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EFFECT OF TEMPERATURE AND AIR RECIRCULATING RATE ON THE WEIGHT LOSSES OF MINT UNDER HYBRID SOLAR DRYING CONDITIONS

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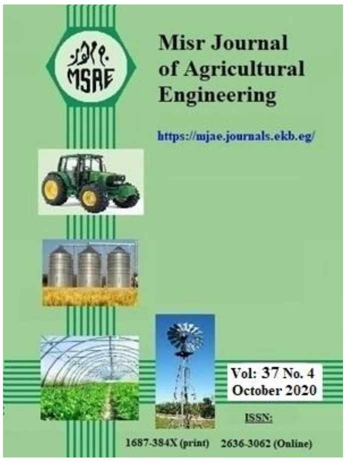

Keywords:
Mint, weight loss, moisture content, drying rate, costs

ABSTRACT

The main aim of this study is to study the effect of drying temperature and air recirculation percentages on the weight losses of mint, drying time, final moisture content and drying rate. Fresh basil was dried using different drying temperatures (50, 55 and 60 °C) and different air recirculating percentages (70, 80 and 90 %). Air temperature on the drying chamber, Weight losses, moisture content and drying rate were recorded. The obtained results indicated that the air temperature of the drying chamber ranged from 20 to 50, 13 to 55 and 18 to 60 °C for 50, 55 and 60 °C drying temperature, respectively. The accumulated weight loss of mint leaves increased from 79.93 to 80.10, 79.99 to 80.15 and 80.05 to 80.29 %, when the drying temperature increased from 50 to 60 °C, respectively, for 70, 80 and 90 % air recirculating. The moisture content of mint leaves ranged from 2.78 to 402.01, 0.80 to 404.02 and 1.61 to 408.13 % d.b. for 50, 55 and 60 °C drying temperature, respectively. The drying rate of mint leaves decreases with increasing drying temperature and air recirculating percentage. The total costs of dried mint decreased from 8.60 to 7.44, 9.73 to 8.03 and 10.91 to 8.85 L.E kg-1 of mint, when the air recirculating percentage increased from 70 to 90 %, respectively at 50, 55 and 60 °C drying temperature.

1. INTRODUCTION

Herbal plants cultivated in all over the world particularly in Egypt for both local consumption and export. Mint (*Mentha spicata L.*) is one of the most important medicinal and aromatic plants throughout the world. Mint is very popular in Mediterranean regions and represent a dominant part of the vegetation as a member of the Labiatae Family. The main component on mint is essential oil, its yield ranged from 0.62 – 1.70 % (g 100 g^{-1} of fresh matter) and from 0.1 – 1.8 % (g 100 g^{-1} of dry matter) **(Hussain *et al.*, 2010)**.

Drying is the most common and effective method that increases the shelf life of herbs which inhibit the microorganisms growth and preventing 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 **(Crivelli *et al.*, 2002 and Khater *et al.*, 2019)**. The drying may cause losses in volatilities or formation of new volatilities as a result of oxidation reactions, esterification reactions **(Diaz-Maroto *et al.*, 2002)**.

Solar drying systems must be properly designed in order to meet particular drying requirements of specific products and to give satisfactory performance with respect to energy requirements. Designers should investigate the basic parameters namely dimensions, temperature, relative humidity, airflow rate and the characteristics of products to be dried. However, full scale experiments for different products, drying seasons, and system configurations are sometimes costly and not possible. The development of a simulation model is a valuable tool for predicting of the performance of solar drying systems. Again, simulation of solar drying is essential to optimize the dimensions of solar drying systems and the optimization technique can be used for optimal design of solar drying systems **(Bala, 1998)**.

Hybrid solar dryer is a continued drying method in off sun shine hours by back up another source of heat energy or storage heat energy. For that reason, drying is completed without stopping and product is saved without spoilage by microbial infestation through adverse weather or off sunshine hours **(Hossain *et al.*, 2008)**. The worthy performance was remarked after the heat supply is added to the solar dryer through the time of low radiation **(Bennamoun and Belhamri, 2003)**. Changing attribute of solar radiation make storage indispensable for continuous the process of drying food **(Miller, 1983)**. Storage and supplementary source could be used to assess adjustment of solar energy to achieve the drying process temperature **(Singh *et al.*, 1983)**.

Ali et al. (2014) studied the influence of different drying air temperatures (40, 50 and 60°C) on drying rate. The initial drying rate was very high at all drying temperatures because high heat was supplied at high temperature due to which more evaporation took place. The drying process at all three temperatures, the drying rate decreased continuously and falling rate was not observed at any temperature, the drying time for oven 50 °C and oven 60 °C up to the constant moisture reading could be shortened by 28.12% and 75% respectively when compared to oven at 40 °C. The total time taken by moringa leaves to reach moisture contents of 4.77, 3.02 and 3.02% at temperatures of 40, 50 and 60 °C were 8, 5.75 and 2h respectively. The results further indicated that all three oven temperatures able to reduce moringa leaves temperature less than 5% that is favorable for further processing.

Temperature and air flow rate during are the most important factors affecting the product quality and shelf life after drying, therefore, the main aim of this work is to study the effect of drying temperature and air recirculation percentages on the weight losses of mint, drying time, final moisture content and energy consumption.

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 January and February, 2020 season.

2.1. Materials:

The fresh mint was brought from the Faculty of Agriculture Farm, Moshtohor, Benha University after harvesting for primary analysis.

2.1.1. Drying system description:

Figure (1) illustrates the solar drying system description. It shows the system which consists of solar collector, drying chamber, trays, blower and burner.

