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Evaluation of some performance parameters of indirect solar dryer for medicinal plants

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Key words: Solar, Cactus, medicinal plants, Basil, dryer.

Abstract

This research aimed to apply solar energy for dry some medical plants. The solar dryer is manufactured at the research center for energy and environment of the ministry of industry and minerals. This study included two dealings, where three levels speeds were selected for the fan (0.045, 0.055, 0.068 m3/s) which represented the main factor and three kind of medical plants, (Basil, garlic and Cactus). The study was concerned on the efficiency of the drying room (%), the rate of drying (%),The daily theoretical proficiency of the solar collector (%),Cost accounting (ID/kg) and the daily practical efficiency of the solar collector (%).Complete Randomized Design was followed to carry out this experiment with three replicates and The Statistical Analysis System (SAS) (2012) was used to study the effect of the dried substance type ,air flow rate and their overlap with studied parameters depending on the complete random design (CRD), differences were compared a many the averages by less significant difference (LSD). The results showed that when the air flow rate increased, the daily theoretical efficiency would increase about 75.52 %, 59.50 %. The greater the theoretical and practical efficiency, the lower the intensity of the fallen solar radiation. The increase in the intensity of the fallen solar radiation leads to a reduction in the efficiency of the solar dryer . Increasing speed leads to lower temperatures, which in turn reduces the extraction of moisture from the plant and thus decreases the moisture mass of the vapors.

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Introduction

Despite many disadvantages, solar drying is still practised in many places around the world such as tropical and subtropical countries. Solar energy is an important alternative source of energy and prefers for other energy sources because it is abundant, inexhaustible and unpolluted. It's also renewable, cheap and eco-friendly. Solar dryers are likely to be used throughout Turkey because of high radiation and the duration of the sunshine. Solar power dryers designed not only to meet certain drying needs of crops of interest but also to increase energy efficiency and conservation of agricultural management practices (Akpinar, 2010). Solar drying is a solar energy conversion technology to thermal energy used to raise the product's grade and evaporation moisture from it the operation may be by solar complexes with a natural or forced thermal load and be either direct or indirect (El Helfe ,2010). Solar drying gives a homogeneous, unshrunken and better nutritional product compared to electric dryers and natural solar drying, and the moisture of the food decreases with the increase in daylight hours (Ali Ashtiyeh and Rana, 2010). Medicinal plants are the main source of many medicinal drugs used for various therapeutic purposes, particularly in the treatment of many diseases chronic being a source of effective materials for the preparation of a lot of pharmaceutical compounds in the form of abstracts or other forms (Chkravarty & AL-Rawi 1998) The main purpose of drying products is to allow storage for longer periods, reduce packaging requirements and reduce freight weights. Solar drying is one of the most common methods used to conserve agricultural products in the world. However, they have some problems related to contamination with dust, soil, sand particles, insects and other weather factors. Also the required drying time can be too long, so drying in closed equipment should be undertaken to improve the quality of the final product .

Materials and methods

Descriptions of solar dryer and work location The solar drying plant was designed and manufactured and the experiment was carried out to dehydrate some medicinal plants in the Industrial Research and Development Authority - Renewable Energy Research Center of the Ministry of Industry and Minerals, Al-Jadriya, located 33.27 North latitude and 44.38 East longitude, 32 meters above sea level. drying for the period from 27/4/2017 to 15/6/2017 (April, May, June). In the experiment, two operators were selected. Three propeller velocities (0.068, 0.055, 0.045 m3/s) were selected and represented by the main factor. Three types of medicinal plants are Basil, garlic and Cactus. The studied qualities are: - efficiency of the drying room (%), the rate of drying (%),The daily theoretical efficiency of the solar collector (%),Cost accounting (ID/kg) and the daily practical efficiency of the solar collector (%).. The experiment was carried out according to Complete Randomized Design and three replicates.

The Statistical Analysis System (SAS) used data analysis to study the effect of the type of dryer material and the airflow rate and their overlap in the studied characteristics according to the complete random design (CRD). The differences between the averages with less significant difference (LSD).

The second unit is the dryer (the dehydrating room), which consists of a box containing a set of shelves on which the material is to be dry Delivering hot air to fan drying room. The objective of this study is to design an indirect solar dryer as the samples are drying by air passing through a radiator containing hot water coming from a solar collector with a vacuum tube type of air. The materials used to build indirect solar dryer are inexpensive and easily accessible in the domestic market.

