DESIGN OF THE EXPERIMENTAL DRYER FOR MEDICAL & AROMATIC PLANTS

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Abstract

Today, the importance of keeping agricultural plants by means of drying is getting increase. Many research studies have been carried out on the development of drying techniques and drying characteristics of agricultural plants. In recent years, increase of usage in health and aroma therapy applications caused to increase requesting of these agricultural materials. The keeping of colour, flavour and essential oil is of great importance during drying process of medical and aromatic plants and it has priority. Based on this information, the relationships amongst the temperature and humidity level of drying air, drying speed, drying duration should be stated in most proper way.

The basic research studies on developing of drying technologies of medical and aromatic plants are priority fields. In this study, an experimental dryer having monitoring abilities for temperature, humidity and drying period of medical and aromatic plants was developed. The data gained through the laboratory experiments was evaluated and performance of experimental dryer is given.

Keywords

medical plants, experimental dryers, drying technology

Introduction

Today, the importance of keeping agricultural plants by means of drying is getting increase. Many research studies have been carried out on the development of drying techniques and drying characteristics of agricultural plants. In recent years, increase of usage in health and aroma therapy applications caused to increase requesting of these agricultural materials. The keeping of colour, flavour and essential oil is of great importance during drying process of medical and aromatic plants and it has priority. Based on this information, the relationships amongst the temperature and humidity level of drying air, drying speed, drying duration should be stated in most proper way.

Around the world, there is a remarkable increase in the consumption and usage of all kind of dried agricultural products (Reynolds, 1997). Turkey is one of the ten big producer of more than 20 agricultural products around the world even the biggest producer of some of them. Turkey supplied 36.3% of dried grape demand of the world with 300 thousand tons in 2008 (TUIK, 2010). Also in 2007, Turkey supplied 39.7% of dried fig demand of the world (TUIK, 2010). However these numbers are different in medical and aromatic products and the drug industry. Even Turkey exports these wet or dried agricultural products, unfortunately has not become the drug producer of these products yet.

For this purpose, the basic research studies on developing of drying technologies of medical and aromatic plants are priority fields. In this study, an experimental dryer having monitoring abilities for temperature, humidity and drying period of medical and aromatic plants was developed. The data gained through the laboratory experiments was evaluated and performance of experimental dryer is given in this study.

Design of experimental dryer

In order to estimate the essential parameters of dried medical and aromatic products, an experimental dryer system designed and produced. This dryer has the ability of electronically control of drying temperature and drying rate.

System consists of an electrical resistance dryer, 4 caged and continuously weighting and data accusation (Figure 1). There are 4 drying shelves having 1 m^2 capacity and located in each of the separate drying cage for experimental repetition purposes. Air heated by the electrical resistance is forced to move to the shelves from bottom by the fan. Drying shelves have independent air outlets and dryer connected to the mixing room which is located behind of the dryer system. In this outlet air capacity and velocity of the dryer are controlled manually by changing diameter of the outlet pipe with the help of clap. Moreover, dryer has property of mixing fresh air with the interior drying air.

