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Basil Drying Performance and Quality under Different Drying Systems

E.G. Khater and A.H. Bahnasawy
Agricultural and Biosystems Engineering Dept., Faculty of Agriculture, Benha Univ., Benha, Egypt
E-Mail: alsayed.khater@fagr.bu.edu.eg

Abstract

The main aim of this study is to investigate the possibility of drying the basil plants under five different drying systems. The obtained results indicated that the accumulated weight losses of basil plants were 77.43, 74.00, 70.48, 74.92 and 77.99 %, for sun-drying system, shadow-d rying system, room-drying system, solar-drying system and oven-drying system, respectively at the end of experimental period. The highest values of equilibrium moisture contents were 13.94 and 37.01 % at 10 and 90 % equilibrium relative humidity was found from Modified Chung-Pfost equation under room system. The lowest values of equilibrium moisture contents were 0.83 and 15.07 % at 10 and 90 % equilibrium relative humidity was found for modified Oswin equation for oven system. The basil oil content values were 5.918, 7.911, 8.472, 6.547 and 5.230 % for the sun-drying, shadow-drying, room-drying, solar-drying and oven-drying, respectively.

Keywords: Basil, Sun-drying, Solar-drying, Oven-drying, Equilibrium moisture content, Oil content

1. Introduction

Medicinal and aromatic plants are cultivated in all over the world particularly in Egypt for both local consumption and export. The sweet basil is one of the most important aromatic plants in Egypt. Its area is about 5050.6 feddans, producing about 9031.82 ton/year from green plants and 135.46 ton essential oil [1].

Basil (Ocimum basilicum L.) belong to the family Lamiaceae is an annual, herbaceous, white to purple flowering plant, 20–60 cm tall, that originated in Iran and India [2 and 3]. Sweet basil is a popular culinary herb and its essential oil has been used for many years to flavour foods, as an ingredient of dental and oral health care products and in fragrances [4]. The areil parts, especially leaves of sweet basil are widely used to enhance the flavor of foods such as salads, pasta, tomato products, vegetables, pizza, meat, soups, marine foods, confectioneries and often products [3 and 5]. In Iranian traditional medicine, the areil parts of the plant are perceived as a carminative, galactogogue, stomachic, and antispasmodic [6].

Drying is the most common and effective method that increases the shelf life of spicy herbs by inhibiting the growth of microorganisms and preventing the onset of some biochemical reactions that may alter the organoleptic and nutritional characteristics of the dried leaf. However, drying must be performed carefully in order to preserve the aroma, appearance and nutritional characteristics of the raw herbs as much as possible [7]. The drying may cause losses in volatilities or formation of new volatilities as a result of oxidation reactions, esterification reactions [8].

Moisture sorption isotherm defines the relation between Equilibrium Relative Humidity (ERH) and Equilibrium Moisture Content (EMC) [9]. This information is required for drying and storage of agricultural and food products, for instance to maintain the quality in the storage period. This knowledge is also required to stop the drying process at the aimed moisture content to avoid quality losses and to save energy [10].

EMC is defined as the moisture content of a hygroscopic material in equilibrium with an environment in terms of temperature and relative humidity. EMC of the product is the result of moisture exchange between the product and the air surrounding the sample. In this condition, the water in a product is in balance with the moisture in the surrounding atmosphere [11]. The relative humidity in this condition is known as the Equilibrium Relative Humidity (ERH) [9]. Moisture sorption isotherms are either measured during desorption (starting from the wet state) or during adsorption (starting from the dry state).

The herbal and medicinal plants are perishable. keeping their quality and prolonging the shelf life is required by drying them. Drying is performed using various methods namely sun, room, shadow, solar and oven drying, therefore, the main aim of this study to compare these drying methods and identify the most efficient one.

2. Materials and methods

The experiment was carried out at Agricultural and Bio-Systems Engineering Department, Faculty of Agriculture Moshtohor, Benha University, Egypt (latitude 30° 21` N and 31° 13` E). During the period of June and July, 2017 season.

