faster). This happens because in food, salt is isolated and can attract a certain amount of water so that the greater the salt concentration, the more water molecules are pulled out by hydrate ions [17].

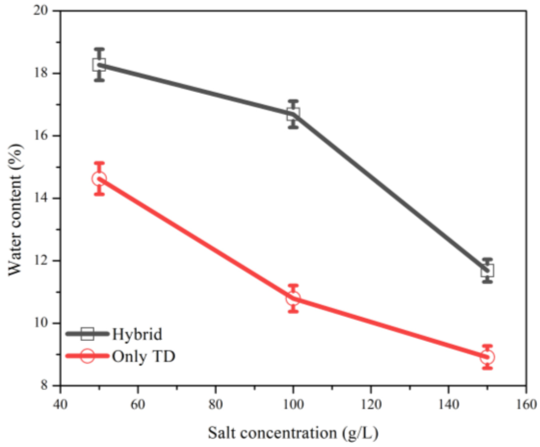

Figure 4. Effect of salt concentration on water content (%)

In the previous study, there was no optimum condition for the immersion salt solution concentration. The obtained conclusion was the same as this study, the higher the concentration of the salt solution, the smaller the moisture content of food ingredients. However, excessive salting causes the protein contained in the food to undergo denaturation. The denatured protein will dissolve in the salt solution. This phenomenon occurs because chemical compounds such as salt can break hydrogen bonds and proceed to protein denaturation [26].

Drying using a tray dryer is more optimal for drying wonton noodles compared to the hybrid method. This is because at a certain time the water content that can be removed when using a tray dryer exceeds the water content released during hybrid drying (drying in the sun for 30 minutes). This phenomenon is also caused by the temperature factor of sunlight which varies during hybrid drying [27]. Based on the results of the ANOVA output, the average different drying methods can reduce the water content significantly.

3.3. EFFECT OF FLOW RATE

Air flow velocity in this study was calculated using an anemometer. Figure 5 shows the effect of variations in air velocity using the hybrid method and tray dryer on the final moisture content after drying. In Figure 5, it can be seen that the greater the air flow rate, the lower the water content. The best treatment was obtained when using the tray dryer method with the highest flow rate variation of 3.3 m/s resulting in a moisture content of 11%. This is due to the phenomenon that rapidly flowing air will make it easier for water to evaporate and diffuse out due to the thrust of the air [28]. This principle allows multiple drying processes using circulating air. The amount of dry air flowing increases the possibility of friction between the air and the material being dried so that heat will flow into the material and the drying chamber. A large amount of air can accommodate a large amount of water vapor as well, so it can speed up the process and produce good drying quality [29]. Previous research conducted by Prasetyaningsih and Mulyanti [30] reported that a large flow rate can reduce water content more quickly so that drying time can be efficient.

The graph also shows that drying using a tray dryer is more optimal for drying noodles compared to the hybrid method. This is because at a certain time the water content that can be removed when using a tray dryer exceeds the water content released during hybrid drying (drying in the sun for 30 minutes followed by a tray dryer for 30 minutes). This phenomenon is also caused by the temperature factor of sunlight which varies during hybrid drying [27]. Based on the results of the ANOVA output, obtained a sig value of 0.012 < 0.05 so it can be concluded that the average different drying methods can significantly reduce the water content. The moisture content of the noodles obtained in the study was considered as the dynamic equilibrium moisture content at 1 hour drying [31].

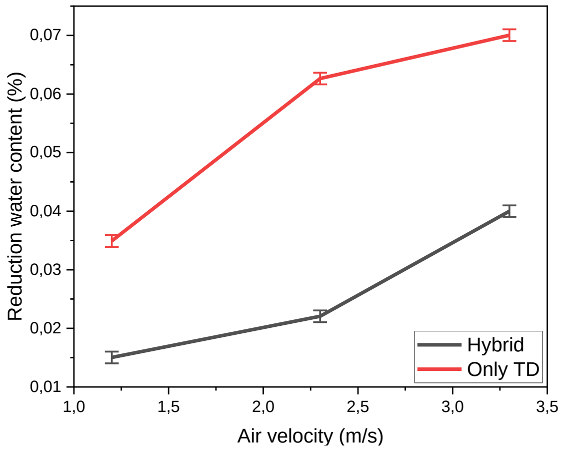

Figure 5. Effect of air velocity on water content reduction (%)

Based on the above results, the effectiveness of drying using a tray dryer is better than hybrid drying. However, hybrid drying could be applied to reduce the moisture content, proved by the ANOVA results with a sig value of 0.017 < 0.05 for the average variation of the hybrid method (solar and Tray dryer combination). The final result of drying noodles using the hybrid method and tray dryer is shown in Figure 6.

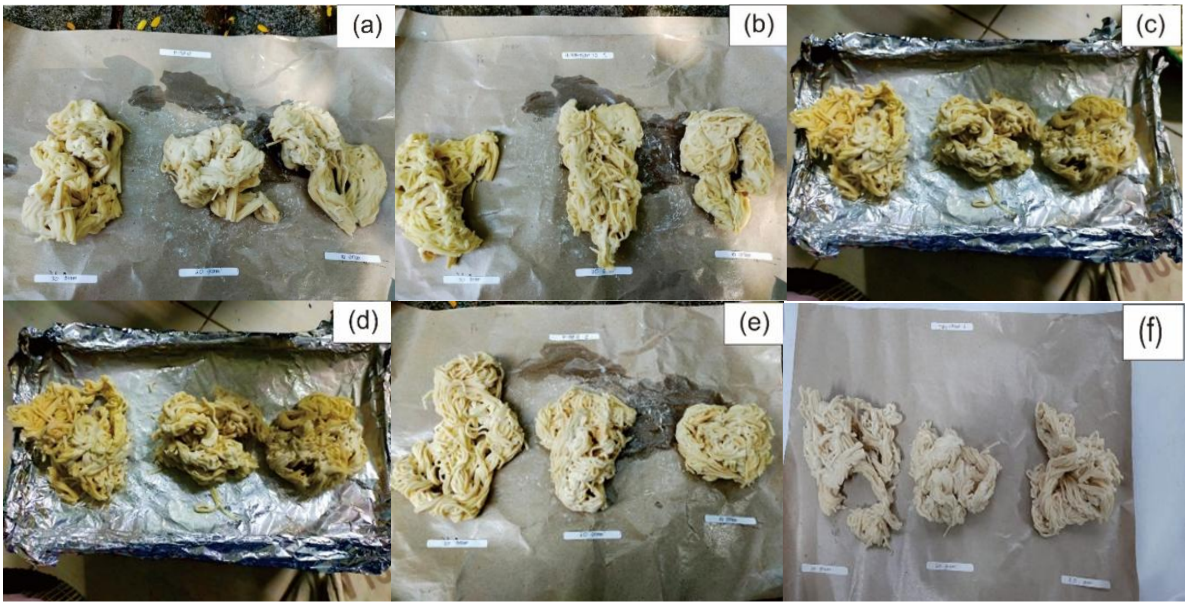

Figure 6. The final result of hybrid drying (a-c) and tray dryer (d-e)

4. CONCLUSION

The drying time and air velocity can reduce the humidity in the drying chamber of the tray dryer. The smaller the humidity, the more water content is evaporated. Soaking wet noodles in 150 g/L salt solution can reduce the water content optimally and the lowest decrease in water content of 11% is obtained at the highest flow rate of 3.3 m/s. The different drying methods can significantly reduce the water content. The two methods have a significant effect on reducing the moisture content of wet noodles, but the tray dryer drying process is more optimal than hybrid drying because it produces noodles with a smaller moisture content.

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