Mathematical models used in the experiment

The efficiency of the drying room

It is the ratio between the energy required to evaporate the moisture and the energy entering the drying chamber and is calculated from the following mathematical relationship (Senadeera *et al.*, 2004).

$$\eta_d = \frac{m_w h_{fg}}{I_c A_c}$$

Mw: Vaporized water mass of food (kg).

$h_{fg=2260}$

I_c:solar radiation

Rate of drying

Is the ratio between the mass of the fumigating water from the material to be dried to the total time of drying and calculated from the following equation (El-Amin *et al.*, 2006).

$$M_{dr} = \frac{m_w}{T_d}$$

Cost accounting (ID/kg) (Atia, 2016)

$$T_C = \frac{\left(\frac{c}{L \times 12} + \frac{r \times c}{12} + OS\right)}{q_m}$$

C: System Price

r: Annual rate of repairs and maintenance (estimated at 3.5 of the initial price (c)

L: Average life of the device per year (estimated about 15 years).

OS :Worker's wages

q_m :Product Quantity

Daily theoretical efficiency of solar complex (%). (Itodo *et al.* 2002).

$$\eta_c = \frac{Q_u}{I_c A_c}$$

Daily practical efficiency of solar complex (%)

Qu= Cpw (Tc-Ta).

Results and discussion

Daily theoretical efficiency of solar complex (%).

Table 1 shows the effect of plant type, air flow rate and overlap in the theoretical competence of the solar collector. It was noted that there was a moral effect of the substance type and the air flow rate on the theoretical competence of the solar collector, due to the increase in the temperature difference between the inner and outward fluid of the solar compound.

Table 1. Effect of material type and air flow rate in theoretical efficiency.

Type of dehydrated substance	Air flow rate (m^3/s)			Average
	First velocity(0.045)	Second velocity(0.055)	Third velocity(0.068)	
garlic	70.13	73.20	77.76	73.69
Cactus	66.53	70.42	75.23	70.73
Basil,	75.00	71.84	73.58	73.47
The average	70.55	71.82	75.52	---

LCD Values: to substance type: 3.72 *, to Air flow rate: 3.72 *, to the overlap:9.232*

Table 2. Effect of material type and air flow rate in practical efficiency.

Type of dehydrated substance	Air flow rate (m^3/s)			Average
	First velocity **(0.045)**	Second velocity **(0.055)**	Third velocity **(0.068)**	
garlic	59.35	63.01	63.76	62.04
Cactus	56.11	54.12	56.58	55.60
Basil,	55.45	56.14	58.17	56.59
The average	56.97	57.76	59.50	---

LCD Values: to substance type: 4.123 *, to Air flow rate: 4.123, to the overlap:7.824*.

These results correspond to the results obtained both (2006) Karim, Khlifa (2007)and Joshi *et al.*, (2005). The Intersect was The binary between the material type and the flow rate is morally higher than the theoretical efficiency and its amount (% 77.76). Resulting from the interference of type (garlic) and speed (0. 065), the less theoretical efficiency has been obtained from the binary interference between the substance (Cactus) and the speed (0.045) and the amount (% 66.53).

Table 3. Effect of material type and air flow rate in drying room efficiency.

Type of dehydrated substance	Air flow rate (m3/s)			Average
	First velocity **(0.045)**	Second velocity **(0.055)**	Third velocity **(0.068)**	
garlic	23.86	18.54	6.13	16.18
Cactus	14.73	10.62	7.34	10.90
Basil,	18.22	15.28	10.72	14.74
The average	18.94	14.81	8.06	---

LCD Values: to substance type: 1.302 *, to Air flow rate: 1.302 *, to the overlap:2.503*.

Table 4. Effect of material type and air flow rate in rate of drying.

Type of dehydrated substance	Air flow rate (m3/s)			Average
	First velocity **(0.045)**	Second velocity **(0.055)**	Third velocity **(0.068)**	
garlic	9.12	6.40	2.38	5.96
Cactus	3.96	3.36	7.41	4.91
Basil,	4.22	4.56	3.88	4.22
The average	5.77	4.77	4.56	---

LCD Values: to substance type: 2.324, to Air flow rate: 2.324, to the overlap:4.678*

Daily practical efficiency of solar complex (%)

Table 2 shows the impact of the plant type and the air flow rate and the overlap between them in the operational efficiency of the solar collector. Resulting from the interference of the type (garlic) and velocity (0.065), the less theoretical efficiency has been obtained from the binary interference Between the type of substance (Cactus) and speed (0.055) and its amount (% 54.12). There was no moral effect of the air flow rate on the operational efficiency of the solar collector.