2.1 Materials

The fresh basil was brought from the Faculty of Agriculture Farm, Moshtohor, Benha University.

2.1.1 Drying systems

The basil was dried using different systems as follows:-

1- Sun-drying

Basil plants were folded into a thin sheet of paper and placed on a flat plate in direct sunlight.

Tray with a dimension of (0.8 m long, 0.6 m wide and 0.1 m high).

2- Shadow-drying

Basil plants were folded into a thin sheet of paper and placed on a flat plate (0.8 m long, 0.6 m wide and 0.1 m high) in shadow.

3- Room temperature-drying

Basil plants were folded into a thin sheet of paper and placed on a flat plate (0.8 m long, 0.6 m wide and 0.1 m high) in room was air-drying at ambient temperature.

4- Solar-drying

The solar dryer consists of solar collector, drying chamber, trolley and trays and fan/blower as shown in fig (1). The solar collector consists of three major components, namely: The glass cover has 12 sheets (2.0 × 2.0 m, 5.5 mm thickness). The reason for selecting this material is due to the structural thermal properties. The absorber plate, (corrugated black aluminum plate). The insulation, (thermal wool with a 5.0 cm thickness). The drying chamber has a length of 2.5 m, width of 2.3 m and height of 2.6 m. It is made of galvanized steel (5 mm thickness). The trolley is made from stainless steel and has a length of 2.3 m, width of 1.1 m and height of 2.4 m. It is designed in such a way that it allows easy insertion of individual trays at a distance of 0.2 m apart and has tires for easy movement of trays. The trays are made of stainless steel and have a length 1.1 m, width 0.74 m and depth of 0.03 m. They have perforated bottom which allows heated air to pass through products. Two air blowers (Model C.C.P. Parma – Flow Rate 720 m3 h-1 – RPM 2800 – Power 1.5 hp 380V 50Hz, Italy) for moving air in the drying chamber.

5- Oven-drying

Basil plants were spread evenly on baking sheets and placed in conventional laboratory oven (Fisher Scientific Isotemp Oven, Model 655F Cat. No. 13-245-655, Fisher Scientific, Toronto, Ontario, Canada).

2.2 Methods

Fresh basil was cleaned by removing undesired stems and waste materials and washed.

2.2.1 Treatments

Five different drying treatments were used to dry basil. The reported data are means of three replications for each treatment. In each replicate 5 kg of cleaned fresh basil was used.

1- Sun-drying

Basil plants were folded into a thin sheet of paper and placed on a flat plate in direct sunlight at an average temperature of 34.5 ± 1.0°C and relative humidity of 58.5 ± 2.0 %.

2- Shadow-drying

Basil plants were folded into a thin sheet of paper and placed on a flat plate in shadow at an average temperature of 31.0 ± 1.0°C and relative humidity of 69.5 ± 2.5 %.

3- Room temperature-drying

Basil plants were folded into a thin sheet of paper and placed on a flat plate in room was air-drying at ambient temperature at an average temperature of 29.0 ± 1.0°C and relative humidity of 58.0 ± 4.0 %.

4- Solar-drying

Basil plants were folded into a thin sheet of paper and placed on a flat plate in solar dryer at an average temperature of 46.0 ± 6.0°C and relative humidity of 40.0 ± 13.0 %.

5- Oven-drying

Basil plants were spread evenly on baking sheets and placed in conventional laboratory oven at temperature of 65°C.

2.2.1 Measurements

The mass was measured by electric digital balance (Model HG – 5000 – Range 0 - 5000 g ± 0.01 g, Japan) daily for sun, shadow and ambient air drying methods and hourly for solar and oven drying methods. Temperature and relative humidity were recorded by using a HOBO Data Logger (Model HOBO U12 Temp/RH/Light – Range -20 to 70 °C and 5 to 95% RH, USA) every hour. The content of oil was determined in basil plants according to [12]. In each method drying process was stopped when the weight became constant in two consecutive readings.

