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Ionic Wind Drying for Leaves of Andrographis Paniculata Bush Plant

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Abstract
Ionic wind drying or High Electric Field Drying is a convective drying technique. It is a non-thermal plasma technology that can effectively remove product moisture whilst retaining heat-sensitive. The purpose of this study was to determine the physical characterization of the dried Andrographis paniculate leaves. The ionic wind is generated using high voltage DC 4 kV is applied on the pin-three rings concentric electrode by the distance between the 4 mm electrodes. Drying time is 5 to 35 minutes at 5 minute intervals. The results showed that the bitter leaf experienced a reduction in mass during drying and obtained values of the drying rate of 11 x 10^{-3} db/min, shrinkage of 10.5% and energy efficiency of 2086 kJ/gram at 30 minutes.
Keywords: Ion wind drying, Drying rate. Shrinkage, Andrographis paniculate leaves
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1. Introduction

Andrographis paniculate (the bitter leaf) is one of the many medicinal plants found in Asia (Kanniappan, Mathuram, & Nataraja, 1991*)*. This plant contains a compound of diterpene, lactone, and flavonoids functioning as antiviral and antibacterial (Chao, & Lin, 2010). Leaves of this plant can be used for the treatment of diarrhea, dysentery, diabetes, toothache and high blood pressure (Pratama,. & Ramadhan, 2013). In general, the leaves of Andrographis paniculate are processed into drugs on a micro scale or industry which must pass the production stage one of which is the drying process (Moradi & Zomorodian, 2009).. Drying is one of the most important processes in various industries, especially the pharmaceutical industry (Gumusay, Borazan, Ercal, , & Demirkol, 2015).. In general, industrial scale drying uses machines (Bruijn, & Bórquez, 2014). ovens (Moradi, & Zomorodian ,2009) and hot steam (Chapchaimoh, Poomsae-ad, Wiset, & Morris, 2016). However, the drying method requires high electrical power and is expensive (Bajgai, & Hashinaga, 2001). to overcome this there is a drying method using plasma technology, namely ionic wind drying or high electric field drying (Hanafizadeh, Gharahasanlo, Ahmadi, Zeraati, & Behabadi, 2016). The principle of ionic wind drying is ionization between charges between the two electrodes connected at high voltage (Kulacki, 1982, producing an electric field and ionic wind (Martynenko , & Kudra, 2016). The electric field and ionic reduced water content in the material and a drying process occurs (Weber, Borup, Darling, Das, Dursch, & Gu, 2015). The advantages of ionic wind drying are low power consumption, saving and environmentally friendly (Kudra, & Martynenko, 2015).. Ion wind drying has also been implemented in various samples (Sumariyah, Khuriati, Pratiwi, & Fachriyah, 2018 & 2019). However, in this study using bitter leaf samples with a variation of drying time of 5-35 minutes with 5 minute intervals aimed to determine the characteristics of the bitter leaf during drying and drying rate values (Doymaz, 2012), shrinkage (Mohsenin, 1986), and specific energy consumption (Cao, Nishiyama, & Koide, 2004).

2. Method

2.1 Sample and experimental preparation

The sample used was the leaf of Andrographis paniculate obtained from Kediri city, East Java, Indonesia with 39.8% humidity and a mass of 300 grams that was put into a Petri dish (Normax Glass).

Ion wind drying uses a concentrated of pin-three rings reactor with an amount of 10 x 10 pairs of electrodes. The pins electrode 0.026 mm in diameter. Concentric three-ring electrodes consist of 3 concentric ring electrodes having thicknesses of 2 mm and 8 mm, 16 mm and 24 mm respectively. The distance between the two electrodes is 4 mm. The ion wind drying time is 5 to 35 minutes with a time interval of 5 minutes with a 4 kV DC (Direct Current) voltage obtained a current of 20 mA. The DC voltage source is connected to a high voltage divider (SEW high voltage probe P20 P28), so the input voltage can be read by a digital voltmeter (CD772 Sanwa Made in Tokyo, Japan) with unit of kV.

The input voltage will flow in the 10 x 10 pairs of pin- three ring reactor systems resulting in the process of ionization and recombination between charges, electrons, and ions in the atmosphere. The ionization process of air in the space of electrode will produce an output current from pin electrode to three ring electrode that is measured using an analog multimeter (Sanwa YX360TRF, Sanwa Electric Instrument CO., LTD, Tokyo, Japan) with mA and an ionic wind which is move though hole beetween ring resulting in the reduction the concentration of water in the Sambiloto leaves (Pour., & Esmaeilzadeh, 2011) . and mass changes occur during the drying process.

For the ion wind drying scheme is shown in Figure 1.

