SOLAR DRYER PERFORMANCE STUDY OF SOME CROPS (MINT, OKRA AND GRAPES)
I - ASSESSING THE DRYING RATES

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ABSTRACT

Three crops were subjected to drying in the passive crop dryer. Crop samples were also open-sun dried as control treatment and the weight losses and temperature were taken. Mint leaves, okra and grapes were dried in the dryer and the same masses of samples were dried in the open–sun (control). The maximum stagnation temperature attained in the dryer is 66 ^{o}c and the corresponding values of solar radiation and ambient temperature were 832 W/m^2 and 36 ^{o}c, respectively. The overall heat loss coefficient of the dryer varied between 28.34 and 21.56 W/m^2 ^{o}c. All the drying process occurred in the falling rate period, starting from the initial moisture contents which are (83 wb or 488 db % for mint), (88.5 wb or 770 db % for okra) and (78 wb or 354 db for% grapes) to the final moisture content after drying were (1.18 and 19 db % for mint), (43 and 108 db % for okra) and (3.8 and 65.8 db % for grapes), for (solar dryer and natural drying) respectively. The assessment of the drying rate of the crops in the solar dryer and in open-sun gives an average of 7.68 g/h and 7.40 g/h for mint leaves, 7.08 g/h and 5.91 g/h for okra and 7.17 g/h and 5.92 g/h for grapes respectively. For mint, drying efficiencies during different days of drying for the dryer and natural drying were (60.92, 7.11 and 2.84%) and (55.51, 9.82 and 2.98%) on (first, second and third drying days), respectively and the averages were 23.62 and 22.77%. For okra drying efficiencies during different days of drying for the dryer and natural drying were (42.93, 17.01 and 2.62%) and (37.09, 15.36 and 4.49%)on (first, second and third drying days), respectively and the averages were 20.85 and 18.98%.For grapes, drying efficiencies during different days of drying for the dryer and natural drying were (34.27, 20.32 and 11.65%) and (40.31, 8.88 and 5.46%) on (first, second and third drying days), respectively and the average values were 22.05 and 18.21%.

Keywords*: crop dryer, weight losses, dryer efficiency, moisture content.*

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INTRODUCTION

Crop drying in solar dryer reduces contamination of the crop by dirt, fungi, insects and animals. The study of the drying process has shown that it may be characterized in two stages in which the rate of drying varies differently. In the first stage, starting with a short heating up period, the drying rate is constant and maximum. The moisture content exceeds the maximum hygroscopic moisture content everywhere in the material. There is movement of moisture under the effect of capillary and osmotic force from the inside to the surface of the material and saturated vapour prevails over the surface. The second stage begins when the materials moisture content is everywhere less than maximum hygroscopic content. Drying rate decrease further in this case and tends asymptotically to zero. However, more significant controlling mechanism in the falling rate period is those of diffusion and capillary. Solar energy in recent times has been given more attention as an alternative to fossil fuel for drying and sometimes heating process as a result of alarming increase in the cost of fossil fuel energy. Drying crops by solar energy is of great economic importance allover the world. Most of the crops and grain harvest are lost to fungal and microbial attacks. These wastages could be easily prevented by proper drying which enhances storage of crops over a long period of time ***(Ezekoyi and Enebe, 2006).*** Some crops can be preserved and stored so that they can be of economic importance both to the farmer and the entire populace. Rural farmers do this by open air drying. Since this crops are easily contaminated by animal droppings and consequent infestation by fungal and bacteria. This method also prolongs drying and may result in the deterioration of the quality of the crops. Moreover, more labor is involved as the crops are watched to prevent attacks from birds and animals and crops are moved in and out during the day and night and from rain. A low temperature passive solar dryer has therefore been fabricated which will be appropriate for drying crops and grains at the low temperature and high relative humidity period of the year. This enables crops to be dried without cracking and hence minimizes the exposure of the crops to fungal and bacteria infestation and wastage and suitable for bulk drying (***Butter and Goodrum, 1998). Pangavhane et al.***