2.2.2 Calculations

Equilibrium moisture content

A number of equations have been suggested in literature to describe the relationship between equilibrium moisture content (EMC) and equilibrium relative humidity (ERH). The modified Henderson, modified Oswin and modified Halsey, modified Chung-Pfost and GAB equation [13] have been adopted by the American Society of Agricultural Engineers as standard equations for describing sorption isotherms [14]. We transformed the equations to get EMC as dependent variable and ERH as independent variable.

Modified Henderson

$$EMC = \left(-\frac{1}{C_1 (T + C_2)} \ln(1 - ERH) \right)^{1/C_3} \quad (1)$$

Modified Halsey

$$EMC = \left(\frac{-\exp(C_1 + C_2 T)}{\ln(ERH)} \right)^{1/C_3} \quad (2)$$

Modified Oswin

$$EMC = (C_1 + C_2 T)\left(\frac{ERH}{1-ERH}\right)^{1/C_3} \quad (3)$$

Modified Chung-Pfost

$$EMC = \frac{1}{C_1}\ln\left(\ln(ERH)\frac{(C_2 - T)}{C_3}\right) \quad (4)$$

GAB equation

$$EMC = \frac{C_1 C_2 C_3 (ERH)}{[1 - C_2(ERH)][1 - C_2(ERH) + C_2 C_3 (ERH)]} \quad (5)$$

Where:

ERH is the equilibrium relative humidity,%

T is the temperature, °C

C_1, C_2 and C_3 are the constants

The parameters C_2 and C_3 in the GAB equation are correlated with temperature using the following equations [15]:

$$C_2 = C_4 \exp\left(\frac{C_6}{RT_a}\right) \quad (6)$$

$$C_3 = C_5 \exp\left(\frac{C_7}{RT_a}\right) \quad (7)$$

Where:

C_4, C_5, C_6 and C_7 are coefficients

T_a is the absolute temperature, K

R is the universal gas constant, R=8.314 kJ/kmol K

Table (1) shows the coefficients for Henderson, Halsey, Oswin, Chung-Pfost and GAB equations of basil leaves for different drying systems.

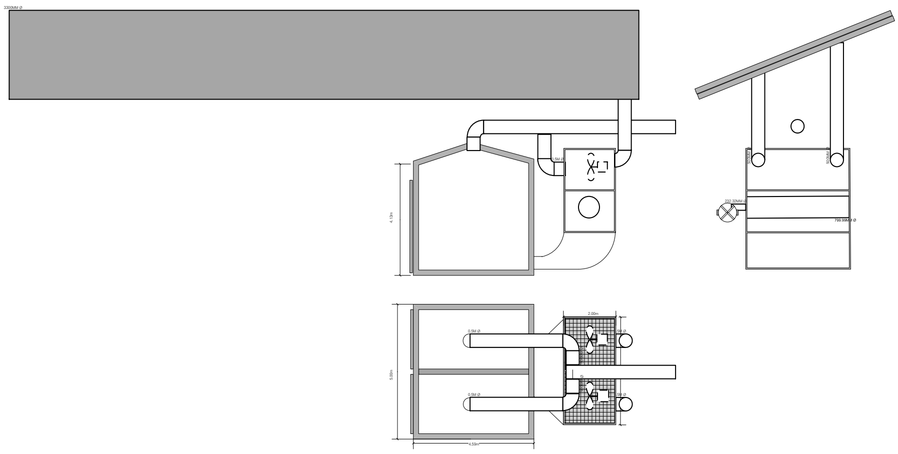

Fig (1) Elevation, plan and side view for the solar dryer.

Table (1) The coefficients for Henderson, Halsey, Oswin, Chung-Pfost and GAB equations of basil leaves for different drying systems [16].

