Seaweed Drying Process Using Tray Dryer with Dehumidified Air System to Increase Efficiency of Energy and Quality Product

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Seaweed Drying Process Using Tray Dryer with Dehumidified Air System to Increase Efficiency of Energy and Quality Product

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Abstract: Seaweed, one of the marine resourceshas a high economic value but easily damaged in fresh condition. Drying method using air dehumidification system is an effort decreased moisture content to prevented using high drying temperature which causes degrading quality. The process of drying seaweed with air dehumidification system using silica gel adsorbent becomes an option to decreased efficiently drying process. The purpose of this study was to examine the drying time and temperature of the moisture content, the rate of drying, energy efficiency, and the physiological properties of the dry product. Seaweed is dried in a tray dryer at 40°C, 50°C, 60°C, and 70°C for 2, 3, and 4 hours. The water content in seaweed is measured every 30 minutes. Seaweed water content according to SNI is obtained at drying for 4 hours at 50°C, 4 hours at 60°C, 2, 3 and 4 hours at 70 °C. The increase in drying temperature is directly proportional to the high drying rate that occurs while over time the drying rate will decrease. At the optimum air temperature and drying time, the highest efficiency of tray dryer is obtained during drying for 4 hours at 50°C that is 91.50%. The highest swelling capacity value is owned by the dried seaweed product with a temperature of 50°C for 4 hours. Best condition in drying process of seaweed is used temperature 50°C at 4 hours.

Keyword: seaweed, drying, dehumidification, efficiency

1. Introduction

Indonesia is an archipelagic country with abundant marine resource potential, one of them is seaweed. Type of seaweed *Euchema cottoni* dan *Gracilaria sp* is widely developed and cultivated [19]. Seaweed has a high economic value in the cosmetic industry, food etc.[25]. Fresh seaweed has a high water content (75-85%), organic and mineral components (15-25%). Freshseaweed is easily damaged and rotted, then drying is an important step before seaweedused in industrial processing[15].

Drying is a process to reduced water content from substances by using thermal energy toobtained dry product[26].The benefit of the drying process is decreased water activity for inhibited growth microbe, maintaining a quality of product and reduced storage volume [22]. Drying with solar energy was widely used for the drying and preserving agriculture product, food, and other products in developing countries, but this process hashigh deficiency such as drying time, drying area, and susceptible to contamination [8].

The main problem of drying method was useda high temperature for the drying process. Seaweed contains polysaccharides, minerals, vitamins and substance of bioactive such as proteins, lipids, and polyphenols [5][4]. However, the organic component in seaweed will be damaged if exposed to hightemperature and a long period of drying time [11]. The high temperature in the drying process will be damaged a lot of nutrition (crude lipid content and amino acid), decreased the physical properties, rehydration and antioxidant activity of seaweed [24]. Drying time will be shorter if used temperature under 70°C [8].

The other problem in the drying method is used energy wastefully[7]. The amount of energy can be reduced if the energy efficiency of the drying processincreased. At present, the ranges of energy efficiencyon the drying system are 30-60%, which means that the energy must be provided 2-3 times from the really needed.The low energy efficiency of the drying process caused an inefficient transfer mass from the material to the drying air. Especially in tropical regions has a high relative humidity (70-80%), it becomes saturated quickly when condition with high relative humidity used to dry media. At high relative humidity, the evaporation process of water will be hampered because driving force of water mass transfer from material to the air (drying media) becomes lower[2].

The process of drying seaweed with air dehumidification system using silica gel for adsorbent becomes an option to replace the drying system that has been developed[8] [21]. In this case, the air will be contacted with the absorbent (silica gel) to remove the moisture content (air dehumidification). Increasing the driving force of the drying process because of relative humidity was decreased [8]. Therefore, the process of drying seaweed will be dried at low temperature to the maintained quality of product and minimize drying energy.The purpose of this study was to examine the drying time and temperature of the moisture content, the rate of drying, energy efficiency, and the physiological properties of the dry seaweed.

2. Material and method

2.1. Materials

This research was used seaweed (*Euchema Cottoni sp.*) from Jakarta and silica gel for an adsorbent agent from Indrasari (Chemical store in Semarang, Indonesia) and try dryer for a dryer.

2.2. Sample preparation

Seaweed samples were washed and soaked in the freshwater until 3 days to the removed soil, salt and coral. The silica gel must be regenerated with thermal treatment (120°C, 3 hours). The outside air as a heating medium is heated at a certain temperature according to the variables (40°C, 50°C, 60°C, 70°C) and the corresponding drying time of the variables are 2, 3, and 4 hours. The water content in the seaweed was measured every 30 minutes by gravimetric method until the moisture content obtained constantly. The analysis in this research will be analyzed of water content used gravimetric method AOAC 2000, energy efficiency calculation, and seawater physiochemical properties test.