Table 5. Effect of material type and air flow rate in daily costs.

Type of dehydrated substance	Air flow rate (m3/s)			Average
	First velocity **(0.045)**	Second velocity **(0.055)**	Third velocity **(0.068)**	
garlic	4135	3384	3277	3598.67
Cactus	3541	3320	3262	3374.33
Basil,	3675	3818	4154	3882.33
The average	3783.67	3507.33	3564.33	---

LCD Values: to substance type: 154.72 *, to Air flow rate: 154.72 *, to the overlap:321.34.

Drying room efficiency (%)

Table 3 shows the effect of plant type and air flow rate and the overlap between them in the efficiency of the drying room. It was noted that there was a moral effect of the substance type and the air flow rate on the theoretical competence of the solar collector, due to the increase in the temperature difference between the inner and outward fluid of the solar compound. These results correspond to the results obtained both (2006) Karim, Khlifa (2007) and Usub *et al.*, (2007).

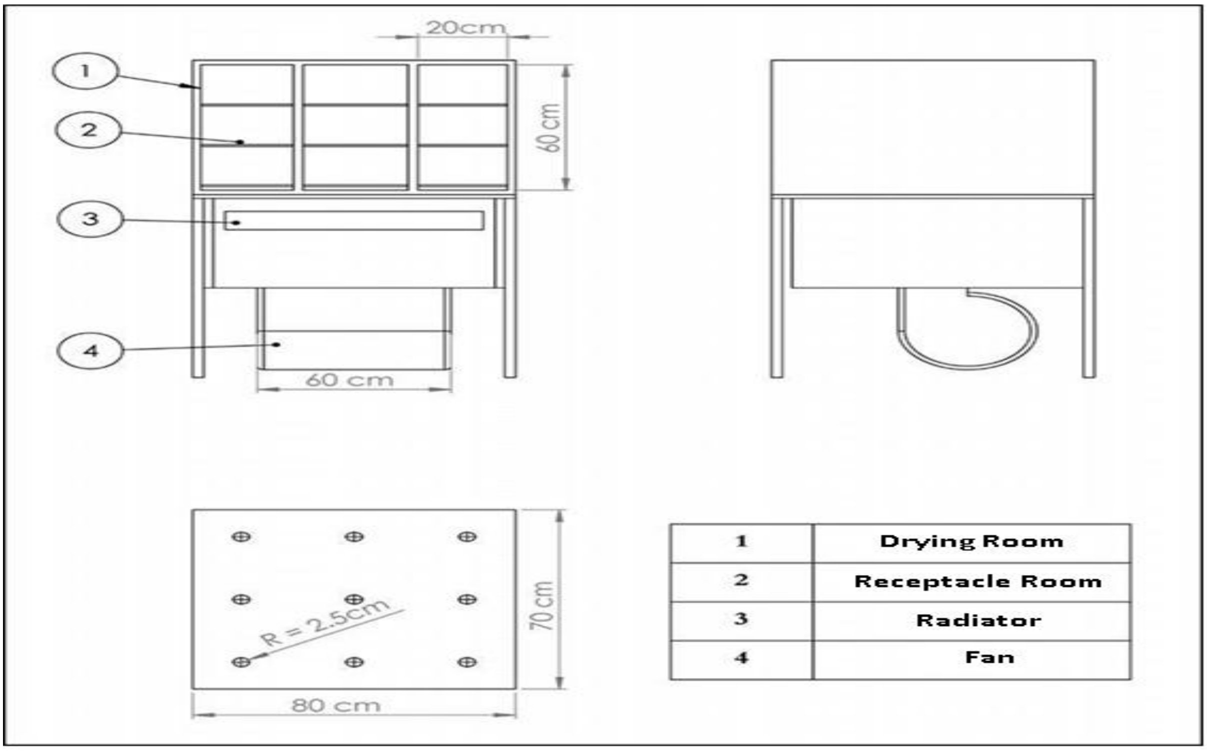

Fig. 1. drying chamber.

The Intersect was The binary between the material type and the flow rate is morally higher than the theoretical efficiency and its amount (% 23.86). Resulting from the interference of type (garlic) and speed (. 0450), the less theoretical efficiency has been obtained from the binary interference between the substance (garlic) and velocity (0.068) and the amount (% 6.13).