Coefficient	Equation				
	Henderson	Halsey	Oswin	Chung-Pfost	Gab
C1	0.1151	-3.235	0.156	13.37	0.049
C2	65.15	-9.62×10^{-3}	-8.20×10^{-4}	13.27	
C3	1.387	1.499	2.053	234.27	
C4					0.652
C5					1.74×10^{-3}
C6					997.96
C7					25000

3. Results and discussion

3.1 Weight loss

Fig (2 and 3) show the accumulated weight loss of basil plants that dried under different drying systems (sun-drying, shadow-drying, room temperature-drying, solar-drying and oven-drying) at different drying air temperature and relative humidity during experimental period. The results indicate that the accumulated weight loss of basil plants increases with increasing drying period. It could be seen that the accumulated weight loss of basil plants increased from 35.52 to 77.43 %, when the drying period increased from 1 to 6 days at drying air temperature ranged from 34.16 to 35.24°C and relative humidity ranged from 55.51 to 60.01 % for sun-drying system.

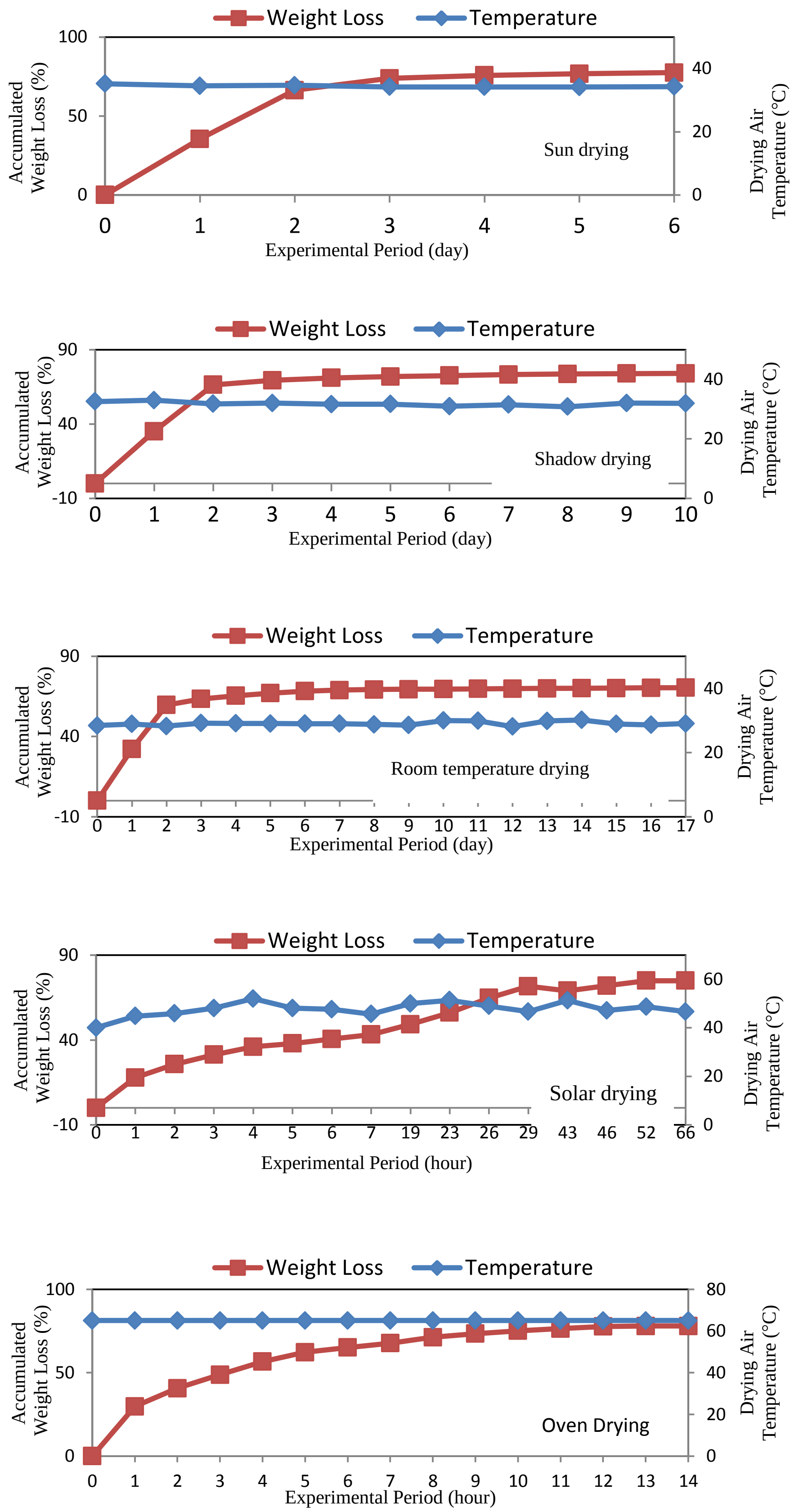

Fig (2) The accumulated weight loss of basil plants at different drying systems at different drying air temperature during experimental period.