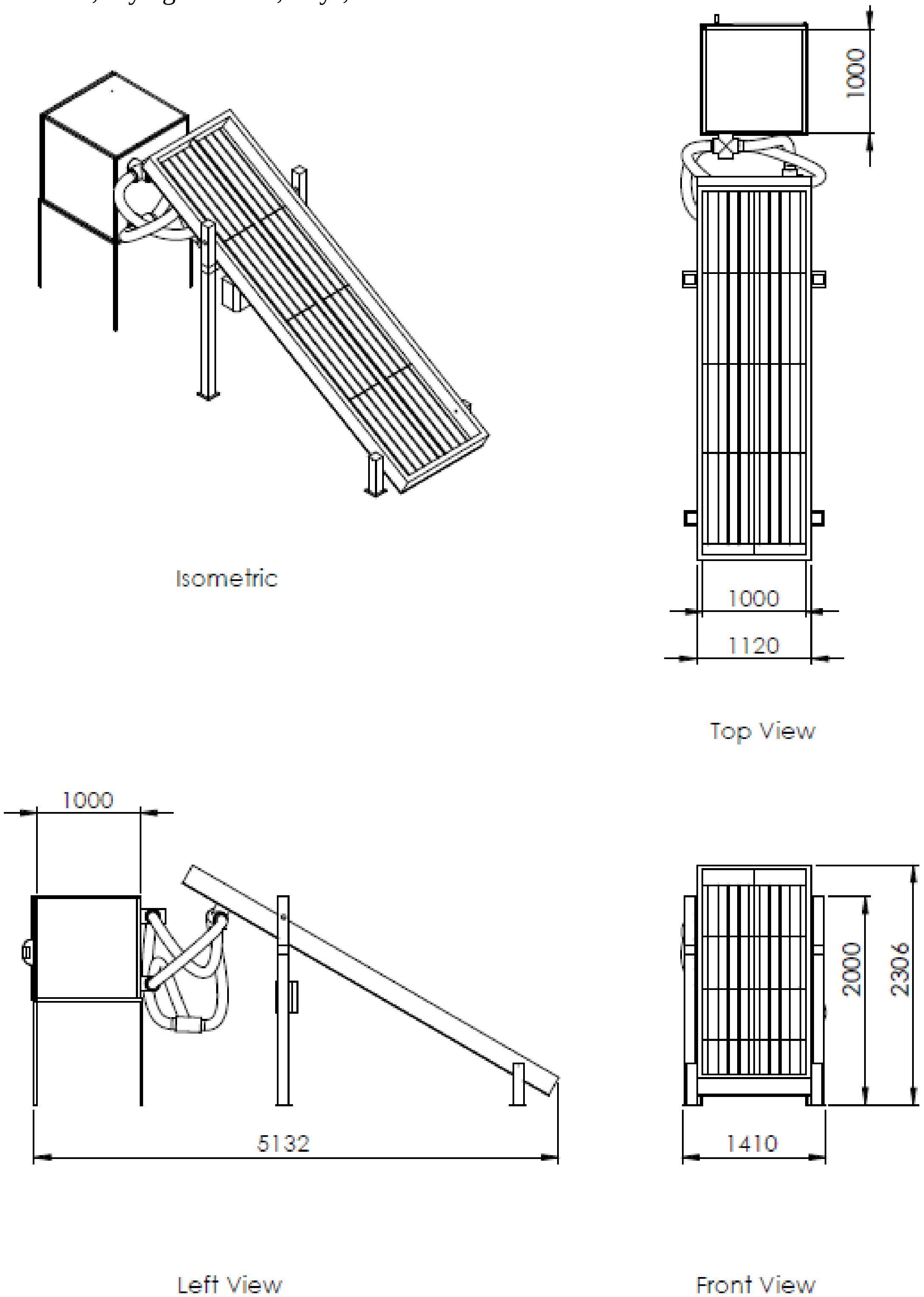

Figure (1): Elevation, plan and side view for the solar dryer.

1- The solar collector:

The solar collector consists of three major components, namely: The glass cover has dimensions of 4.0 m long, 1.0 m width and 5.5 mm thickness. The cover is fixed on a wooden frame with a thickness of 10 cm. It is divided into two lanes, 50 cm wide each. The absorber plate is made from corrugated black aluminum plate. The insulation is a thermal wool with a 5.0 cm thickness as shown in figure 2.

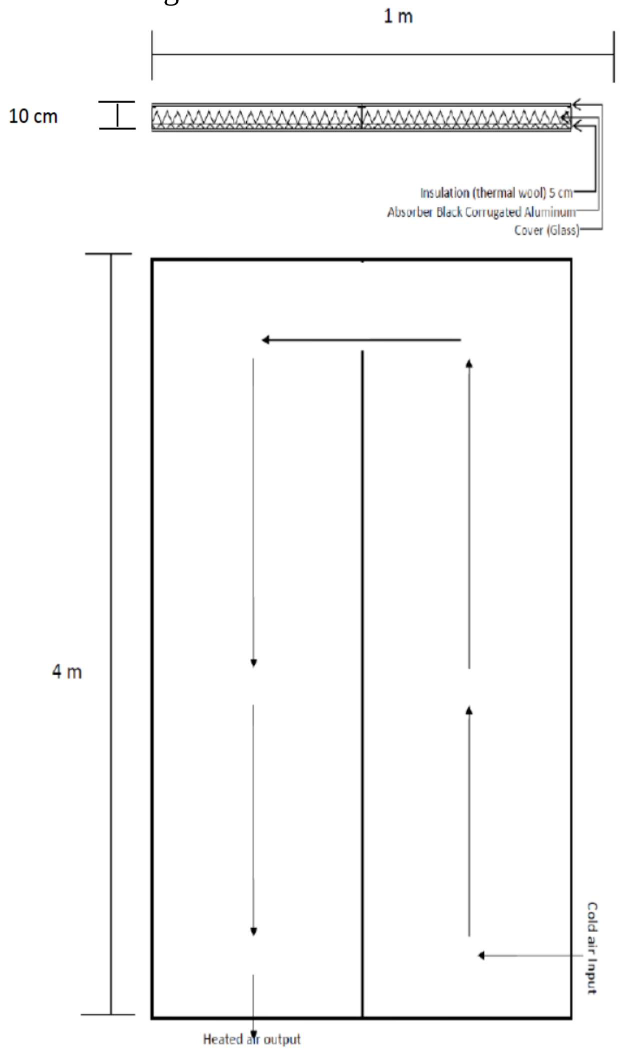

Figure 2: Solar collector.

2- The drying chamber:

The drying chamber has a length of 1.0 m, width of 0.75 m and height of 1.0 m. It is made of galvanized steel (5 mm thickness). The inner surface of drying chamber is covered an isolated materials to reduce heat loss from the walls as shown in figure 3.

3- The trays:

The trays are made of stainless steel and have a length of 0.90 m, width of 0.65 m and height of 0.25 m. They have perforated bottom which allows heated air to pass through products.