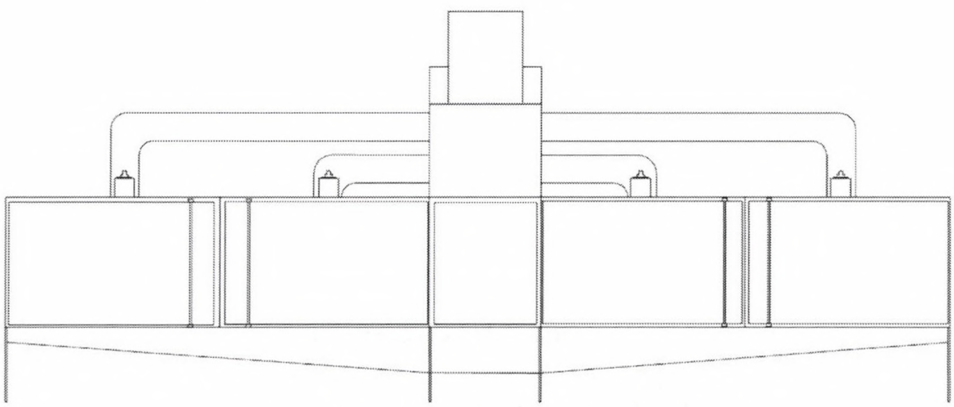

Figure 1. Schematic front view of the experimental dryer


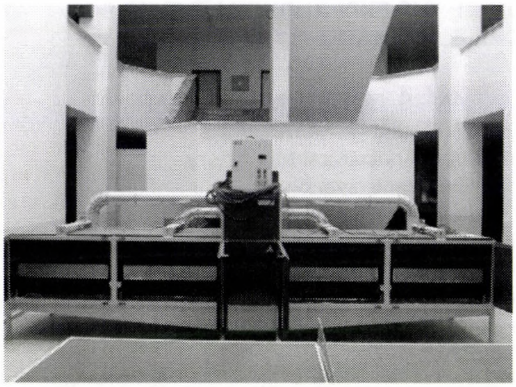

Figure 2. Outer view of the experimental dryer


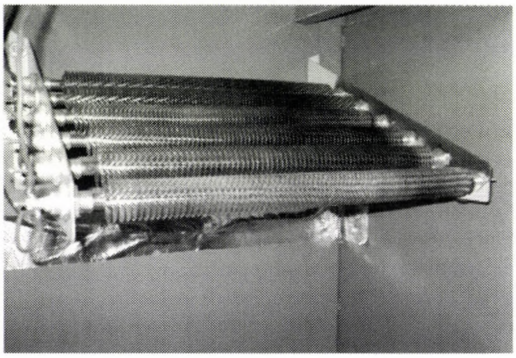

Figure 3. Shelf and heater of the experimental dryer

Micro-data loggers are located in different places in the dryer system. These data-loggers record the temperature, relative humidity and light luminance in chosen time interval continuously. Electronic drying temperature control system has the accuracy of 0.1°C between 30-60°C. Inlet air velocity is controlled by single and common clap, but outlet air velocities are controlled by four different claps for each outlet pipe, and also these four pipes attached to a main outlet pipe which has another clap. In this way; air velocity in the system can be controlled separately for each shelf or four of them together. In order to calculate drying curve exactly, each shelves weighted continuously with load-cell having accuracy as 1g. All these recorded data inputted and processed by MATLAB software.

Experimental drying system has 10 measurement points (Figure 4): 1 fresh air inlet, 1 common air outlet and 4 shelf inlets (located bottom of the shelf) and 4 shelf outlet (located in the shelf or in the pipe of shelf outlets).

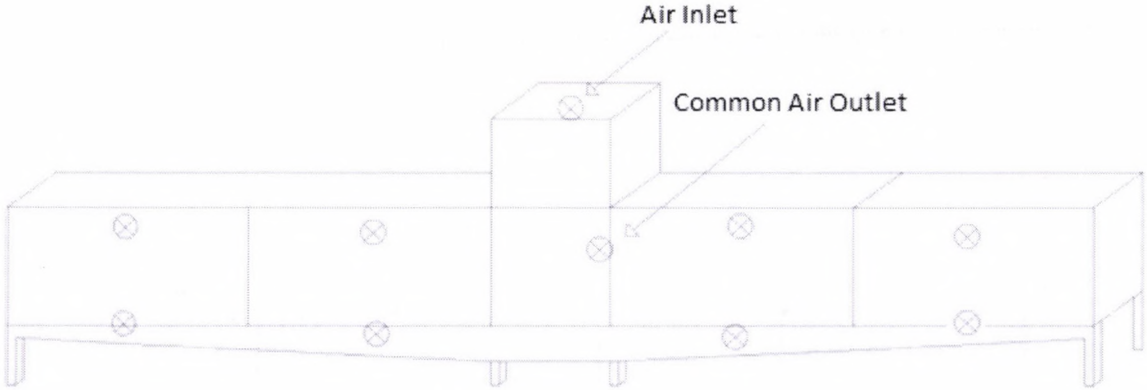

Figure 4. Measurement points

Experimental dryer system tested with Rosa damascane (Figure 5) in different drying temperature (30-50°C) and also other medical and aromatic plants such as Lavender.

Figure 5. Rosa damascane before and after drying

Drying characteristics of agricultural products

Moisture content of agricultural products is calculated by two different methods based on wet base and dry base (Greig, 1970; Molnar, 1995; Öztekin and Soysal, 1998). Moisture content based on dry matter (X_{DB}) is calculated by dividing moisture content of product (m_M) to dry matter of product (m_{DM}) (Equation 1).

$$X_{DB} = \frac{m_M}{m_{DM}} \quad 1$$

Moisture content based on wet matter (X_{WB}) is calculated by dividing moisture content of product (m_M) to total mass of product (m) (Equation 2).

$$X_{WB} = \frac{m_M}{m} \quad 2$$

By using the relation of different values of X_{DB} and X_{WB} with respect to time drying curves are plotted in order to see end of drying. Figure 6 represents an example graph of drying characteristics of Rosa damascene in 41°C.