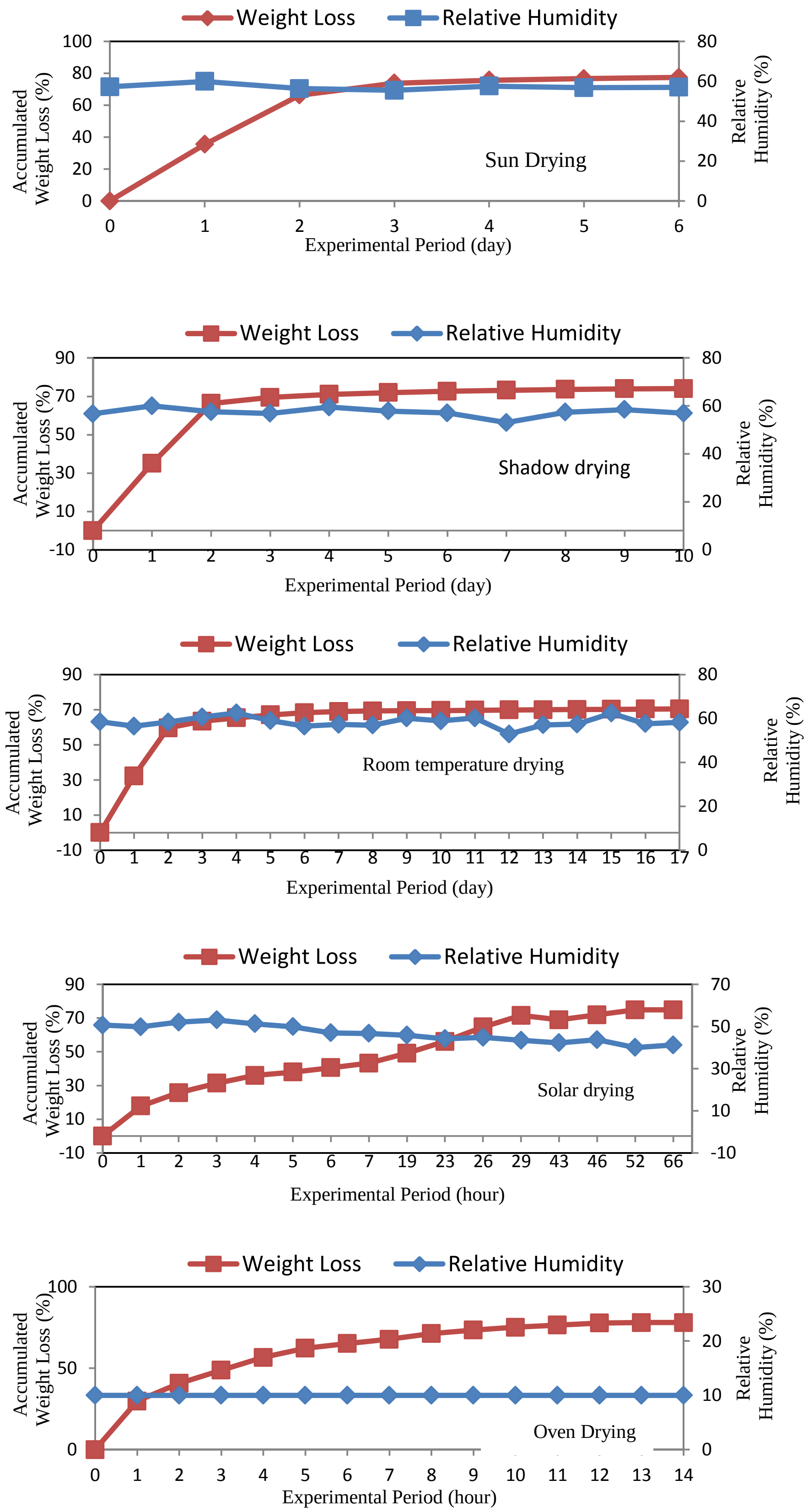

Fig (3) The accumulated weight loss of basil plants at different drying systems at different relative humidity during experimental period.

For shadow-drying system, the accumulated weight loss of basil plants increased from 35.06 to 74.00 %, when the drying period increased from 1 to 10 days at drying air temperature ranged from 30.82 to 32.99°C and relative humidity ranged from 53.71 to 60.02 %. For room temperature-drying system, the accumulated weight loss of basil plants increased from 32.32 to 70.48 %, when the drying period increased from 1 to 17 days at drying air temperature ranged from 28.24 to 30.18°C and relative humidity ranged from 52.93 to 62.46 %. For solar-drying system, the accumulated weight loss of basil plants was increased from 17.82 to 74.92 %, when the drying period increased from 1 to 66 hours at drying air temperature ranged from 40.01 to 52.00°C and relative humidity ranged from 40.07 to 53.09 %. For oven-drying system, the accumulated weight loss of basil plants was increased from 29.85 to 77.99 %, when the drying period increased from 1 to 14 hours at drying air temperature was 65°C and relative humidity was 10.0 %.

The results also indicate that the shorter drying period (14 hours) was occurred under the oven-drying system due to the higher temperature (65°C) and lower relative humidity (10 %). Meanwhile, the longer drying period (17 days) was occurred under the room temperature-drying system due to the lower temperature (28.24 to 30.18°C) and higher relative humidity (52.93 to 62.46 %). The results show the highest rate of weight loss was occurred at the first and second days under the sun-drying, shadow-drying and room temperature-drying systems. It could be seen that the weight losses were 35.52 and 30.83, 35.06 and 31.27 and 32.32 and 27.35 % for sun-drying, shadow-drying and room temperature-drying systems, respectively.