4- The blower:

Two air blowers were used to force and re-circulate the drying air to the drying chamber (Model C.C.P. Parma – Flow Rate 6.6 $m^3 h^{-1}$ – RPM 2800 – Power 150 W, 220V 50Hz, Italy).

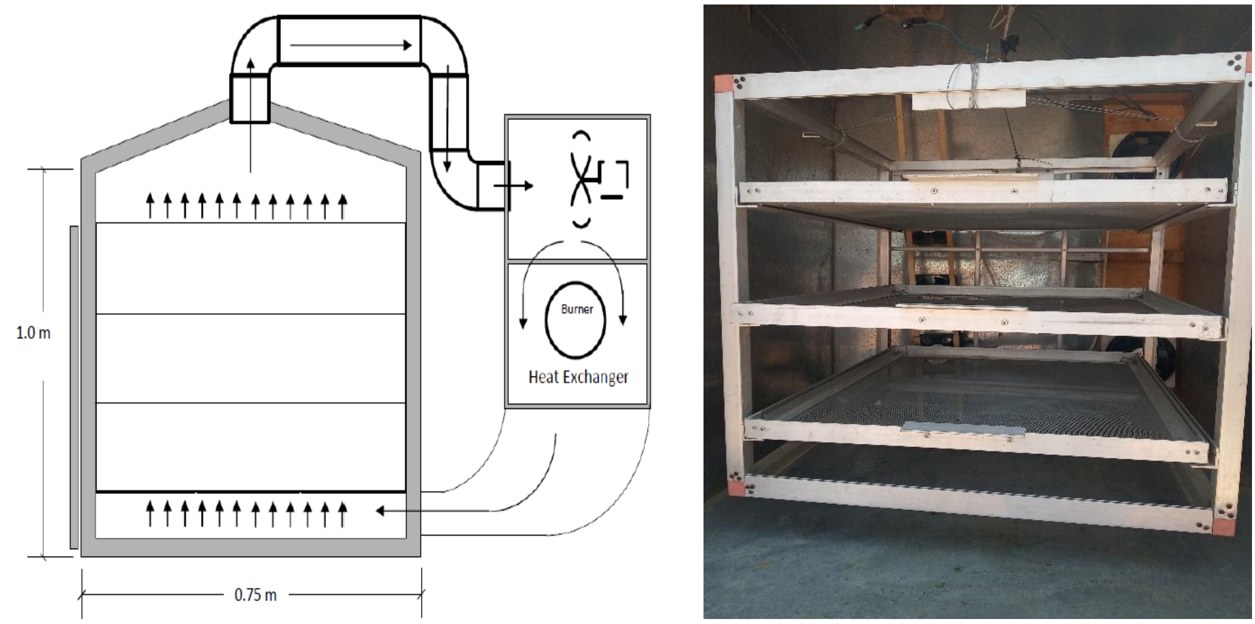

Figure 3: The drying chamber.

5- The burner:

The dryer uses a chamber burner system in which heat is being produced. The burner incorporates switches with a sparking mechanism that ignites the gas when it is fed from the gas bottle.

2.2. Methods:

Mint was cleaned by removing undesired stems and waste materials as shown in the process flow chart (figure 4).

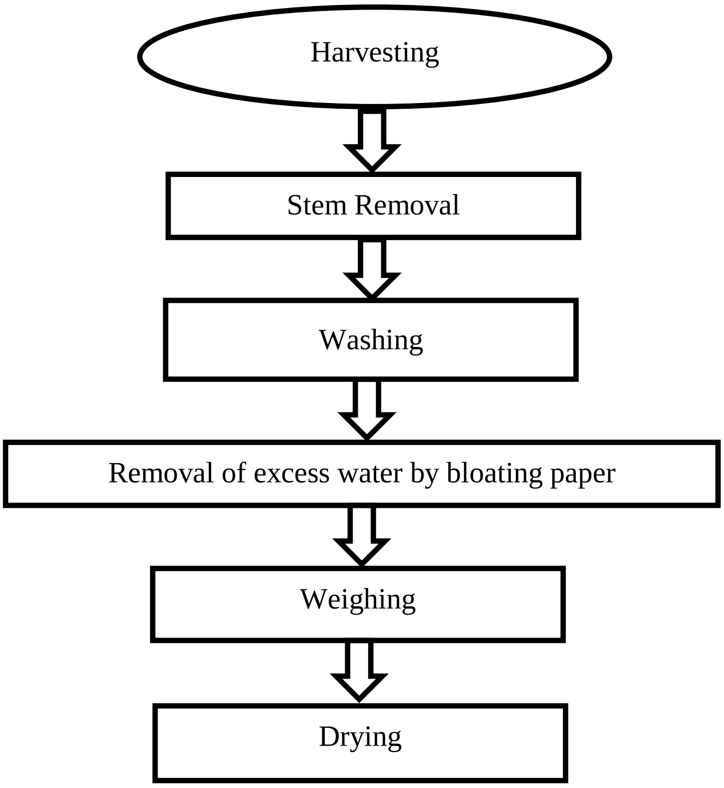

Figure (4): Flow chart of mint processing

2.2.1. Treatments:

In this study, the treatments include: three drying temperatures (50, 55 and 65 °C) and three air recirculation percentages were 70, 80 and 90 %. The experimental design was a split plot.

2.2.2. Measurements:

The mass was measured by electric digital balance (Model HG – 5000 – Range 0 - 5000 g ± 0.01 g, Japan) hourly for solar and hybrid solar 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. Fuel consumption will be recorded for propane fuel sources.

2.2.3. Calculations:

- Moisture content:

Moisture content of the fresh and dried mint leaves was determined using conventional laboratory oven kept at 105 °C until constant weight was reached. Triplicate determinations were made and the moisture content calculated as the following equation:

$$MC = \frac{M_{wet} - M_{dry}}{M_{dry}} \times 100 \qquad (1)$$

Where:

MC is the moisture content, % d.b.

M_{wet} is the wet mass of samples, g

M_{dry} is the dry mass of samples, g

- Drying rate:

The drying rate (DR) of mint was calculated using the following equation:

$$DR = \frac{M_{t+dt} - M_t}{dt} \qquad (2)$$

Where:

DR is the drying rate, ($kg_{water}/kg_{dry\ base}.hr$)

M_t is the moisture content at any time t, % d.b.

M_{t+dt} is the moisture content at t+dt, % d.b.

