EVALUATING OF INDIRECT SOLAR DRYER EFFICIENT PERFORMANCE AND IT'S IMPACT ON SOME MEDICAL PLANTS ACTIVITY

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ABSTRACT

The solar dryer is designed and manufactured to dry some medical plants at the Research Center for Energy and Environment of the Ministry of Industry and Minerals. this experiment was included two factors, where three levels speeds for the fan were selected (0.101, 0.065, 0.056 m3/s) which represented the main factor and three kind of medical plants ,(mint, pepper and ginger).factorial experiment within Complete Randomized Design with three replications was used to study the effect of the dried substance type ,air flow rate and their overlap with studied parameters. The results indicated that when the air flow rate increased, daily theoretical efficiency increased by 6.74%. and the theoretical and practical efficiency increases as you say the intensity of the fallen solar radiation. The increased intensity of the fallen solar radiation is resulting in a lower efficiency of the solar dryer. The alcohol extract of ginger was more effective against the growth of *E.Coli* bacteria than the rest of the extracts where the diameters ranged 20-25 mm. The alcohol extract of the pepper was effective against the growth of the *Staphy.aureus* bacteria better than the rest of the extracts where the diameters ranged (11-17) mm.

Key wards: Solar, drying, medicinal plants, mint.

***Bart of M.Sc. thesis of the second author.**

تقييم كفاءة أداء مجفف شمسي غير مباشر مصنع محلياً وأثره في فعالية بعض النباتات الطبية

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المستخلص

تم تصميم وتصنيع المجفف الشمسي لتجفيف بعض النباتات الطبية في هيئة البحث والتطوير الصناعي– مركز بحوث الطاقة المتجددة التابعة لوزارة الصناعة والمعادن. تضمنت التجربة عاملين، حيث انتخبت ثلاث سرع للمروحة (0.101، 0.065، 0.056 m3/s) ومثلت بالعامل الرئيس. وثلاثة انواع من النباتات الطبية هي النعناع ،الفلفل والزنجبيل. نفذت التجربة العاملية حسب التصميم العشوائي الكامل (Complete Randomized Design) وبثلاث مكررات. وبينت النتائج إنه عند زيادة معدل تدفق الهواء ازدادت الكفاءة النظرية اليومية بنسبة 6.74% . وتزداد الكفاءة النظرية والعملية كلما قلت شدة الاشعاع الشمسي الساقط. وإنّ زيادة شدة الاشعاع الشمسي الساقط تؤدي إلى انخفاض كفاءة المجفف الشمسي. كان المستخلص الكحولي للزنجبيل ذو فعالية مضادة لنمو البكتريا المعوية أفضل من باقي المستخلصات حيث تراوحت أقطار التثبيط بين (20–25) ملم. وكان المستخلص الكحولي للفلفل ذو فعالية مضادة لنمو البكتريا العنقودية أفضل من باقي المستخلصات حيث تراوحت أقطار التثبيط بين (11–17) ملم .

الكلمات المفتاحية: شمسي، تجفيف ،النباتات الطبية ،نعناع.

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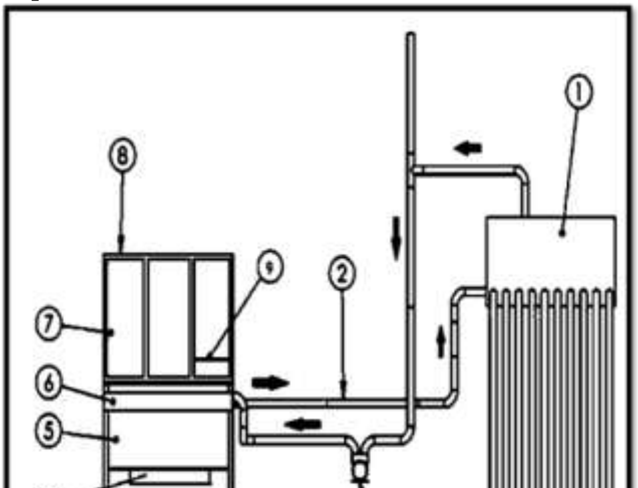
INTRODUCTION