3.2 Equilibrium moisture content

Fig (4) shows the equilibrium moisture content of basil plants for different drying systems (sun-drying, shadow-drying, room temperature-drying, solar-drying and oven-drying) and different equation models (modified Henderson, modified Halsey, modified Oswin, modified Chung-Pfost and Gab models).

The results indicate that the equilibrium moisture content of basil plants increases with increasing equilibrium relative humidity for different drying systems. It could be seen that the equilibrium moisture content of basil plants was increased from 3.39 to 31.42, 3.47 to 32.04, 3.54 to 32.72, 3.1to 28.73 and 2.80 to 25.92 % for sun, shadow, room temperature, solar and oven drying systems, respectively, when the equilibrium relative humidity increased from 10 to 90 % for modified Henderson equation. For modified Halsey equation, the EMC of basil plants was increased from 5.31 to 41.55, 5.40 to 42.27, 5.50 to 43.03, 4.88 to 38.18 and 4.36 to 34.16 % for sun, shadow, room temperature, solar and oven drying systems, respectively, when the equilibrium relative humidity increased from 10 to 90 %. For modified Oswin equation, the EMC of basil plants was increased from 1.30 to 15.32, 1.80 to 15.34, 2.48 to 15.36, 1.03 to 15.21 and 0.83 to 15.07 % for sun, shadow, room temperature, solar and oven drying systems, respectively, when the ERH increased from 10 to 90 %. For modified Chung-Pfost equation, the EMC of basil plants was increased from 11.72 to 34.79, 12.72 to 35.78, 13.94 to37.01, 8.11 to 31.18 and 5.06 to 28.13 % for sun, shadow, room temperature, solar and oven drying systems, respectively, when the ERH increased from 10 to 90 %. For GAB equation, the EMC of basil plants was increased from 4.15 to 36.66, 4.24 to 37.51, 4.33 to 38.47, 3.70 to 33.10 and 3.07 to 29.61 % for sun, shadow, room temperature, solar and oven drying systems, respectively, when the ERH increased from 10 to 90 %.

