C16_Electrohydrodynamic drying of plant seeds with the shape variation

by Ainie Khuriati

Electrohydrodynamic drying of plant seeds with the shape variation

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Abstract. Electrohydrodynamic (EHD) drying is a dryer that does not require moving parts and is environmentally friendly and it   results   more durable. The purpose of it study is to compare among the physical characteristics of the results of the EHD Drying of the crop seeds with variations in shape. This research used samples of Cucumber (Cucumis sativus) seeds, Long Bean (Vegna Unguiculata ssp) Seeds and Winged bean (Psophocarpus Tetragonolobus) Seeds. It is in variations in diameter of seeds form. EHD flow is yield corona discharge plasma. It is using 10 pairs x 10 pairs of electrodes wich have configuration pin-three concentris ring . It is generated with applied high voltage of 18 kV, the gap electrode 4 mm and drying time 0-35 minutes with a 5 minute time interval. According to the results obtained, the graph of drying rate and the energy efficiency of all seeds sample is the maximum at the beginning of drying is after a 30 minute drying time and then decays with additional drying time. The drying rate and energy efficiency of the cucumber seeds is the largest and the winged bean seeds are the smallest.

1. Introduction

Drying is one of the most important processes in various fields, especially in agriculture [1]. Because, the majority of yields and seeds will be carried out drying which aims to prolong the storage period in a certain period [2]. In general, drying utilizes natural energy sources namely sunlight [3], but this method still has various obstacles, namely requiring large areas, less hygiene and weather dependent. As technology developed, drying began to use hot steam [4], machines [5], microwaves [6], and ovens [7]. The various drying processes still require high electrical power and require expensive costs [8], so that a new innovation in drying arises namely electrohydrodynamic drying [9].

Electrohydrodynamics (EHD) is a non-thermal plasma technology as an alternative to conventional drying with heat-sensitive materials [10]. The principle of EHD drying is the phenomenon of charge transfer which is located between the two electrodes connected at high voltage [11]. The transfer of charge that occurs causes a reaction that results in heat transfer and ionic wind [12,13], both of which will move and increase the mass transfer of water so that evaporation occurs in a sample [14].

EHD energy consumption is lower than machine drying because EHD targets a reduction in humidity [15]. Various applications of EHD drying have been carried out mainly in agriculture that focuses on vegetables such as tomatoes [16], mushrooms [17], and potatoes [18]. In this study drying times of 5 minutes, 10 minutes, 15 minutes, 20 minutes, 25 minutes, 30 minutes and 35 minutes were selected for each sample. The purpose of this research is to determine the physic characterization of ehd drying with

variations in the shape of seeds and the samples used are cucumber seeds, long bean seeds and winged bean seeds. Cucumber (Cucumis sativus L.) is a fresh vegetable which is rich in gixzi and water content [19] and mantimun seeds have benefits such as preventing osteoporosis or cervix [20]. Long Beans (Vigna sinensis L.) is a legume family plant that has a variety of protein, vitamin A, thiamine, riboflavin, iron, phosphorus, potassium, vitamin C, folate, magnesium, and manganese and has good water moisture [21]. Whereas, winged bean (Psophocarpus tetragonolobus L.) is a climbing plant that has a relatively small seed form [22], winged bean also has various ingredients such as minerals and vitamins [23]. All three of these samples have in common that they contain high water content and are sensitive to heat then both during the drying process. After drying mass differences, drying rate [24], shrinkage [25, 26], and energy efficiency [27] were obtained from the three samples. The value obtained is used as a reference for storing seeds in a certain period of time until they are ready to be planted.

2. Method

The samples of EHD drying were seeds from cucumbers, winged beans and long beans purchased from the local market in Semarang. The seeds that have been separated from their flesh are measured by initial mass and moisture as in Table 1 and each sample is placed in a petri dish during drying. The mass of the petri dish is 46.06 grams made of glass.