(2002) developed a multipurpose natural convection solar dryer. They reported that ‘‘the drying airflow rate increased with increase in ambient temperature by the thermal buoyancy in the collector. In this study, grapes were dried and the qualitative analysis showed that the traditional drying of grape, shade drying and open sun drying required 15 and 7 days, respectively, while the natural convection solar dryer took only 4 days and produced better quality raisins. The drying time of the grapes is also reduced by 43% compared to the open sun drying. The developed natural convection solar dryer could produce the average temperature between 50 and 55 ^{o}c, which was optimum for dehydration of the grapes as well as for most of the fruits and vegetables’’. ***Gallali et al. (2000)*** reported that the mixed and indirect modes of drying were more effective than open sun, since the final moisture contents for grapes were about 13, 20 and 68%, respectively. ***Akpinar (2010)*** reported that the enzymatic activity in plants inhibits and ceases at temperatures 50 to 60 ºc. For some active substances as volatile compounds, i.e., essential oils in herbs, the recommended temperature of drying should not exceed 35 to 45 ºc. ***Al-Juamily et al. (2007)*** found that the best drying results for grapes are obtained at 65°C, 0.3 m/s speed of air, and 30% relative humidity within the chamber. ***Radwan (2002)*** mentioned that, quality evaluated tests of the dried grape (raisins) showed that vitamin “C” content was the only chemical component significantly decreased during a sun drying method compared with solar drying method, dehydration ratio of solar dried raisin was higher than that of sun dried samples and sun dried raisin was lightly darker than solar dried samples. ***Abdel-Galil and El-Nakib (2008)*** reported that the essential oil content of fresh mint, direct solar dryer and indirect solar dryer were 2.98,1.76 and 1.64 respectively ,while chlorophyll (A,B) contents of fresh mint, direct solar dryer and indirect solar dryer were (6.77,4.20),(4.10,1.96) and (3.54,1.82) respectively. ***Doymaz (2011)*** found that the time taken for drying of okra from the initial moisture contents of 88.7% (wb) to final moisture content of around 15±0.5% (wb) were 100 h in open sun drying. ***Mohamed et al. (2010)*** reported that using the indirect solar dryer for drying okra with air flow rate of 0.075 m^3/s gave the best results. The objective of this work is to evaluate the drying rate of three crops: mint leaves, okra and grapes inside a solar crop dryer comparing with the open-sun drying as control.

MATERIALS AND METHODS

Description of the solar dryer:

The solar dryer was designed and manufactured in El-Zagazig, Sharkia governorate (longitude =35° 30° and latitude =31° 31°).

The main components of each drying system are:-

1- Solar dryer

The solar dryer (100×50×40 cm) is made of wood and single layered transparent glass which serves as a solar collector that brings about the transformation of solar radiation to heat energy needed for proper drying process inside the dryer. Cooler air goes into the dryer through the chimney (20×20×20 cm) and the heated air leaves the dryer by convection which would hasten the drying of the crops. Solar collector area is 0.5 m^2. The drying chamber was equipped by one drying shelf which made of stainless steel screen mesh. The dryer is shown in figures (1and 2).

2 - Open Sun Draying

Consists of tray which made of wooden frame (95 × 45 cm) and stainless steel screen mesh in the bottom.

Drying experiments

All fresh crops (mint, okra and grape) used for the drying experiments were obtained

from local market. The samples were stored in closed plastic bag at 4°c refrigerator

before they were used in this study. Before the drying process, the samples were taken out of the refrigerator and leaves of the leafy vegetables were separated from stems. To determine the initial moisture content, three 10 g of samples were dried in an oven

at 105 °c for 24 h and averages were reported. The samples were spread in a single layer on the shelf inside the dryer and the same mass spread in a single layer on a tray as the open sun. Moisture contents of samples were determined at each hour interval. When the samples weights at three consecutive times were constant, the drying process was cut and the moisture content at that time was considered as the equilibrium moisture content.

Measurements

Weight of samples was measured using electric balance (accuracy 0.01g and maximum weight 3000g). Solar radiation and temperature of ambient air were measured by "Watchdog" weather station model 900 ET. The Weather station measures wind speed (0-175 mph) ± 5%, wind direction (2^o increments) ± 7°, temperature (-30° : 100° c), relative humidity (20 - 100%) ± 3%, rainfall (0.01- 0.25 cm) ± 2% and solar radiation (1 - 1250 W/m^2).Air temperature inside the dryer was recorded at different positions using thermometers with accuracy of 1 ^{o}c with maximum of 100°c and with calibrated thermocouples connected to a multi channel digital display with an accuracy of 0.05 ^{o}c. Moisture content was measured using the electric oven. Humidity was measured using Klima Guard digital thermo-hygrometer, the range for relative humidity form (1 to 99 %) with accuracy of (±3.5 %). Air velocity was measured using the anemometer model, the range for air velocity form (0 to 45 m/s) with accuracy of (±0.3 m/s).

Determination of dryer thermal efficiency:

Thermal performance of the solar collector:

The thermal performance of the solar collector can be described in terms of several parameters which are usually employed to assess that performance. These parameters and their effect on thermal performance can be calculated according to **Shewen et al. (1980)** as follows:

1. Solar energy available (Q): $Q = R A_c \quad , W$

Where :R : Solar energy flux incident on the surface of solar collector, W/m^2 and A_c : Surface area of the solar collector, m^2.

2. Absorbed solar energy (Q_a): $Q_a = \tau R A_c \quad , W$

Where: τ: Effective transmittance of solar collector cover system, decimal.