The results indicated that the highest value of equilibrium moisture content was found from Modified Chung-Pfost equation under room system. It could be seen that the equilibrium moisture contents were 13.94 and 37.01 % at 10 and 90 % equilibrium relative humidity for room temperature system. Meanwhile, the lowest value of equilibrium moisture content was found for modified Oswin equation for oven system. It could be seen that the equilibrium moisture contents were 0.83 and 15.07 % at 10 and 90 % equilibrium relative humidity for oven system.

3.3 Content of oil

Fig (5) shows the basil oil content for different drying systems (sun-drying, shadow-drying, room temperature-drying, solar-drying and oven-drying) at the end of experiment. It could be seen that the basil oil content values were 5.918, 7.911, 8.472, 6.547 and 5.230 % for the sun-drying, shadow-drying, room temperature-drying, solar-drying and oven-drying, respectively. The results indicate that the highest value of the basil oil content (8.472%) was obtained when the basil dried at room temperature system. Meanwhile, the lowest value of the basil oil content (5.230%) was found at the oven-drying system.

4. Conclusion

The experiment was carried out to study was conducted to investigate the possibility of drying the basil plants under different systems. The obtained results can be summarized as follows: The accumulated weight loss of basil plants increased from 35.52 to 77.43, 35.06 to 74.00, 32.32 to 70.48, 17.82 to 74.92 and 29.85 to 77.99 %, for sun-drying system, shadow-drying system, room temperature-drying system, solar-drying system and oven-drying system, respectively. The highest values of equilibrium moisture contents were 13.94 and 37.01 % at 10 and 90 % equilibrium relative humidity was found from Modified Chung-Pfost equation under room temperature system. The lowest values of equilibrium moisture contents were 0.83 and 15.07 % at 10 and 90 % equilibrium relative humidity was found for modified Oswin equation for oven system. The basil oil content values were 5.918, 7.911, 8.472, 6.547 and 5.230 % for the sun-drying, shadow-drying, room temperature-drying, solar-drying and oven-drying, respectively.