Table 1. List of EHD drying samples

Seeds Sample	Initial Mass (Gram)	Initial Humidity (%)	Shape
Cucumber	16.00	39.8	
Winged bean	16.00	17.4	
Long bean	16.00	29.8	

EHD drying uses   pin electrode and three-ring electrode with an amount of 10 pairs x10 pairs each. Pin Electrode as a cathode has a pointed end diameter of 0.026 mm. Concentric three-ring electrodes as anodes consist of 3 concentric ring electrodes which have the same width and thickness of 2 mm and 8 mm, 16 mm and 24 mm respectively. The distance between the two electrodes is 4 cm with a variation of time 5 minutes, 10 minutes, 15 minutes, 20 minutes, 25 minutes, 30 minutes, and 35 minutes at the input voltage DC (Direct Current) 18 kV obtained a current of 45 mA. The voltage measurement is given to the system through a high voltage probe P20 P28 and the installed voltage can be measured using a digital voltmeter (CD772 Sanwa Made in Tokyo, Japan). EHD drying uses   pin electrode and three-ring electrode with an amount of 10 pairs x10 pairs each. Pin Electrode as a cathode has a pointed end diameter of 0.026 mm. Concentric three-ring electrodes as anodes consist of 3 concentric ring electrodes which have the same width and thickness of 2 mm and 8 mm, 16 mm and 24 mm respectively. The distance between the two electrodes is 4 cm with a variation of time 5 minutes, 10 minutes, 15 minutes, 20 minutes, 25 minutes, 30 minutes, and 35 minutes at the input voltage DC (Direct Current) 18 kV obtained a current of 45 mA. The voltage measurement is given to the system through a high voltage probe P20 P28 and the installed voltage can be measured using a digital voltmeter (CD772

Sanwa Made in Tokyo, Japan). The experiment setup of Electrohydrodynamic Drying of Plant Seeds with the Shape Variation as shown in Figure. 1

Figure 1. The experiment setup of electrohydrodynamic drying

EHD drying will release heat energy along with ionic wind which will increase the mass transfer of liquid in the sample, resulting in a mass difference between the initial mass (m_0) and final mass (m_a) during the drying time (Δt) [28]. Measurement parameters after EHD characterization and EHD drying in mathematical samples obtained the value of the drying rate [29] was calculated using Eq. (1) expressed as db / minute and Shrinkage [30] in equation (2) expressed as (%) as follows:

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$$DR = \frac{\Delta m}{\Delta t} \qquad\qquad (1)$$

$$SR = \frac{\Delta m}{m_0} \times 100\% \qquad\qquad (2)$$

Δm is the mass difference after and before drying (db), Δt is the time difference after and before drying (minutes), m_0 is the mass before drying (db) [31]. The two measurements are interrelated because they are influenced by the mass difference of the sample. Whereas, the Moisture Content affected by the initial humidity in each sample (in Table 1) can be calculated using equation (3) expressed as (% db)

$$SR = \frac{\Delta m}{m_0} \times 46,6\% \qquad\qquad (3)$$

and to know the Energy Efficiency [32] which is determined from the electric power supplied (kW) and the drying rate (kg / s) of the sample can be calculated in equation (4) as (kJ / gr).

$$\eta = \frac{VI}{\Delta m} \times \Delta t \qquad\qquad (4)$$

Where, V is the input voltage (kV), and I is the output current (mA).

3. Results and discussion

3.1. I-V characteristics

Characterization of EHD drying with a 10 x 10 pairs of the pin electrodes to the three-ring concentric electrodes is obtained a current curve as a function of voltage as in Figure 2.
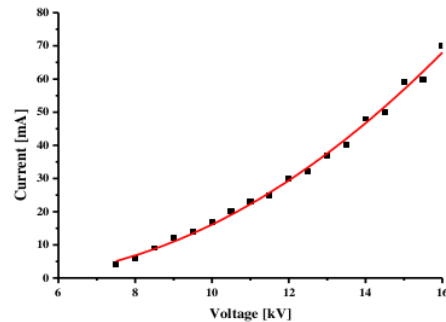

Figure 2. *I-V* characteristics

When the EHD reactor is connected to a DC voltage source at distance of between the electrodes 4 mm, a charge transfer occurs resulting in the ionization process [33]. The ionization will produce a measured current (mA), heat transfer and ionic wind [34]. Figure 2 also shows that the measured current increases with the increase in applied voltage due to ionization which is affected by the electric field and coulomb force [35,36]. This is used for evaporation of water content in samples of cucumber seeds, winged beans and Long bean seeds.