The energy crisis has happened due to the increase in energy consumption, the decrease in the reserves of countries from traditional energies (coal and oil), the high oil prices after 1973 and the pollution resulting from the use of traditional energies. This led to the search for alternative energies in the early stages(5). Medical plants are the main source of many medicinal drugs used for various purposes especially in the treatment of many chronic diseases as it is a source of active substances that are involved in the preparation of many pharmaceutical compounds in the form of extracts or other forms(4). Ginger has health benefits from them that he is a tonic for the circulatory system, this plant also prevents a lot of heart disease as it reduces the speed of blood clotting, expands the vascular system and reduces the level cholesterol is a ginger of antioxidants and for the Zingbell the ability to influence cancer cells(14). And that the main characteristics of mint It is antiseptic and a healer for cramping, edema, brain and stomach. It is mainly consumed in many forms (liquid, aromatic oils and dried). The aromatic oils of mint contain many ingredients that are used in the manufacture of pharmaceuticals(15). Chili is one of the world's most widely cultivated plants and is grown in various parts of Iraq and its fruits are either red or green with a warm taste very much used in food industries and used as popular prescriptions to handle many pathological cases(3). The quality of the product depends on many factors, including drying temperature and drying time. Medicinal herbs require a low temperature. The basic components are stripped by drying at high temperatures (9)drying of agricultural and marine products is one of the most cost-effective solar energy applications. Many types of solar dryer have been designed and developed in different counties of the world, producing varying degrees of technical performance. Basically there are four types of solar dryer: direct solar dryer, indirect solar dryer, mixed mode dryer multiple disadvantages of solar dryer, it is still practiced in many places around the world such as tropical and subtropical countries. In fact, solar energy is an important alternative source of energy and is preferable to other sources of energy because it is abundant, inexhaustible and uncontaminated. They also have the ability to regenerate as well as being cheap and environmentally friendly(2).. In solar dryer, the product does not include any type of preservative or other additive chemicals, and the product is not exposed to any kind of harmful electromagnetic radiation or electromagnetic electrodes (1). The main purpose of product drying 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, it has some problems related to pollution with dust, soil, sand particles, insects and other weather factors. Also, the drying time required can be very long, so the dehydrating process should be carried out in closed equipment to improve the quality of the final product. A properly designed solar dryer can mitigate the defects associated with open sun drying (natural solar drying) and improve the quality of the dried product, which in turn causes high benefits to producers. Solar drying systems must be properly designed to meet special needs for specific crop drying and to give satisfactory performance in terms of energy needs(19). This study was conducted to study the performance of solar thermal collector, find the rate of drying ratio and maintain the active material of the medicinal plant.

MATERIAlS AND METHODS

The experiment was carried out from15th feb.to 26th April 2017 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 33.27º North latitude and 44.38º East longitude, 32 meters above sea level. Three air flow rate were adopted namely(201.6,234 and 363.6)m3/hr were selected and represented by the main factor. Three types of medicinal plants were used , mint, pepper and ginger. The studied parameters are: - Daily theoretical efficiency of the solar collector (%), daily practical efficiency of solar collector (%), efficiency of drying room (%) and medicinal plant efficacy. Factorial experiment was carried within

Complete Randomized Design and three replicates. The Statistical Analysis System software (17) 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 means compared using less significant difference (LSD). The indirect solar drying system consists of two separate units, the first one being the solar collector (Solar water heater) ,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 received from a evacuated tube 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. Figure 1 shows the main components of the dryer. It consists of the solar collector (water heater) and the drying room containing three drying depots.



1. Tubular sun heater\ no. of tubes 10\ length of tube 180 cm\ tube diameter 6.3.
2. Connecting Tubes. 3. Rotating pump.
4. Fan. 5. Tube to guide the air towards the radiator 6. Radiator.
7. Dehydrating Room.
8. Sandwich Panel (5 cm).
9. Metallic buckle.

Figure 1. schematic diagram of indirect dryer

Data processing

Useful energy extracted from the solar complex.

$Q_u = \dot{m}\, Cp_w(T_c\text{-}T_a)$ (1

$\dot{m}$: Mass flow rate of water outside the solar collector (kg / s)

Cpw: Specific thermal capacity of water (kJ / kg. K)

Tc: Surface temperature of the absorbent part (K).

Ta: Ambient temperature (K).

The theoretical efficiency of the solar collector can be defined (10) as:

$$\eta_c = \frac{Q_u}{I_c A_c} \qquad (2)$$

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 (19).

$$\eta_d = \frac{m_w h_{fg}}{I_c A_c} \qquad (3)$$

Mw: Vaporized water mass of food (kg).

Solar collector Area (14)

$$\boldsymbol{Ac} = \frac{\mathbf{mw}\ h_{fg}}{\mathbf{IT}(\tau\acute{\alpha})\boldsymbol{tAc\eta c}} \qquad (4)$$

QL Is the sum of the losses caused by convection and radiation heat transfer and can be written in another form as received from (9):

QL= UL Ac (Tc-Ta) (5)

The total energy needed to dry out a certain amount of nutrients can be estimated using the basic energy balance formula for evaporation of water(7,20):

mw Lv = ma Cp (T1 – T2) (6)

RESULTS AND DISCUSSION

1- Daily theoretical efficiency of solar complex (%).