- Total Costs

The cost calculation based on the following parameters was also performed:

- Depreciation costs (D_c):

$$\eta = \frac{P_d - S_r}{L_d} \qquad (3)$$

Where:

Dc is the depreciation cost, LE $year^{-1}$.

P_d is the automatic feeder purchase price, 17000 LE.

Sr is the salvage rate ($0.1P_d$) LE.

Ld is the automatic feeder life, 5 year.

- Interest costs (In):

$$I_n = \frac{P_d + S_r}{2} \times \mathrm{i}_\mathrm{n} \qquad (4)$$

Where:

I_n is the interest, LE $year^{-1}$.

i_n is the interest as compounded annually, decimal. (12%)

- Shelter, taxes and insurance costs (Si):

Shelter, taxes and insurance costs were assumed to be 3 % of the purchase price of the automatic feeder (P_m).

Then:

Fixed cost (LE h^{-1}) = Dc + In + 0.03 Pm / hour of use per year (5)

- Repair and maintenance costs (R_m):

R_m = 100 % deprecation cost / hour of use per year (6)

- Energy costs (E):

E = EC x EP (7)

Where:

E is the energy costs, LE h^{-1}.

EC is the electrical energy consumption, kWh.

EP is the energy price, 0.57 LE kW^{-1}.

-Labor costs (La):

La = Salary of one worker x No. of workers (8)

Where:

La is the Labor costs, LE h^{-1}.

Salary of one worker = 10 LE h^{-1}.

No. of workers = 1

Then:

Variable costs (LE h^{-1}) = R_m + E + La (9)

Total costs (LE h^{-1}) = Fixed costs (LE h^{-1}) + Variable costs (LE h^{-1}) (10)

3. RESULTS AND DISCUSSION

3.1. Air temperature in the drying chamber:

Figure (5) shows the effect of different drying temperature (50, 55 and 60 °C) and different air recirculating percentage (70, 80 and 90%) on the air temperature of the drying chamber during experimental period. The results indicate that the air temperature of the drying chamber ranged from 24 to 50, 24 to 50 and 20 to 50 °C for 70, 80 and 90 % air recirculating, respectively, at 50 °C drying temperature. The maximum air temperature of the drying chamber was 50 °C after 135, 135 and 50 min for 70, 80 and 90 % air recirculating, respectively. At 55 °C drying temperature, the air temperature of the drying chamber ranged from 27 to 55, 29 to 55 and 13 to 55 °C for 70, 80 and 90 % air recirculating, respectively. The maximum air temperature inside drying chamber was 55 °C after 120, 105 and 60 min for 70, 80 and 90 % air recirculating, respectively. At 60 °C drying temperature, the air temperature of the drying chamber ranged from 25 to 60, 29 to 60 and 18 to 60 °C for 70, 80 and 90 % air recirculating, respectively. The maximum air temperature inside drying chamber was 60 °C after 120, 120 and 45 min for 70, 80 and 90 % air recirculating, respectively.

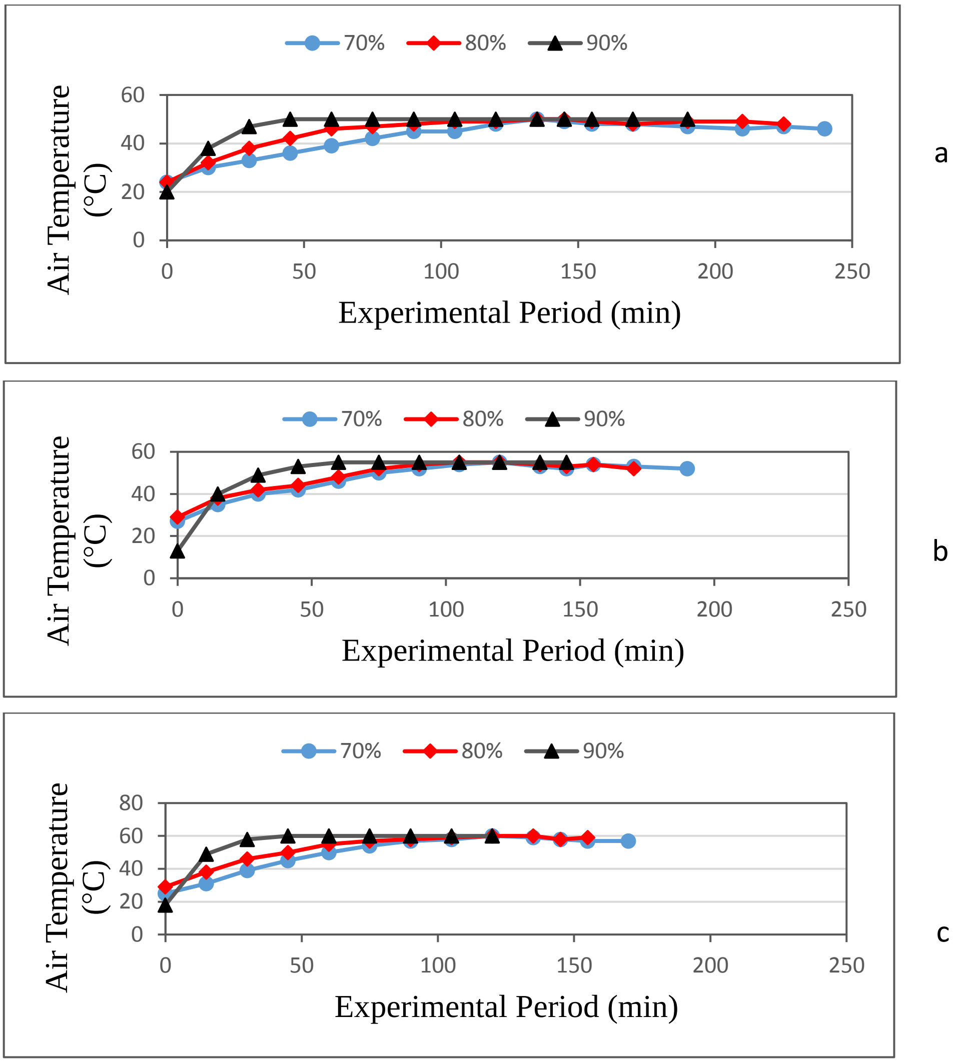

Figure (5): Effect of different drying temperature and air recirculating on the air temperature inside drying chamber during experimental period.
a: 50 °C b: 55 °C c: 60 °C