3. Absorption efficiency (η_a): $\eta_a = (Q_a / Q) \times 100 \quad , \%$

4. Useful heat gain to storage (Q_c): $Q_c = m c_p (T_{ao} - T_{ai}) \quad , W$

Where: m: Mass flow rate of air, kg/s, c_p: Specific heat of air, J/kg/ °c, T_{ao}: Outlet temperature of air, °c and T_{ai}: Inlet temperature of air, °c.

5. Heat transfer efficiency (η_h): $\eta_n = (Q_c / Q_a) \times 100 \quad , \%$

6. Solar collector heat losses (Q_L): $Q_L = Q_a - Q_c \quad , W$

7. Overall thermal efficiency (η_s): $\eta_s = (Q_c / Q) \times 100 \quad ,\%$

Drying Efficiency:

Amount of heat required to evaporate the moisture inside the product is called as drying efficiency. Total heat in case of solar dryer is the availability of solar radiation on collector surface of the dryer. This drying efficiency was calculated by equation, $\eta_d = W \times l / A_c \times I_c \times t \quad ,\%$

Where, *W*= Moisture evaporated (kg), *l* = Latent heat of vaporization of water, 2320 (kJ/kg), I_c= Isolation upon collector, (W/m²), A_c=Area of collector (m²) and t = Time of drying (s).

The overall heat loss coefficient:

The overall heat loss coefficient of the dryer based on aperture area was calculated from the experimental data as: $U = I \ \tau (T_s - T_a) \quad ,W / m^{2\,o}c$

Where: I: solar radiation incident on aperture (W/m^2); Ts: stagnation temperature (^{o}c); Ta: ambient temperature (^{o}c) and τ: transmissivity of glass cover (0.85).

Moisture content (MC): $MC = (M_i - M_f) / M_i \quad ,\%$

Where M_i: Mass of sample before drying (g) and M_f: Mass of sample after drying (g).

Moisture Loss (ML): The moisture loss (g) is given as: $ML = M_i - M_f \quad ,g$

Average drying rate (R_d): $R_d = \dfrac{M_{t-dt} - M_t}{dt}$ g/h

Where :M_{t-dt} and M_t are the moisture contents at t-dt and t , respectively(db%), and dt is the drying time period(h).

RESULTS AND DISCUSSION

Test at no load

The experiments at no load were conducted during the month of September 2013. All openings of air outlet were closed to determine stagnation temperature of the dryer with zero useful heat gain. The dryer was placed in the south facing the sun from 10:00 a.m. and the experiment was continued up to 4:00 p.m. Solar irradiation on the aperture of the dryer, ambient temperature and air temperature in the dryer was recorded every an hour. Figure (3) shows the variation of temperature in the dryer, ambient temperature and solar radiation intensity during the day. The maximum stagnation temperature attained in the dryer is 66 ^{o}c and the corresponding values of solar radiation and ambient temperature were 832 W/m^{2} and 36 ^{o}c, respectively. The overall heat loss coefficient of the dryer based on aperture area was calculated from the experimental data given in figure (3).The values varied between 28.34 and 21.56 W/m^{2o}c. Then, the arithmetic average of these values was taken as the average overall heat loss coefficient of the dryer and it was found to be 24.95 W/m^{2o}c.

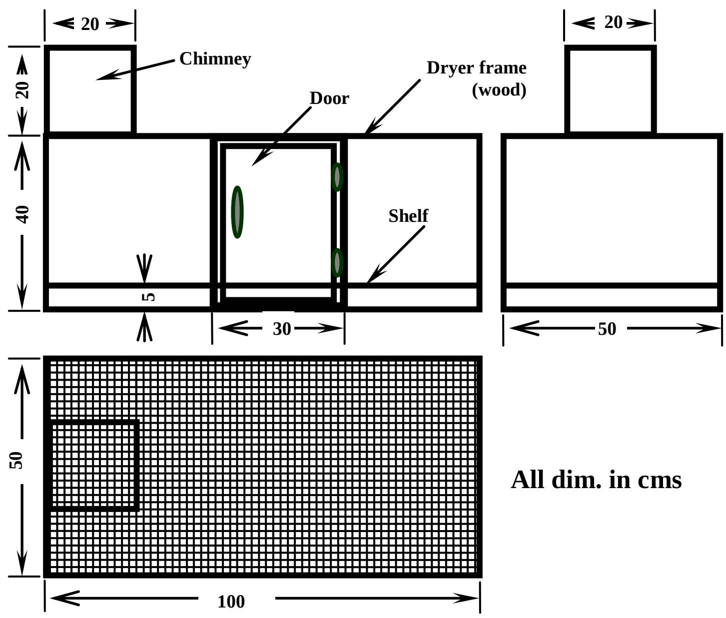


Figure (1): Schematic diagram of the solar dryer.