2.3. Energy Efficiency

Energy efficiency depends on several characteristics of a process such as a rate evaporation of water in material, steam as an air heater and heat energy. A general definition of energy efficiency in the drying process was a total energy used to evaporated water and it was divideda total energy in the process [7].

$$\eta = \frac{Q\ out}{Q\ in} \times 100\%$$

Energy efficiency (η) was calculated baseon the amount of heat released (Q_{out}) to raised the temperature of seaweed($Q_{sensible\ seaweed}$), raised the temperature of water in seaweed($Q_{sensible\ water}$), evaporated water from the surface of seaweed($Q_{latent\ water}$), raised the air of dryer and evaporated water from seaweed divided by heat energy enter in the form of hot air ($Q_{hot\ air}$). Calculation of heat value (Q) calculated by equation [23] as follows:

$$Q = m.Cp.\Delta T$$
$$Q = m.\ Hv$$

Information: Q is the heat needed (J/Kg), Cp water, Cpv is the specific heat of air and water vapor (J/Kg °C); ΔT is the changing temperature in and out (°C); Hv is a heat of evaporation (J/Kg).

3. Physico-Chemical Properties

3.1. Water Swelling Capacity (WSC)

Aquadest 10 ml was mixed with 0,5-gram seaweed powder. The mixture was stirred in a measuring cup and left for 18 hours in the room conditions. The volume of water absorbed into the sample, it will be measured as swelling volume (ml/ gram drying sample). Test of the swelling capacity was carried out three times.

4. Results and discussion

4.1. Relation of time and temperature to water content

Figure 1 shows that the diffusion process of water into the dry air occurred. The water content of seaweed was decreased by the time [1].The results of modeling drying with tray dryer are the water content decrease rapidly until the decline slows and constant. The higherdrying air temperature cause the lower water contents. A decrease water content will be faster because the greater heat energy is carried and the greater difference between heating media and foodstuffs will be encouraged evaporation process of water [14].The higher dryer air temperature, the lower relative humidity of the air [9]. Because of decrease relative humidity, heat and mass transfer will be a greater and increase the drying kinetics rate. According to the Indonesian Nasional Standard (SNI) about Quality Standard of Dry Seaweed, the water content of seaweed to storage is20% ± 5%. The optimum time and temperature used to obtain water content 20% ± 5% were drying process 4 hours at 50°C and 60°C, 2 hours, 3 hours and 4 hours at 70°C.

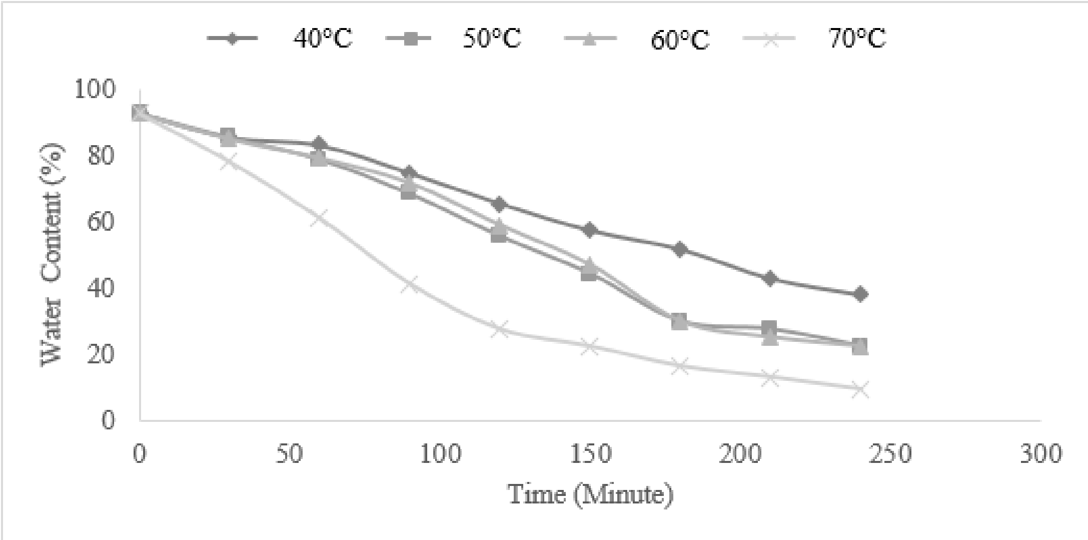

Figure 1. Effect of time and temperature on water content during the drying process at 2 hours, 3 hours and 4 hours.