3.2. Weight loss:

Figure (6) shows the accumulated weight loss of mint leaves that dried under different drying temperatures (50, 55 and 60 °C) and different air recirculating percentage (70, 80 and 90%) during experimental period. The results indicate that the accumulated weight loss of mint leaves increases with increasing drying temperature and air recirculating during drying period. It could be seen that the accumulated weight loss of mint leaves increased from 7.52 to 79.98, 9.25 to 79.98 and 10.59 to 80.10 %, when the drying period increased from 15 to 240, 15 to 225 and 15 to 190 min, respectively, for 70, 80 and 90 % air recirculating at 50 °C drying temperature. At 55 °C drying temperature, the accumulated weight loss of mint leaves increased from 9.59 to 79.99, 10.82 to 80.09 and 12.18 to 80.15 %, when the drying period increased from 15 to 190, 15 to 170 and 15 to 145 min, respectively, for 70, 80 and 90 % air recirculating. At 60 °C drying temperature, the accumulated weight loss of mint leaves increased from 11.16 to 80.05, 12.62 to 80.16 and 13.75 to 80.29 %, when the drying period increased from 15 to 170, 15 to 155 and 15 to 120 min, respectively, for 70, 80 and 90 % air recirculating.

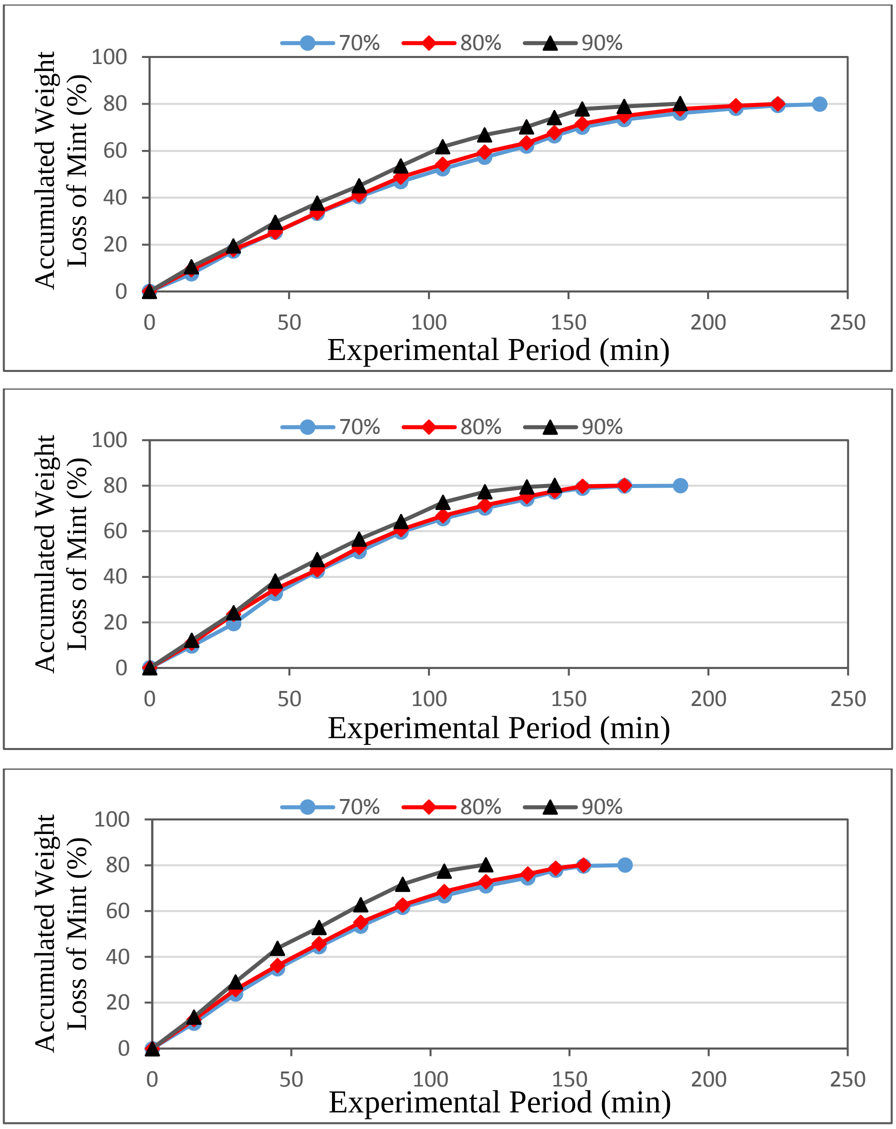

Figure (6): The accumulated weight loss of mint leaves at different drying temperatures and different air recirculating during experimental period.

a: 50 °C b: 55 °C c: 60 °C

The results indicate that the accumulated weight loss of mint leaves increases with increasing drying temperature, it could be seen that the accumulated weight loss of mint leaves increased from 79.93 to 80.10, 79.99 to 80.15 and 80.05 to 80.29 %, when the drying temperature increased from 50 to 60 °C, respectively, for 70, 80 and 90 % air recirculating. These results agreed with those obtained by **Doymaz (2006)** whose found the weight loss increases with increasing drying temperature.

The results also indicate that the shorter drying period (120 min) was occurred under the 90 % air recirculating due to the higher temperature (60 °C). Meanwhile, the longer drying period (240 min) was occurred under the 70 % air recirculating due to the lower temperature (50 °C). The trend of these results agreed with those obtained by **Khater and Bahnasawy (2017)**.

Multiple regression analysis was carried out to obtain a relationship between the accumulated weight loss as dependent variable and different both of drying temperature, air recirculating and experimental period as independent variables. The best fit for this relationship is presented in the following equation:-

$$For\ \ 50\ ^{\circ}C \qquad WL = -19.79 + 0.36AR + 0.38t \qquad \mathrm{R}^2 = 0.94 \qquad (11)$$

$$For\ \ 55\ ^{\circ}C \qquad WL = -21.80 + 0.47AR + 0.41t \qquad \mathrm{R}^2 = 0.92 \qquad (12)$$

$$For\ \ 60\ ^{\circ}C \qquad WL = -31.78 + 0.50AR + 0.55t \qquad \mathrm{R}^2 = 0.90 \qquad (13)$$

Where:

WL is the accumulated weight loss, %

AR is the air recirculating percentage, %

t is the experimental period, min

This equation could be applied in the range of 70 to 90% air recirculating percentage and from 1 to 240 min of experimental period.