Figure (2): The solar dryer.

Test with load

Mint leaves, okra and grapes were dried in the dryer and same samples in the open- air (control). At the end of the first day, on visual observation, very large void spaces could be seen from the products in the dryer. This was due to shrinkage of products during drying. The results for mint leaves, okra and grapes respectively of the tests are recorded in Tables 1 to 6. It is apparent that moisture content decreases continuously with drying time. As indicated in these curves figure (4, 5 and 6), there was no constant rate period in drying of mint, okra and grapes. All the drying processes occurred in the falling rate period, starting from the initial moisture content (83 wb or 488 db % for mint), (88.5 wb or 770 db % for okra) and (78 wb or 354 db for% grapes) to the final moisture content after drying were (1.18 and 19 db % for mint), (43 and 108 db % for okra) and (3.8 and 65.8 db % for grapes), for (solar dryer and natural drying) respectively. These results are in agreement with the observations of earlier researchers ***(Lahsasni et al. 2004; Togrul and Pehlivan, 2004).***

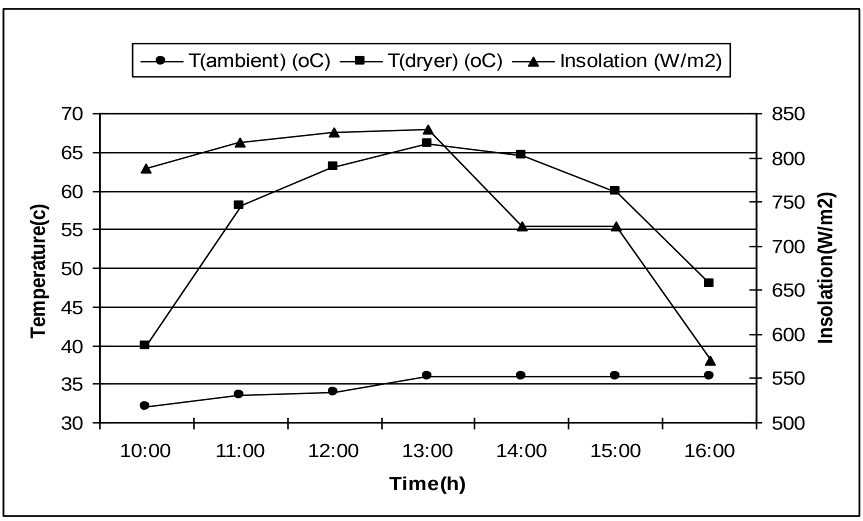


Figure (3) The variation of temperature in the dryer, ambient temperature and solar radiation intensity during (15 / 9 / 2013)

Table 1: Mint leaves sample inside the solar dryer.

Day	Initial mass (M_i) , g	Final mass (M_i) , g	Mass diff. (M_i - M_g), g	Moisture content (w.b.) , %	Ambient temp. , ^{0}c	Dryer temp. , ^{0}c
1	3000	860	2140	41.39	37	56
2	860	610	250	17.37	37	55
3	610	510	100	1.17	36.5	55

Table 2: Mint leaves sample in open sun (control test).

Day	Initial mass (M_i) , g	Final mass (M_i) , g	Mass diff. (M_i - M_g), g	Moisture content(w.b.) , %	Ambient temp. , ^{0}c
1	3000	1050	1950	52	37
2	1050	705	345	28.50	37
3	705	600	105	16	36.5

Table 3: Grapes sample inside the solar dryer.

Day	Initial mass (M_i) , g	Final mass (M_i) , g	Mass diff. (M_i - M_g), g	Moisture content(w.b.) , %	Ambient temp. , ^{0}c	Dryer temp. , ^{0}c
1	3000	1796	1204	63.75	35	57.5
2	1796	1082	714	49.23	32.5	52
3	1082	675.80	406.2	3.67	32	54

Table 4: Grapes sample in Open sun (control test).

Day	Initial mass (M_i) , g	Final mass (M_i) , g	Mass diff. (M_i - M_g), g	Moisture content(w.b.) , %	Ambient temp. , ^{0}c
1	3000	1584	1416	58.90	35
2	1584	1272	312	48.82	32.5
3	1272	1080	192	39.72	32

Table 5: Okra sample inside the solar dryer.

Day	Initial mass (M_i) , g	Final mass (M_i) , g	Mass diff. $(M_i - M_g)$, g	Moisture content(w.b.) , %	Ambient temp. , ^{0}c	Dryer temp. , ^{0}c
1	3000	1281	1719	73.07	33.5	48.5
2	1281	600	681	42.50	34.5	58
3	600	495	105	30.30	34.5	59.5

Table 6: Okra sample in Open sun (control test).