3.2. Drying rate
EHD drying on cucumber seeds, winged beans and long bean seeds was obtained at a voltage of 18 kV with time variations. The drying rate is obtained from the mass difference of the sample before and after drying the EHD each drying time so the drying rate curve is obtained in Figure 3.
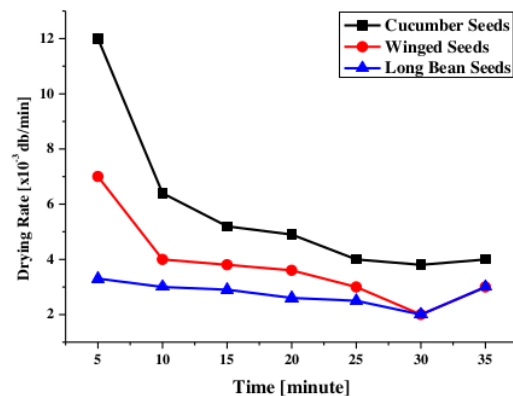

Figure 3. drying rate in the sample

In Figure 3. shows the drying time to 5 minutes, the three samples are in almost the same condition because the difference in mass obtained 0.01 - 0.02 grams. This is due to the diffusion process [37] when the material is still in the initial conditions. In the next drying time occurs degradation the drying

rate is faster as the drying time increases. However, at the 30th minute all three samples had the same tendency and at the 35th minute the drying rate of the three samples increased again. This is influenced by the presence of osmotic conditions [38] the moisture content that is on the surface of each sample. The osmosis process is caused by the coulomb force and the electric field [39] which moves opposite from the positive to negative electrodes. The movement carries water molecules content moving upwards towards the surface of the sample which has a low concentration of water content.

3.3. Shrinkage

Shrinkage during drying increases with increasing time given [40] as in Figure 4. This is due to cell wall damage in the sample during the drying of the EHD [41] which results in reduced mass in the sample.
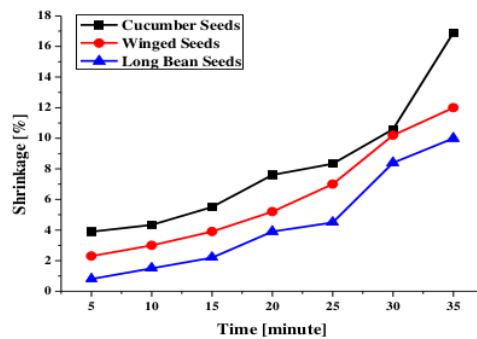

Figure 4. sample shrinkage

In Figure 4 shows the three samples have the same tendency at minute 30 for cucumber seeds 10.59%; Winged bean 10.2% and Long bean seeds 8.4% due to the mass transfer process in the sample during drying.

3.4. Energy effeciency

Energy consumption during the EHD drying process is determined by the electrical power used, namely the DC input voltage and the measured current [42]. Energy consumption of the three samples with time variations is obtained as shown in Figure 5.
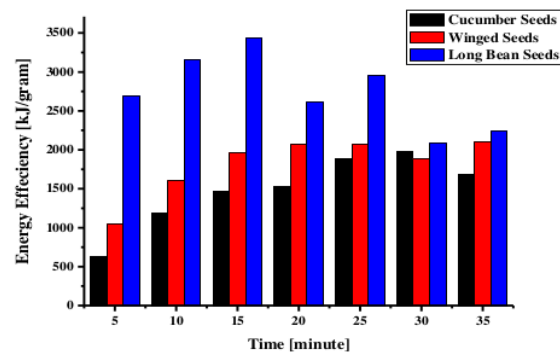

Figure 5. EHD drying energy consumption in the sample

EHD drying only requires less power than using microwave or machine drying [43]. Drying energy consumption is influenced by the ionization process and ionic wind currents that are formed in each time variation. In Figure 5. the optimum energy consumption of the three samples is at the 30th minute ie for cucumber seeds 1972 kJ / gram; wing bean seeds 1890 kJ / gram and Long bean seeds 2081 kJ / gram.

4. Conclusion

Electrohydrodynamics flow is yielded from corona discharge can be used for drying samples that are sensitive to heat. The optimal drying time in the 30th minute obtained values of drying rate, shrinkage and energy consumption in each sample. The drying rate value is inversely proportional to the depreciation value. The energy consumption of draining energy is influenced by the input voltage and the flow of ion currents. Cucumber seed samples are the most sensitive to heat because of the value of the drying rate, shrinkage and the most optimum energy consumption during the EHD drying process.

Acknowledgments

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FINAL GRADE

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GENERAL COMMENTS

Instructor