3.3. Moisture content:

Figure (7) shows the moisture content of mint leaves that dried under different drying temperatures (50, 55 and 60 °C) and different air recirculating percentage (70, 80 and 90%) during experimental period. The results indicate that the moisture content of mint leaves decreases with increasing drying temperature and air recirculating during drying period. It could be seen that the moisture content of mint leaves decreased from 396.03 to 2.78, 400.00 to 4.40 and 402.01 to 5.62 % d.b., when the drying period increased from 15 to 240, 15 to 225 and 15 to 190 min, respectively, for 70, 80 and 90 % air recirculating at 50 °C drying temperature. At 55 °C drying temperature, the moisture content of mint leaves decreased from 400.00 to 0.80, 402.01 to 2.01 and 404.02 to 3.23 % d.b., when the drying period increased from 15 to 190, 15 to 170 and 15 to 145 min, respectively, for 70, 80 and 90 % air recirculating. At 60 °C drying temperature, the moisture content of mint leaves decreased from 402.01 to 1.61, 404.03 to 7.26 and 408.13 to 14.23 % d.b., when the drying period increased from 15 to 170, 15 to 155 and 15 to 120 min, respectively, for 70, 80 and 90 % air recirculating.

The results indicate that the moisture content of mint leaves increases with increasing drying temperature, it could be seen that the moisture content of mint leaves increased from 396.03 to 402.01, 400.00 to 404.02 and 402.01 to 408.13 % d.b., when the drying temperature increased from 50 to 60 °C, respectively, for 70, 80 and 90 % air recirculating after 15 min of drying period. Increased drying temperature and air recirculating further decrease the relative humidity of a product. This can be explained by the fact that increased temperature and hot airflow inside the drying chamber increases mass and heat transfer, leading to sharper drops in moisture content. These results agreed with those obtained by **Doymaz (2006)** whose found the moisture content increases with increasing drying temperature.

The results indicate that the highest rate of the decrease moisture content of baisl plants (99.80%) was happened under the 70 % air recirculating due to the higher temperature (55 °C). Meanwhile, the lowest rate of the decrease moisture content of baisl plants (96.51%) was found under the 70 % air recirculating due to the lower temperature (60 °C). The trend of these results agreed with those obtained by **Danso-Boateng (2013)**.

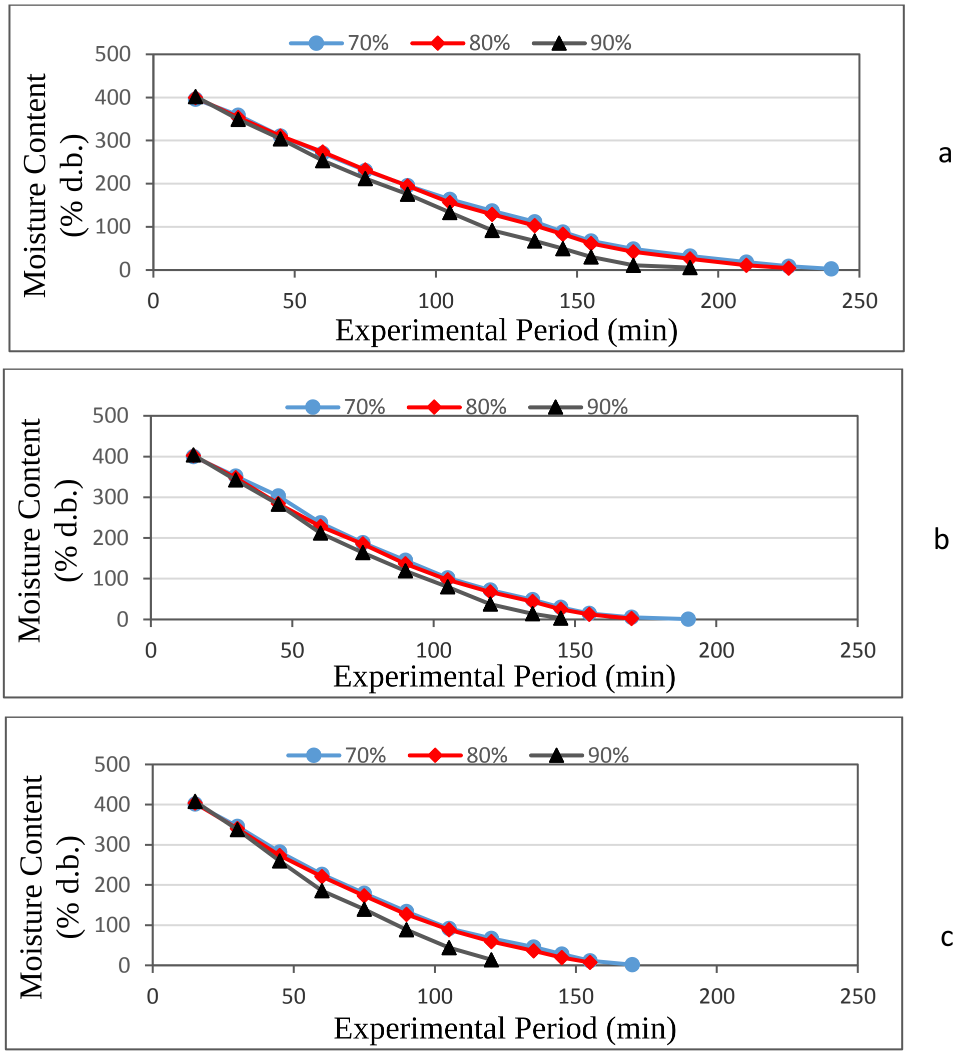

Figure (7): The moisture content of mint leaves at different drying temperatures and different air recirculating during experimental period.
a: 50 °C b: 55 °C c: 60 °C

Multiple regression analysis was carried out to obtain a relationship between the accumulated weight loss as dependent variable and different both of drying temperature, air recirculating and experimental period as independent variables. The best fit for this relationship is presented in the following equation:-

$$For\ 50\ ^{\circ}C \qquad MC = 492.66 - 1.92AR - 1.73t \qquad R^2 = 0.95 \qquad (14)$$

$$For\ 55\ ^{\circ}C \qquad MC = 498.88 - 2.50AR - 1.80t \qquad R^2 = 0.93 \qquad (15)$$

$$For\ 60\ ^{\circ}C \qquad MC = 538.89 - 2.71AR - 2.29t \qquad R^2 = 0.92 \qquad (16)$$

Where:

MC is the moisture content, % d.b.