Day	Initial mass (M_i) , g	Final mass (M_i) , g	Mass diff. $(M_i - M_g)$, g	Moisture content(w.b.) , %	Ambient temp. , ^{0}c	Dryer temp. , ^{0}c
1	3000	1515	1485	77.22	33.5	33.5
2	1515	900	615	61.66	34.5	34.5
3	900	720	180	52.08	34.5	34.5

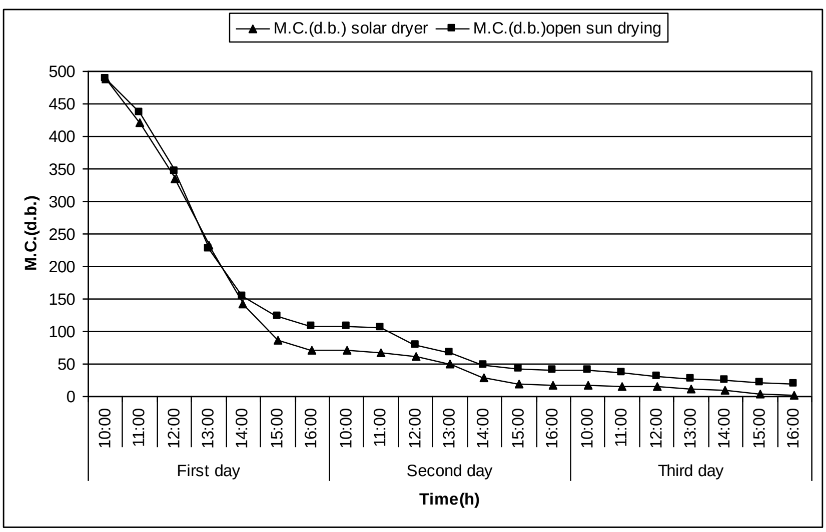


Figure (4) Variation of moisture content with drying time of mint in solar dryer and open sun.

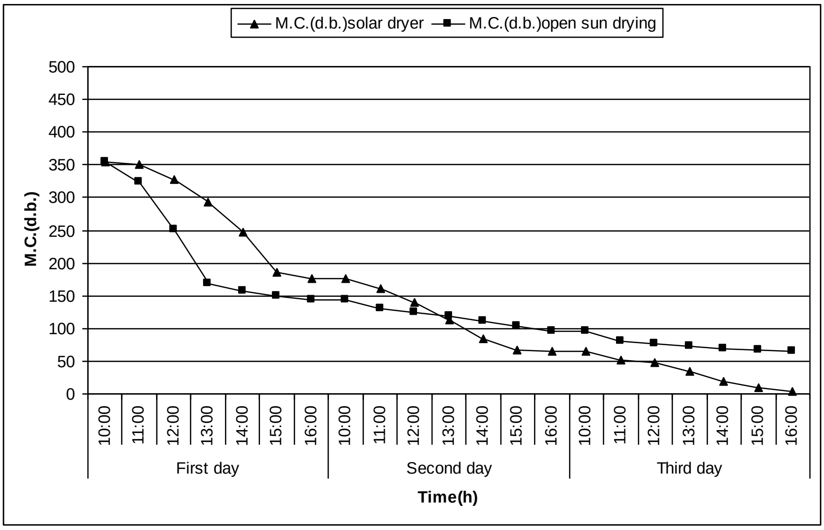


Figure (5) Variation of moisture content with drying time of grapes in solar dryer and open sun.

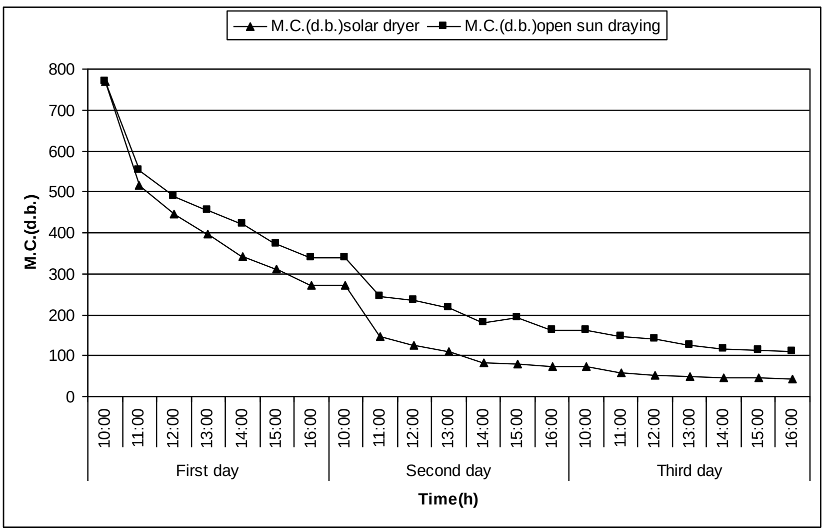
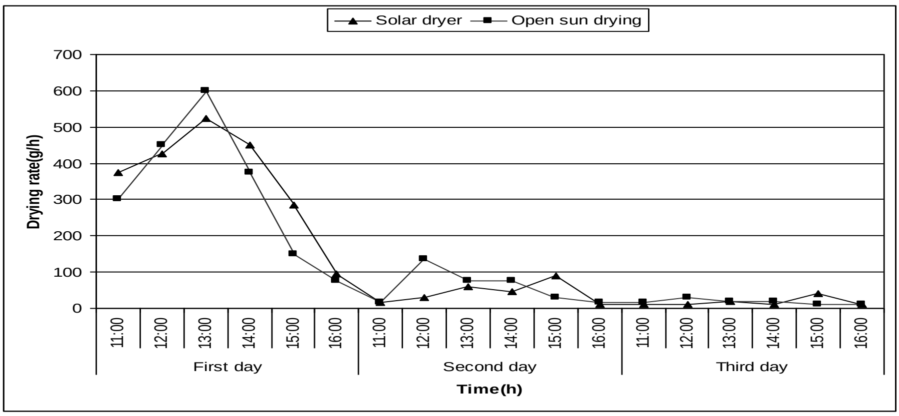