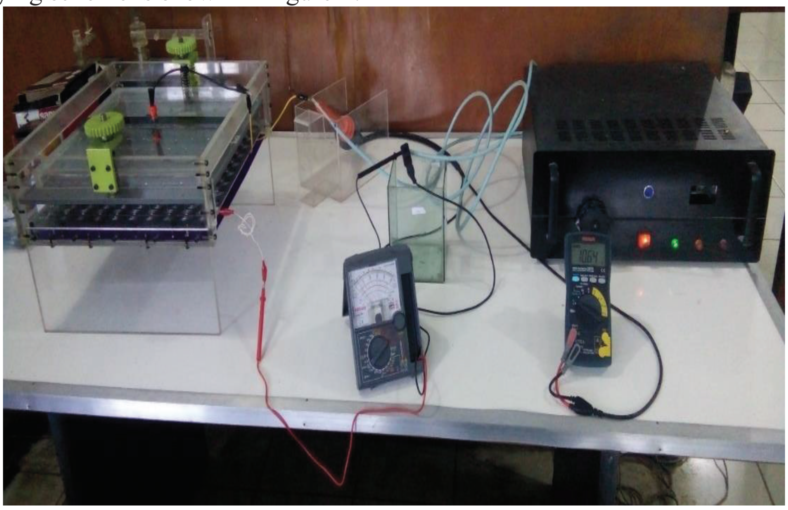

Figure 1. Scheme of research equipment series

2.2. Applications of HMS

The mass of Andrographis paniculate leaves was measured before and after drying for 30 minutes. The drying rate (DR) is calculated using Eq. (1) and expressed as db / minute.

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

Where, Δm is the difference in mass after and before drying(db), Δt is the difference in time after and before drying $(minutes)$.

2.3. Shrinkage

Depreciation on potato slices is affected by the condition of the initial moisture content in the sample (100%) at each mass difference in the sample slices dried. Depreciation can be calculated using equation (2) and expressed as (%).

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

Where, Δm is the difference in mass after and before drying(db), m_0 is the mass before drying(db)

2.4. Moisture Content

The water content in the potato slices is different after drying EHD, with an initial humidity of 46.6%. The moisture content of the sample slices can be calculated using equation (3) and expressed as (% db).

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

Where, Δm is the mass difference after and before drying(db), m_0 is the mass before drying (db) .

2.5. The Specific Energy Consumption

Specific Energy Consumption is determined from the electric power supplied (kW) and the drying rate (kg/s) on potato slices which can be calculated in equation (4) as (kJ/gr).

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

Where, Δm is the mass difference after and before drying (db), Δt is the time difference after and before drying (minutes), V is the input voltage (kV),and I is the current output (mA)[..

3. Result and Discussion

3.1 Voltage Current Characterization

Current and voltage characterization curves on bitter leaf drying are shown in Figure 2.

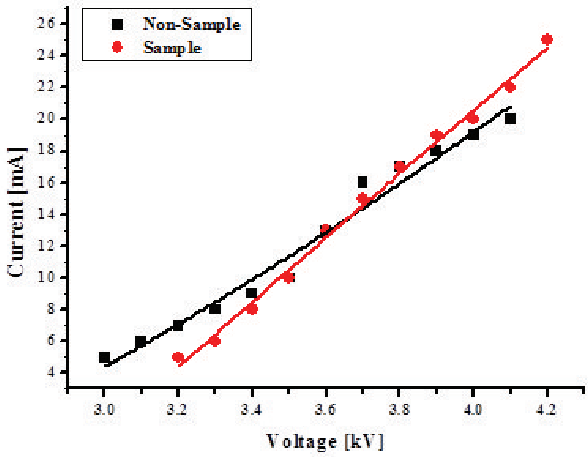

Figure 2. Current and voltage characterization curve\

Figure 2 shows that the current increases with increasing input voltage when there are with sample and with out samples were drained. this is due to the presence of ionized strong electric fields (Sumariyah, Kusminarto, Nuswantoro, & Rahmanto, 2016). The ionization process at 4 kV produces an increase in the electric field and heat transfer (Martynenko, & Kudra, (2016). resulting in the evaporation of the mass of water and an increase in the current formed.

3.2 Voltage Current Characterization

Drying the bitter leaf with time variation of 5-35 minutes with a time interval of 5 minutes at a voltage of 4 kV obtained the level of drying in Figure 3.