This equation could be applied in the range of 70 to 90% air recirculating percentage and from 1 to 240 min of experimental period.

3.4. Drying rate:

Figure (8) shows the drying rate of mint leaves that dried under different drying temperatures (50, 55 and 60 °C) and different air recirculating percentage (70, 80 and 90%) during experimental period. The results indicate that the drying rate of mint leaves decreases with increasing drying temperature and air recirculating during drying period.

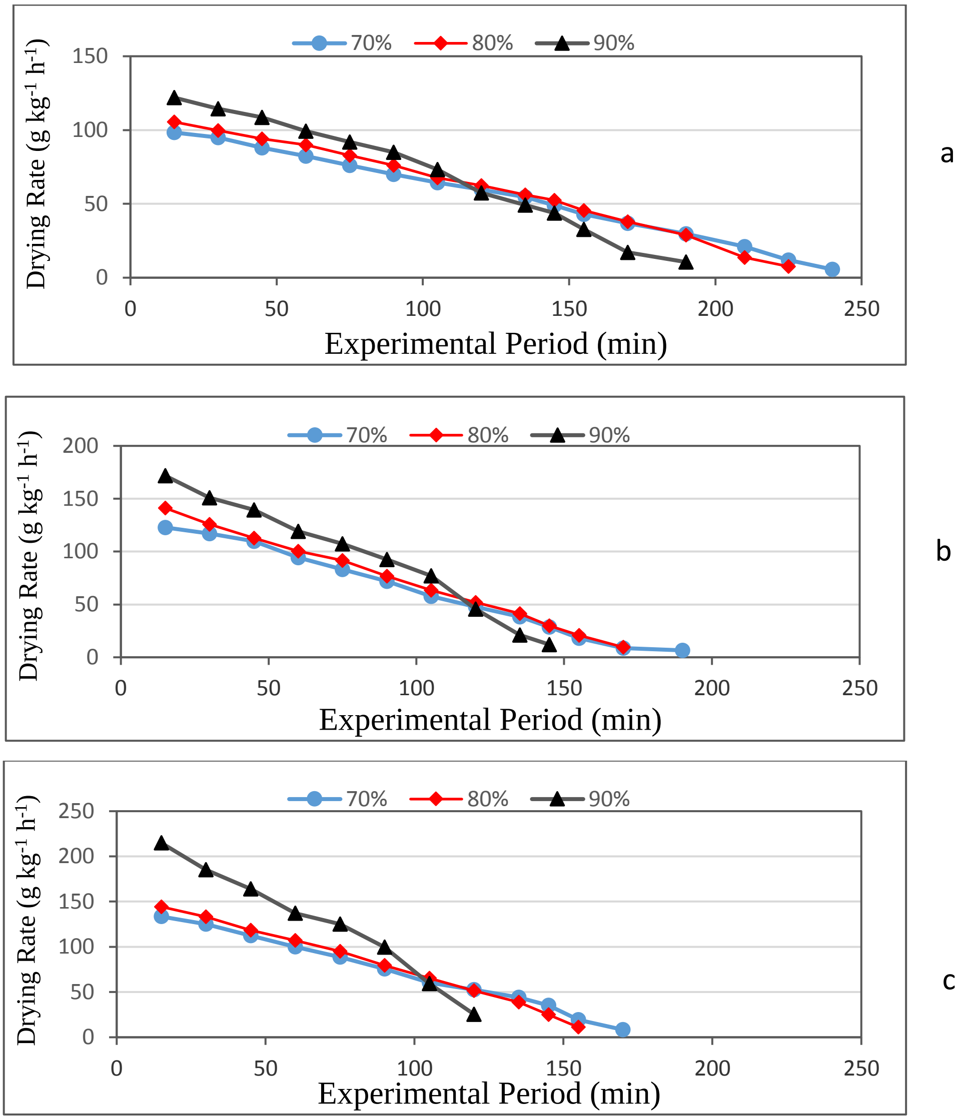

Figure (8): The drying rate of mint leaves at different drying temperatures and different air recirculating during experimental period.

a: 50 °C b: 55 °C c: 60 °C

It could be seen that the drying rate of mint leaves decreased from 98.31 to 5.60, 105.49 to 7.60 and 121.96 to 10.58 g_{water} kg^{-1} h^{-1}, when the drying period increased from 15 to 240, 15 to 225 and 15 to 190 min, respectively, for 70, 80 and 90 % air recirculating at 50 °C drying temperature. At 55 °C drying temperature, the drying rate of mint leaves decreased from 122.83 to 6.59, 141.18 to 9.54 and 171.77 to 12.04 g_{water} kg^{-1} h^{-1}, when the drying period increased from 15 to 190, 15 to 170 and 15 to 145 min, respectively, for 70, 80 and 90 % air recirculating. At 60 °C drying temperature, the drying rate of mint leaves decreased from 133.47 to 8.26, 144.28 to 11.03 and 214.86 to 25.37 g_{water} kg^{-1} h^{-1}, when the drying period increased from 15 to 170, 15 to 155 and 15 to 120 min, respectively, for 70, 80 and 90 % air recirculating.

The results indicate that the drying rate of mint leaves increases with increasing drying temperature, it could be seen that the drying rate of mint leaves increased from 98.31 to 121.96, 122.83 to 171.77 and 133.47 to 214.86 g_{water} kg^{-1} h^{-1}, when the drying temperature increased from 50 to 60 °C, respectively, for 70, 80 and 90 % air recirculating after 15 min of drying period. These results agreed with those obtained by **Amer *et al.* (2018)**.

Multiple regression analysis was carried out to obtain a relationship between the accumulated weight loss as dependent variable and different both of drying temperature, air recirculating and experimental period as independent variables. The best fit for this relationship is presented in the following equation:-

$$For\ 50\ ^{\circ}C \qquad DR = 90.67 - 0.47AR + 0.25t \qquad R^2 = 0.95 \tag{17}$$

$$For\ 55\ ^{\circ}C \qquad DR = 76.06 - 0.84AR + 0.84t \qquad R^2 = 0.95 \tag{18}$$

$$For\ 60\ ^{\circ}C \qquad DR = 26.35 - 0.93AR + 1.66t \qquad R^2 = 0.91 \tag{19}$$

Where:

DR is the drying rate, g_{water} kg^{-1} h^{-1}.