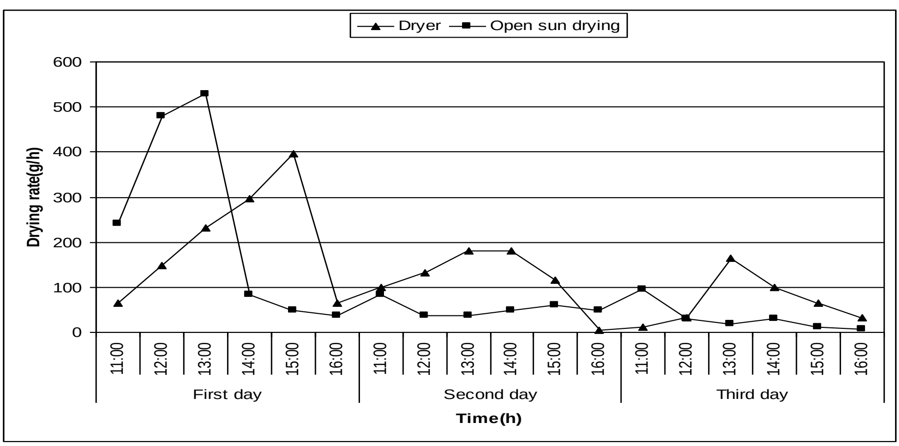
Figure (6) Variation of moisture content with drying time of okra in solar dryer and open sun.

Figures (7, 8 and 9) showed the rate of drying of crop samples in the solar dryer and in the open sun. The assessment of the drying rate of the crops in the solar dryer and in open-sun gives an average of 7.68 and 7.40 g/h for mint leaves, 7.17 g/h and 5.92 g/h for grapes and 7.08 g/h and 5.91g/h for okra. Figure (7) showed that for mint leaves sample, drying progressed rapidly in the solar dryer and in open-sun on the first day of exposure while on the second day, the difference in the rate of drying is almost the same and this may be attributed to low sun intensity on that day.

In the third day of the experiment, it can be seen that the rate of drying was much higher for samples in the solar dryer than in the open-sun. This same trend is observed for the rate of drying of grapes and okra shown in Figures (8 and 9). The result of the analysis indicated that mint leaves has higher drying rates than grapes and okra.



Figure(7) Variation of drying rate with drying time of mint in solar dryer and open sun .



Figure(8) Variation of drying rate with drying time of grapes in solar dryer and open sun .

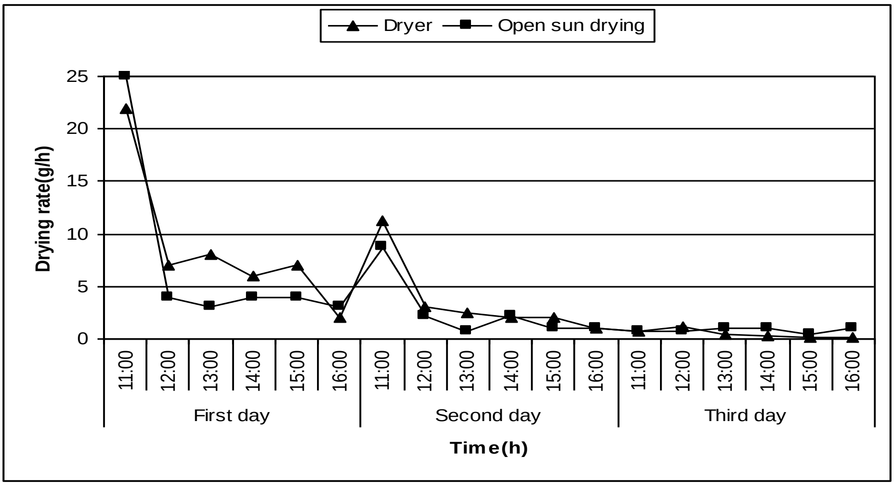


Figure (9) Variation of drying rate with drying time of okra in solar dryer and open sun.