Rate of drying (%)

Table 4 shows the effect of plant type and air flow rate and the overlap between them in the rate of drying. It was noted that there was no moral effect on the type of substance and the rate of air flow at the rate of drying. The binary overlap between the type of material and the flow rate was immaterial, with the highest theoretical efficiency and the amount (% 9.12).

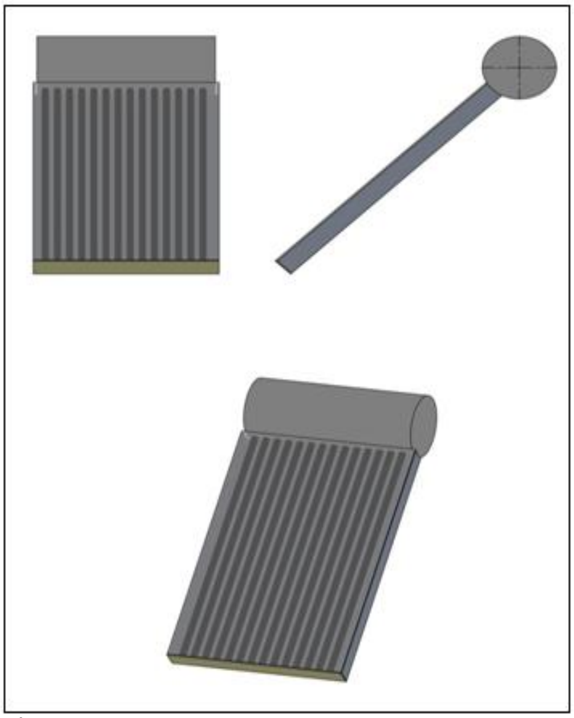

Fig. 2. Solar collector.

Resulting from the interference of type (garlic) and speed (. 0450), the less theoretical efficiency has been obtained from the bilateral overlap between the substance (garlic) and the velocity (0.068) and its amount (%2.38).These results are consistent with what he's got Bukola and Ayoola, (2008).

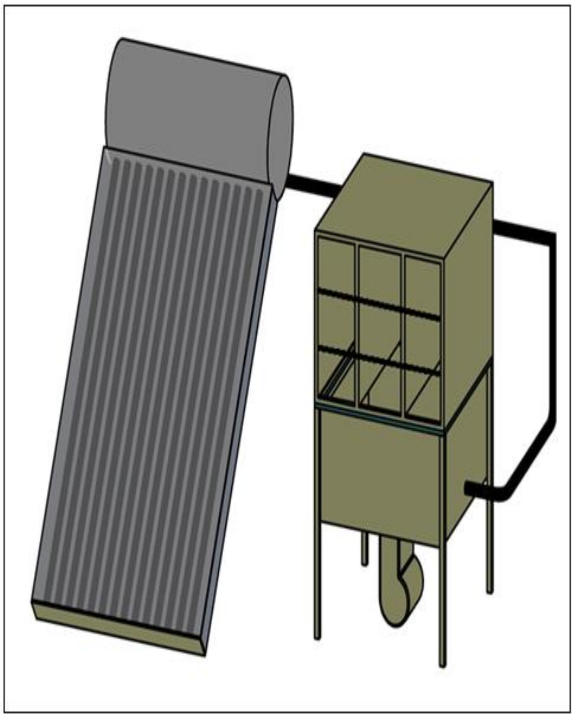

Fig. 3. Solar Drying System.

Cost accounting (ID/kg)

Table (5) shows the effect of the substance type, the air flow rate and the overlap on daily costs. It was noted that there was a moral effect on the type of material and the air flow rate on the daily costs. The binary overlap between the type of substance and the air flow rate did not have an impact on costs.

Conclusion

From this study it can be concluded that when the increased air flow rates led to an increase in thetheoretical and practical efficiency of the solar dryer could be increasedabout 75.52 %, 59.50 % respectively. Increased air flow rates reduce the water mass during the day as a result of lower temperatures within the drying room and thus a decrease in the efficiency of the dryer. The drying air again in the solar dryer and increasing intensity of the fallen solar radiation resulted in a lower efficiency of the solar dryer. Increasing speed leads to lower temperatures, which in turn reduces the extraction of moisture from the plant and thus decreases the moisture mass of the vapors. The incorporeal overlap between plant type and air flow rate has had a moral effect on the efficiency of the drying room, the rate of drying and costs.

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