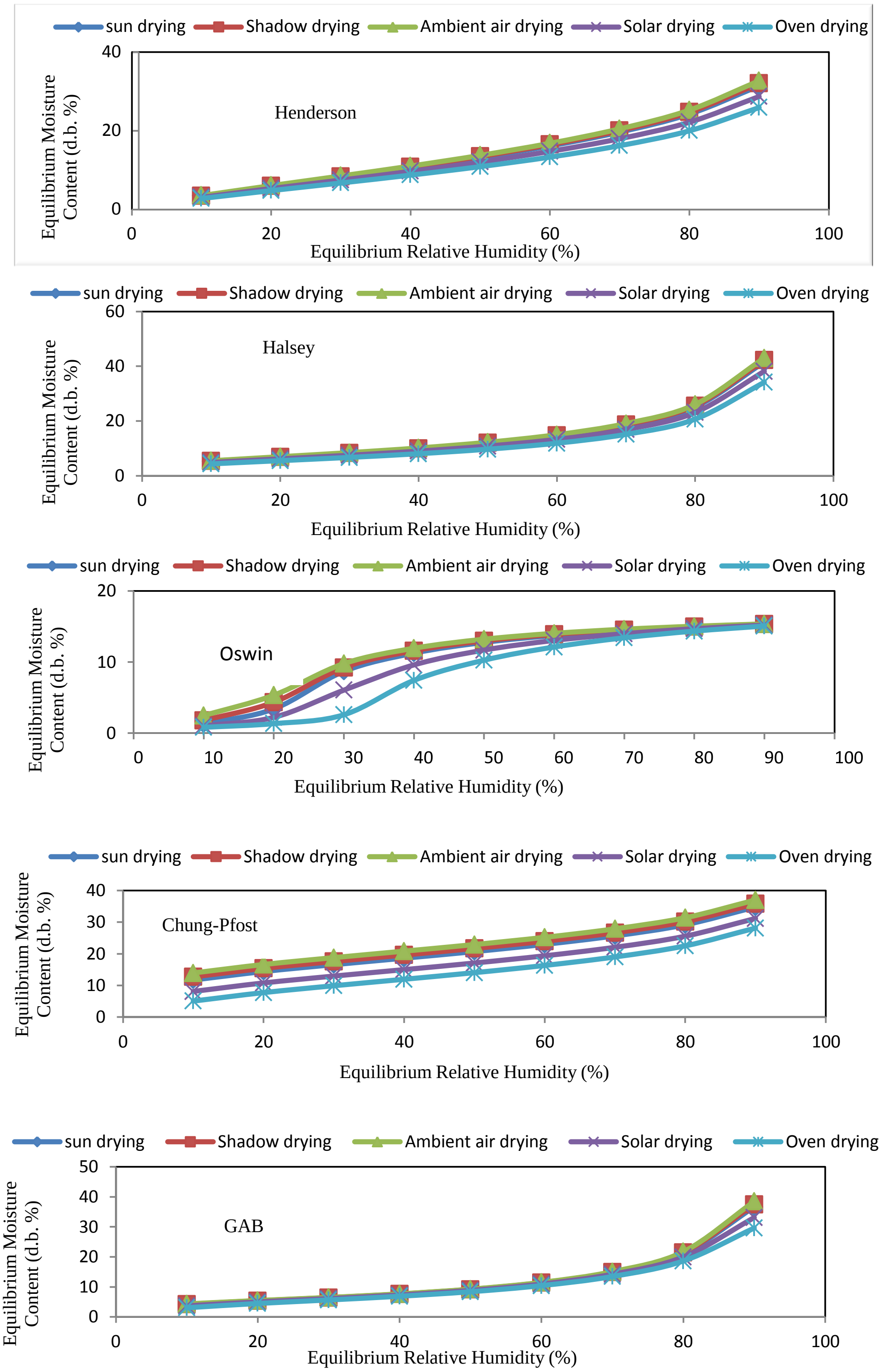

Fig (4) The equilibrium moisture content of basil plants.

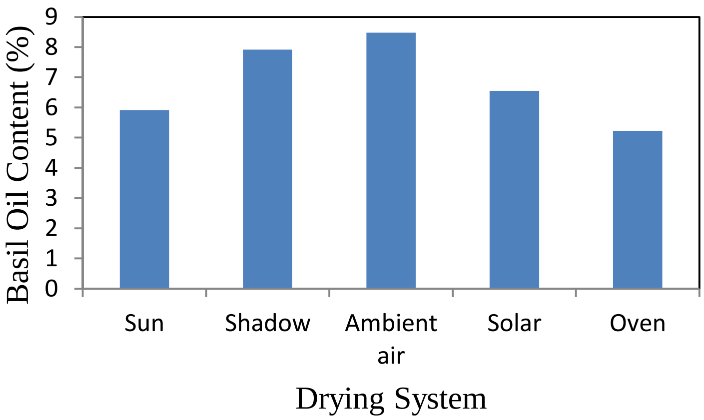

Fig (5) The basil oil content for different drying systems.

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