Drying efficiency:

Drying efficiencies during different days of drying for the dryer and natural drying were (34.27, 20.32 and 11.65%), (40.31, 8.88 and 5.46%) on first, second and third drying days, for grapes respectively and the averages were 22.05 and 18.21%, drying efficiencies during different days of drying for the dryer and natural drying were (60.92, 7.11 and 2.84%), (55.51, 9.82 and 2.98%) on first, second and third drying days, for mint respectively and the averages were 23.62 and 22.77% and drying efficiencies during different days of drying for the dryer and natural drying were

(42.93, 17.01 and 2.62%), (37.09, 15.36 and 4.49%) on first, second and third drying day, for okra respectively and the averages were 20.85 and 18.98%. The drying efficiency reduced during successive days of drying. The reason for the reduction in efficiency on the second day is because the amount of water in the products were lower than in the first day . Also, surface moisture on the first drying day contributes to higher efficiency. On the third drying day, the efficiency further reduced due to the same reason.

Thermal efficiency of the solar collector and the dryer:

The thermal performance of the solar collector can be described in terms

of several parameters which are usually employed to assess that performance
performance.

1- Solar energy available (Q):

Table (6) shows the solar energy available, it ranged from 285 to 416W.

2- Absorbed solar energy (Qa):

Table (6) shows the absorbed solar energy, it ranged from 242.25 to 353.60 W.

3 - Absorption efficiency (ηa):

Table (6) shows the absorption efficiency, it ranged from 84.99 to 85.00 %.

4 – Useful heat gain to storage (Qc):

Table (6) shows the useful heat gain to storage, it ranged from 33.50 to 125.46 W

5- Heat transfer efficiency (ηh):

Table (6) shows the heat transfer efficiency, it ranged from 10.00 to 38.84 %.

6- Solar collector heat losses (QL):

Table (6) shows the Solar collector heat losses, it ranged from 187.91 to 301.40 w.

7- Overall thermal efficiency (η_s):

Table (6) shows the overall thermal efficiency, it ranged from 8.50 to 33.01 %.

Conclusion

Three crops were subjected to drying in the passive crop dryer. The crop samples were also open-sun dried as control and the weight losses and temperature were taken. The solar drying system was designed and manufactured in El-Zagazig, Sharkia governorate. Mint leaves, okra and grapes were dried in the dryer and same samples in the open- air (control). From the analysis of the results:

1. The maximum stagnation temperature attained in the dryer is 66 C^o, the corresponding values of solar radiation and ambient temperature were 832 W/m^2 and 36 ^oc, respectively.
2. The overall heat loss coefficient of the dryer varied between 21.56 and 28.34 $W/m^2\,^oc$.
3. All the drying process occurred in the falling rate period, starting from the initial moisture content (83 wb or 488 db % for mint), (88.5 wb or 770 db % for okra) and (78 wb or 354 db for% grapes) to the final moisture content after drying were (1.18 and 19 db % for mint), (43 and 108 db % for okra) and (3.8 and 65.8 db % for grapes), for (solar dryer and natural drying) respectively.

4. The assessment of the drying rate of the crops in the solar dryer and in open-sun gives an average of 7.68 and 7.40 g/h for mint leaves, 7.17 g/h and 5.92 g/h for grapes and 7.08 g/h and 5.91g/h for okra.
5. Drying efficiencies during different days of drying for the dryer and natural drying were (34.27, 20.32 and 11.65%), (40.31, 8.88 and 5.46%) on first, second and third drying day, for grapes respectively and the averages were 22.05 and 18.21%,drying efficiencies during different days of drying for the dryer and natural drying were (60.92, 7.11 and 2.84%), (55.51, 9.82 and 2.98%) on first, second and third drying day, for mint respectively and the averages were 23.62 and 22.77% and drying efficiencies during different days of drying for the dryer and natural drying were (42.93, 17.01 and 2.62%), (37.09, 15.36 and 4.49%) on first, second and third drying day, for okra respectively and the averages were 20.85 and 18.98%.

Table 6: Solar collector thermal performance and efficiency.