This equation could be applied in the range of 70 to 90% air recirculating percentage and from 1 to 240 min of experimental period.

3.5. Total Costs:

Table (1) shows the total costs of mint leaves that dried under different drying temperatures (50, 55 and 60 °C) and different air recirculating percentage (70, 80 and 90%) during experimental period. The results indicate that the total cost of dried mint increases with increasing drying temperature and decreases with increasing air recirculating percentage. It could be seen that the total costs of dried mint decreased from 8.60 to 7.44, 9.73 to 8.03 and 10.91 to 8.85 L.E kg^{-1} of mint, when the air recirculating percentage increased from 70 to 90 %, respectively at 50, 55 and 60 °C drying temperature.

Table (2): The total costs of dried mint leaves.

Drying Temperature, °C	Air Recirculating Percentage, %		
	70	80	90
	Total Cost, LE kg^{-1}		
50	8.60	8.07	7.44
55	9.73	8.75	8.03
60	10.91	9.38	8.85

4. CONCLUSION

The experiment was carried out to study the effect of drying temperature and air recirculation percentages on the weight losses of mint, drying time, final moisture content and energy consumption. The obtained results can be summarized as follows:

- The air temperature of the drying chamber ranged from 20 to 50, 13 to 55 and 18 to 60 °C for 50, 55 and 60 °C drying temperature, respectively.
- The accumulated weight loss of mint leaves increased from 79.93 to 80.10, 79.99 to 80.15 and 80.05 to 80.29 %, when the drying temperature increased from 50 to 60 °C, respectively, for 70, 80 and 90 % air recirculating.
- The moisture content of mint leaves ranged from 2.78 to 402.01, 0.80 to 404.02 and 1.61 to 408.13 % d.b. for 50, 55 and 60 °C drying temperature, respectively.
- The drying rate of mint leaves increased from 98.31 to 121.96, 122.83 to 171.77 and 133.47 to 214.86 g_{water} kg^{-1} h^{-1}, when the drying temperature increased from 50 to 60 °C, respectively, for 70, 80 and 90 % air recirculating after 15 min of drying period.
- The total costs of dried mint decreased from 8.60 to 7.44, 9.73 to 8.03 and 10.91 to 8.85 L.E kg^{-1} of mint, when the air recirculating percentage increased from 70 to 90 %, respectively at 50, 55 and 60 °C drying temperature.

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تأثير درجة الحرارة ودوران الهواء
على الفاقد فى الوزن للنعناع تحت ظروف التجفيف الشمسي الهجين

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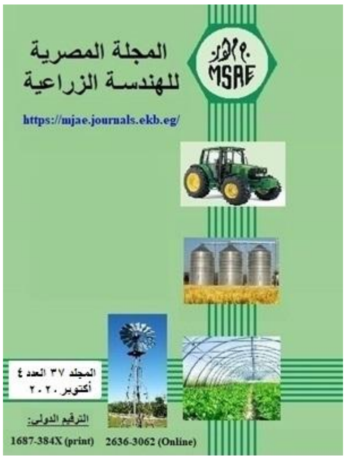
[٣] استاذ الهندسة الزراعية - كلية الزراعة بمشتهر – جامعة بنها – مصر.
[٤] رئيس بحوث معهد بحوث تكنولوجيا الأغذية – مركز البحوث الزراعية بالدقي – الجيزة – مصر.



الكلمات المفتاحية:
نعناع، الوزن المفقود، المحتوى الرطوبي، معدل التجفيف، التكاليف

الملخص العربى

يهدف هذا البحث الى دراسة درجة الحرارة ونسبة دوران الهواء على الفاقد فى الوزن والمحتوى الرطوبى ومعدل التجفيف للأوراق النعناع. وتم إجراء هذه التجربة فى قسم هندسة النظم الزراعية والحيوية – كلية الزراعة بمشتهر – جامعة بنها – محافظة القليوبية. وتم تجفيف النعناع تحت تأثير ثلاث درجات حرارة (٥٠ و٥٥ و٦٠ °م) وثلاث نسبة تغيير للهواء (٧٠ و٨٠ و٩٠%). وتم تقدير كلا من الفاقد فى الوزن والمحتوى الرطوبى ومعدل التجفيف وتكاليف التجفيف. وكانت أهم النتائج المتحصل عليها كما يلي: تراوحت درجة الحرارة داخل غرفة التجفيف من ٢٠ إلى ٥٠ ومن ١٣ إلى ٥٥ ومن ١٨ إلى ٦٠ °م لكل من ٥٠ و٥٥ و٦٠°م حرارة تجفيف على الترتيب. زاد الفاقد التراكمي فى الوزن للنعناع المجفف من ٧٩,٩٣ إلى ٨٠,١٠ ومن ٧٩,٩٩ إلى ٨٠,١٥ ومن ٨٠,٨٠,٢٩ % عند زيادة حرارة التجفيف من ٥٠ إلى ٦٠ °م لكل من نسبة تغيير الهواء ٧٠ و٨٠ و٩٠ % على الترتيب. تراوح المحتوى الرطوبى للنعناع المجفف من ٢,٧٨ إلى ٤٠٤,٠١ ومن ٠,٨٠ إلى ٤٠٤,٠٢ ومن ١,٦١ إلى ٤٠٨,١٣ % على أساس الوزن الجاف لكل من ٥٠ و٥٥ و٦٠°م حرارة تجفيف على الترتيب. زاد معدل التجفيف للنعناع المجفف بزيادة كلا من حرارة التجفيف ومعدل تغيير الهواء. انخفضت تكاليف تجفيف النعناع من ٨,٦٠ إلى ٧,٤٤ ومن ٩,٧٣ إلى ٨,٠٣ ومن ١٠,٩١ إلى ٨,٨٥ جنيه لكل كجم نعناع عند زيادة معدل تغيير الهواء من ٧٠ إلى ٩٠ % لكل من ٥٠ و٥٥ و٦٠ °م حرارة تجفيف على الترتيب.