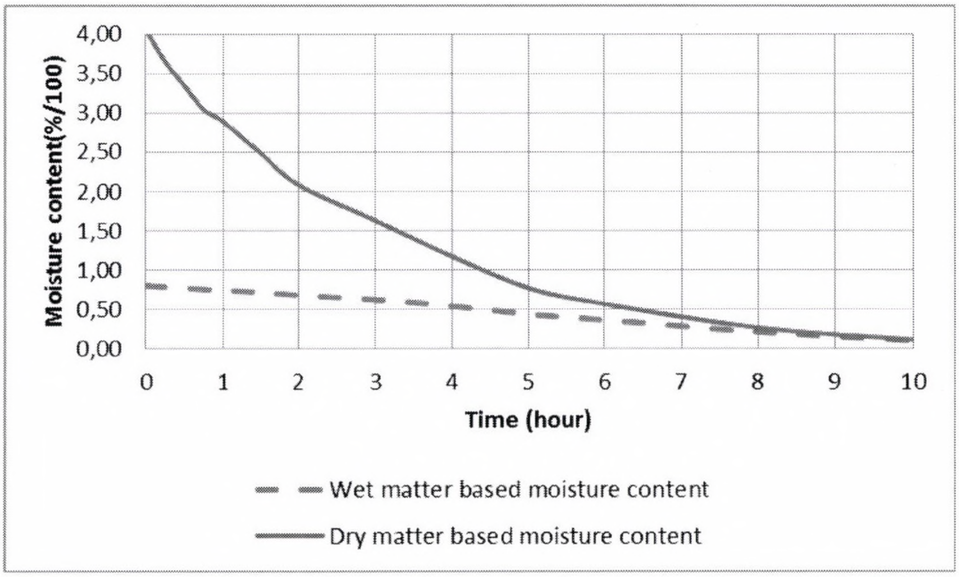

Figure 6. Drying Curves of Rosa damascene in 41°C

Also by using these drying curves, drying ratio and drying phases could be calculated. There are three phases of drying; first one is the heating and constant drying phase, second one is the decreasing drying phase and the last is the equilibrium phase (Krischer, 1963; Soysal and Öztekin, 1999; Soysal and Öztekin, 2001).

Drying ratio is also an important and commonly used parameter in drying calculations. Average drying ratio (g_{mean}, kg/m²h) is calculated by using slope of dry matter based moisture content (Equation 3) (Yagcıoglu, 1996).

$$g_{mean} = \frac{m_{Lost}}{F \cdot t} \quad 3$$

Where F (m²), is the unit drying space, t (hour) is the time and mLost is the moisture loss. Drying ratio can be plotted according to time and also % moisture content (Demir and Günhan, 2002).

Discussion and conclusions

After many experiments conducted on different medical and aromatic plants in different temperatures, it is shown that designed experimental drying system is capable to estimate optimum drying parameters and conditions mentioned. This system is capable to adjust velocity of drying air for each cage, and by this way different drying ratios in same temperature are obtained. By monitoring drying phases, end of drying (equilibrium phase) can be automatically achieved. However; in different drying air velocities, weight error is occurred. Dynamic average value method is applied to minimize the weight error.

To conclude, this developed experimental drying system for medical and aromatic plants through R&D studies is proved itself, when monitoring and automation, advanced accuracy of the device considered.

References

1. Demir, V. and Günhan, T. (2002), Tarım Ürünlerinin Kuruma Karakteristik Değerlerinin Belirlenmesi, Tarım Ürünleri Kurutma Tekniği Çalıştayı, İzmir.

2. Greig, D. J. (1970). The Determination of the Rate Constant in Thin Layer Drying of Agricultural Crops, Journal of Agricultural Engineering Research, 15 (2), 106-110.

3. Krischer, O. (1963), Die wissenchaftlichen Grundlagen der Troccknungstechnik, Bd. I, Springer Verlag, Berlin.

4. Molnar, K. (1995), Experimental Techniques in Drying In: Handbook of Industrial drying (Edited by Mujumdar A S), Second Edition, Marcel Decker, Inc., 270 Madison avenue, New York 10016, 1, 41-70.

5. Öztekin, S. and Soysal, Y. (1998), Tarım Ürünlerini Kurutma Tekniğine Giriş, Çukurova Üniversitesi Ziraat Fakültesi Tarım Makinaları Bölümü, Adana.

6. Reynolds, S. (1997). Drying fruits and vegetables. Athens, GA: University of Georgia, Cooperative Extension Service.

7. Soysal, Y. and Öztekin, S. (1999), Equilibrium Moisture Content Equations for some Medicinal and Aromatic Plants. Journal of Agricultural Engineering Research, 74 (3), 317-324.

8. Soysal, Y. and Öztekin, S. (2001), Comparison of seven Equilibrium Moisture Content Equations for some Medicinal and Aromatic Plants. Journal of Agricultural Engineering Research, 78 (1), 57-63.

9. Turkish Statistical Institute (TUIK). (2010). Crop Production Statistics. Retrieved from http://www.tuik.gov.tr/bitkiselapp/menu_ing.zul

10. Yağcıoğlu, A. (1999), Tarım Ürünleri Kurutma Tekniği, Ege Üniversitesi Ziraat Fakültesi yayınları, İzmir, No: 5536.