Time	Solar Rad. W/m^2	Av. solar energy, (Q), W	Abs. solar energy, (Q_a), W	Abs. effi., (η_a), %	Useful heat gain, (Q_c), W	Heat transfer effi., (η_h), %	Solar collector heat losses, (Q_L), W	Overall thermal effi., (η_s), %
10:00	788	394.00	334.90	85.00	33.50	10.00	301.40	8.50
11:00	817	408.50	347.22	84.99	102.60	29.50	244.61	25.11
12:00	829	414.50	352.32	84.99	121.45	34.47	230.86	29.30
13:00	832	416.00	353.60	85.00	125.64	35.53	227.96	30.20
14:00	723	361.50	307.27	84.99	119.35	38.84	187.91	33.01
15:00	723	361.50	307.27	84.99	100.51	32.71	206.75	27.80
16:00	570	285.00	242.25	85.00	50.25	20.74	192.00	17.63

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الملخص العربى

دراسة اداء مجفف شمسى لبعض المحاصيل (النعناع والعنب والبامية)
I - تقييم معدلات التجفيف في مجفف شمسي

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يهدف البحث إلى اختبار مجفف شمسي ذو حمل طبيعي لاستخدامه في تجفيف بعض المحاصيل (تم الاختبار على النعناع والعنب والبامية). يتكون هذا المجفف من إطار من الخشب أبعاده (١٠٠× ٥٠ × ٤٠) سم والجوانب والسطح من الزجاج (سمك ٣ مم) والقاع من الخشب. مثبتت بداخله رف التجفيف على مسافة ٥ سم من قاع المجفف وهو عبارة عن شبكة دقيقة من السلك وعلى السطح توجد مدخنة لدخول وخروج الهواء أبعادها (٢٠ × ٢٠ × ٢٠) سم ومغطاة من أعلى بغطاء من السلك. ويعمل هذا المجفف بفكرة الاحتباس الحرارى. تم تجفيف طبقة رقيقة من المحصول بالمجفف وكذلك تم تجفيف طبقة مماثلة فى أشعة الشمس المباشرة على صينية أبعادها (٩٥ × ٤٥) سم وهى نفس أبعاد رف التجفيف بالمجفف. تم رصد درجات الحرارة وكمية الأشعة الساقطة ونسب الرطوبة وسرعة الهواء داخل المجفف وخارجة.

وقد أوضحت النتائج ما يلي :

١- أعلى درجات حرارة تم رصدها داخل المجفف ٦٦ درجة مئوية فى حين كانت الحرارة الخارجية ٣٦ درجة مئوية و الأشعة الساقطة كانت ٨٣٢ وات/ م^{٢}.

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٢- المعامل الكلى للفقد الحرارى للمجفف يتراوح ما بين ٢١,٥ و ٢٨,٥وات/ م٢.درجة مئوية تقريبا.

٣- بالنسبة للنعناع عند بداية التجفيف كانت نسبة الرطوبة على أساس رطب حوالى ٨٣ % وصلت فى نهاية التجفيف الى ١,١٦ % فى المجفف و ١٦ % فى التجفيف الطبيعى , أما بالنسبة للعنب عند بداية التجفيف كانت نسبة الرطوبة حوالى ٧٨ % وصلت فى نهاية التجفيف الى ٣,٦٧ % فى المجفف و ٣٩,٧٢ % فى التجفيف الطبيعى , وبالنسبة للبامية عند بداية التجفيف كانت نسبة الرطوبة حوالى ٨8.5 % وصلت فى نهاية التجفيف الى ٣٠,٣٠ % فى المجفف و ٥٢,٠٨ % فى التجفيف الطبيعى.

٤- معدل التجفيف للنعناع حوالى ٧,٦٨ و ٧,٤٠ جم/ساعة للمجفف والتجفيف الطبيعى على التوالى , معدل التجفيف للعنب حوالى ٧,١٧ و ٥,٩٢ جم/ساعة للمجفف والتجفيف الطبيعى على التوالى اما معدل التجفيف للبامية كان حوالى ٧,٠٨ و ٥,٩١ جم/ساعة للمجفف والتجفيف الطبيعى على التوالى .

٥- كفاءة التجفيف وصلت الى ٢٣ و ٢٢ % للمجفف والتجفيف الطبيعى على التوالى بالنسبة للنعناع اما العنب وصلت كفاءة التجفيف الى ٢٢ و ١٨ % للمجفف والتجفيف الطبيعى على التوالى وبالنسبة للبامية وصلت كفاءة التجفيف الى ٢٠,٨٥ و ١٨,٩٨ % للمجفف والتجفيف الطبيعى على التوالى.

التوصيات:

١- يمكن تصنيع المجفف بواسطة المزارعين الصغار أو ربات البيوت باستخدام خامات بسيطة ومتوفرة.

٢- يمكن استخدام المجفف مع تجفيف منتجات زراعية أخرى.

٣- يمكن زيادة إنتاجية المجفف بزيادة أبعاده وبالتالى زيادة عدد أرفف التجفيف بداخله وكذلك يمكن تزويده بوحدة تخزين الطاقة للاستفادة منها فى التجفيف ليلا.