4.2. Relation of Time (t) and Temperature (T) Drying Process to Drying Rate.

Analysis drying rate was obtained by the reduction weight of wet seaweed which dried in the tray dryer at various temperature and time.This analysis aimed to comparethe drying rate that occurs with variations temperature and time in the drying process. Quantity evaporated of water content per unit of time(gram/minute) or decreased water content in units of time was calling drying rates. The drying rate was usually increased at the beginning of the drying processand then constant. After that, it was decreased with time and decreased the water content of the material. Drying rate wasa quantity of water content in the material which evaporated bya unit of dry weight in the material and unit of time [15]. In this drying process was equipped with an air dehumidification system and silica gel foran adsorbent agent to reduced moisture in the drying air.Using air dehumidification and silica gel will improvethe ability to dry air to carry out moisture although at low temperatures[12].

The drying temperature was increased proportional to the high drying rates, especially if the material still contains a lot of moisture content at the beginning of the drying time.However, drying rate was decreased after it will a constant with the time of drying process. Increasing the drying rate was affected by the rise in temperature.The drying rate was decreased because less amount of water was evaporated as time goes by drying.In the beginning, the drying rate was very high because a lot of water on the surface area of the seaweed material evaporated.Furthermore,molecules of water werediffusion from the seaweed cells into the surface layer [18].Time in the diffusion process was longer needed that evaporation was occurred slowly [20].

4.3. Relation of Time (t) and Temperature (T) Drying Process aboutEnergy Efficiency.

At the beginning of the drying process, the efficiency of tray dryer was high and decreased over time. During the longer drying time,the water content in the seaweed will be lower because the amount of the water willbe lessevaporatedand the efficiency of the drying process decreases.Calculation of energy efficiency (η) was calculated based on the amount of heat to evaporated the water from the material (Qevap) divided by total heat requirements to regenerated the absorber and increase the air temperature (Qintr) [9]. The higher the drying temperature, the higher the heat to evaporate the water and the evaporation process of water will decrease. Because of using high temperature, efficiency drying processwas higher at the beginningof drying seaweed. From the calculation of data, the average efficiency value of each variable was obtained as follows:

Table 1. The efficiency of energy in the drying process at various temperature and time

Temperature	Efficiency (%)		
	2 hours	3 hours	4 hours
40 ^{0}C	90,768	90,148	90,219
50 ^{0}C	91,040	90,503	91,506
60^{0}C	91,485	91,237	90,743
70 ^{0}C	91,328	91,110	90,384

Based on the data, the optimum conditions were obtained when drying time and temperature at 4 hours 50°C, 4 hours 60°C, 2 hours, 3 hours and 4 hours 70°C. From these optimum conditions, the highest efficiency value was obtained during the drying process at 4 hours 50° C which was 91.506%.

4.4. Analysis of Physiochemical Properties of Seaweed Dry Products with Swelling Capacity Test

Swelling capacity test in the dried seaweed was obtained from the optimum condition in the several variables of the drying process. Result the swelling capacity test of seaweed follows by table. This research was conducted by the amount of water that absorbed into the dry seaweed from drying process using tray dryer. The most optimum variable was obtained from comparison selected variables (energy efficiency and quality of seaweed products). Swelling Capacity was absorbed the amount of water in the dry material every unit of weight dry[16]. Physiochemical properties such as swelling capacity can describe the fiber content in seaweed, as well as the polysaccharides, alginate, uronic acid, carrageenan, and proteins in the wall cell [27][3]. Characteristic of swelling will very important, especially for ingredients of the dietary food. Because of ability fiber to absorb and retain water, fiber can maintain health of colon and faciliate defecation process [13].

Based on Table 2, the highest swelling capacitywas obtained by a variable of drying process at 4 hours 50°C.Swelling capacity tends to decrease when the drying process take a long time and high temperatures. A high temperature in the drying process will damaged organic compounds in the ingredients of food because many polysaccharide chains will damage [12].

Table 2. Swelling capacity from the optimum condition

Selected variable		Swelling Capacity (ml/g *dry sample*)
Drying temperature (°C)	Drying time (hours)	
50	4	10.85
60	4	9.62
70	2	10.01
70	3	9.37
70	4	8.99

5. Conclusion

In this research,increasing drying temperature was directly proportional to the high drying rate while the drying rate will decrease at over time. The water content of seaweed was obtained during at 4 hours 50°C, 4 hours 60°C, 2 hours, 3 hours and 4 hours 70°Cin accordance with SNI. Efficiency drying was higher at the beginning of drying process before, constant and decreased at over time. The highest swelling capacity and tray dryer efficiency were obtained when drying at 4 hours 50°C, which was 10.85 ml / g dry sample for swelling capacity and 91.50% for the efficiency of tray dryer.Best condition in drying process of seaweed is used temperature 50°C at 4 hours.

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