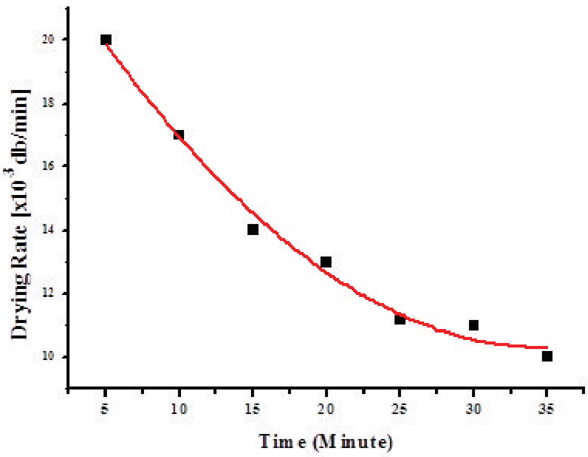

Figure 3. Curve rate of bitter leaf drying

Figure 3 shows that the drying rate decreases with increasing time allotted. At the 35th minute the smallest drying rate is 10 x 10^{-3} db/min, this is due to the longer ionization process which will reduce the drying rate in the sample and increase the reduction in mass in the bitter leaf (Pertiwi & Susanto, 2014).

3.3 Shrinkage

The process of drying the “bitter leaf” of Andrographis paniculate, shrinkage will occur as shown in Figure 4.

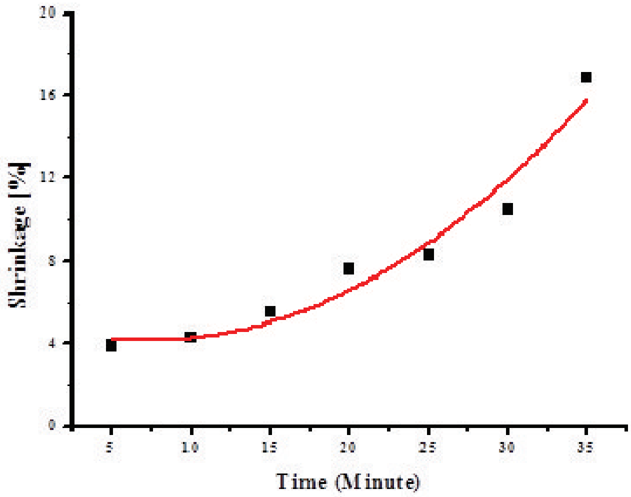

Figure 4. Curvature curve of bitter leaf

Figure 4 shows that, shrinkage increases with increasing drying time. The same shrinkage also was founded evolution during drying of tropical fruits (Talla, Puiggali, Jomaa ,& Jannot, 2004). This is due to the osmosis process that lasts a long time and heat transfer which results in damage to cell walls in the sample (Hashinaga, Bajgai, Isoble, & Barthakur, 1999). In minutes 35th the highest mass depreciation was 16.9%

The graph in Figure 4 shows that weight shrinkage is a function of second order polynomials as a function of ion wind exposure time.

3.4. The Specific Energy Consumption

The specific energy consumption is defined as amount of energy needed to evaporate unit mass of water in $kJ \cdot kg^{-1}$. To calculate the value the specific energy consumption of the bitter leaf of each drying treatment for multiple needles-to-plate electrode under AC electric field. In Figure 5 shows the value of Specific

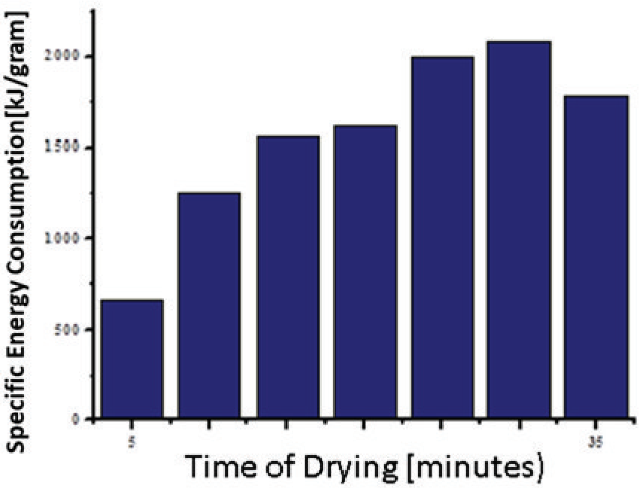

Figure 5. Energy efficiency Curve

In Figure 5 shows, the Energy Efficiency value increases with the increasing time given (Cao, Nishiyama, & Koidel, 2004), but in the 35th minute, there is a decrease of 1783 kJ/gram caused by the diffusion process. The diffusion process causes the water content towards the surface of the sample again because of the difference in concentration from high to low and a decrease in the electron produced (Dinani, Havet, Hamdami, & Shahedi, 2014).

4.Conclusion

Ion wind drying can be used for drying bitter leaves. The resulting current will increase with the increasing voltage applied to the dryer system both without samples and with samples. Ion wind drying at 4 kV produces a current of 20 mA. The drying rate decreases as increasing drying time. Shrinkage and energy efficiency increases with increasing drying time. The most optimal drying time is the 30th minute, it is found that the degree of drying is 11 x 10^{-3} db/min, shrinkage of 10.5 % and energy specific consumption of 2086 kJ/ gram.

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