Table 1 shows the effect of the plant type and the rate of air flow and their interplay in the Daily theoretical efficiency of the solar collector. It was noticed that there were significant efficiency difference according to plant type (peppers and mint) with a percentage increase from 76.72 to 82.43 by 6.92%. There were inconsiderable differences in the type of substance between pepper and ginger, as well as ginger and mint. Significant increase of collector efficiency were found when the airflow rate changed from 0.056 m3 / s to 0.101 m3 / s. The theoretical efficiency increased from 76.92 to 82.48 by 6.74 %. There were no significant differences between the first and second speeds as well as the second and third,. These results are consistent with the results obtained by other Researchers (12,13). The binary interference between the material type and the flow rate was significant, with the highest theoretical efficiency (%84.1) (Ginger) and velocity (0.101m3/s).The minimum efficiency obtained from the binary interference between the material type (Pepper) and speed (0.056) was(73.1%)

Table 1. Effect of plant type and airflow rate in theoretical efficiency

Type of dehydrated substance	Air flow rate (m^3/s) (0.056)	(0.065)	(0.101)	mean
Pepper	73.10	77.28	79.77	76.72
Ginger	75.62	79.57	84.18	79.79
Mint	82.05	81.73	83.50	82.43
mean	76.92	79.53	82.48	---
LCD Values: to substance type: 5.23*, to Air flow rate: 5.23*, Interaction: 9.062*				

2- Daily practical efficiency of solar complex (%)

Table 2 shows the effect of plant type and the rate of air flow on the daily operation efficiency of the solar collector. The efficiency decreased from 63.46 to 56.61 with a percentage decrease of 10.79% for pepper and ginger. A significant differences are reported for peppers and mint where the efficiency decreased from 63.46 to 57.40 the percentage of decline 9,54 %,, and this reduction is due to the increase of the intensity of solar radiation to the maximum limits at that time. the differences were no significant in the type of substance between ginger and mint. Also were no significant differences in air flow rate in the daily operation efficiency of the solar collector. The interaction between the material type and the airflow rate was significant, with the highest practical efficiency (64.8%), resulting from the interaction the type (pepper) and velocity (0.101m3/s). The lowest theoretical efficiency was obtained from the binary interaction between the material type (Ginger) and speed (0.065m3/s) and the amount(55.1%).

Table 2. Effect of plant type and air flow rate in process efficiency

Type of dehydrated substance	Air flow rate (m^3/s) (0.056)	(0.065)	(0.101)	mean
Pepper	60.76	64.78	64.83	63.46
Ginger	57.12	55.12	57.58	56.61
Mint	56.48	56.53	59.18	57.40
mean	58.12	58.81	60.53	---
LCD Values: to substance type: 4.627*, to Air flow rate: *, *4.627interaction:8.015*				

3- Efficiency of the drying room (%)

Table 3 shows the effect of plant type and the rate of air flow on the efficiency of the solar dryer. It was noticed that there was a significant effect of the type of substance between pepper and ginger, where the efficiency decreased from 17.95 to 12.18 by a decrease of 32.14% and increased by mint to 16.17 by increase of 24.67%. The decrease in efficiency is due to the increase in the intensity of the solar radiation falling on the absorbent board. These results are consistent with that of the results of other researchers (11,21) The interaction between the material type and the air flow rate was significant, with the highest efficiency of the dryer and its percentage (26.9%), resulting from the overlap of type (pepper) and velocity (0.056). Pepper) and speed (0.101) and the amount (7%).

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

Type of dehydrated substance	Air flow rate (m^3/s) (0.056)	(0.065)	(0.101)	mean
Pepper	26.97	19.88	7.00	17.95
Ginger	16.80	11.53	8.21	12.18
Mint	19.35	16.30	12.85	16.17
mean	21.04	15.91	9.36	---
LCD Values: to substance type: 1.273 *, to Air flow * 1.273 :rate2.205 *, interaction:				

4- Medical plant efficiency

Table 4 shows the effect of the alcohol extracted from ginger, peppers and mint on the diameter of the inhibition area of the *E.Coli* bacteria. It was found that the alcohol extracted from ginger is more effective against the bacterial growth than the rest of the extracts. The diameters ranged from 20-25 mm. Increases the production of dermicidin in sweat, a substance that protects the Adhesion and growth of E. coli. As for peppers, the diameters ranged 12-17 mm and the least affected mint on *Staphy.aureus* bacteria where the diameters ranged between 12-14 mm. This may be due to the plant extracts themselves, which may contain compounds that inhibit or inhibit the growth of some microorganisms, but some of them may lose their inhibitory ability during extraction or storage methods. In addition, this activity is already reduced in some plant extracts or during certain reactions. Its concentration is an important and influential factor in the inhibitory action of each extract.

Table 4. Effect of alcohol extracts of ginger, peppers and mint on the diameter of the inhibition area (mm) of E.coli bacteria

Third flow rate (0.101)	Second flow rate (0.065)	First flow rate (0.056)	Type of dehydrated substance
22	25	20	Ginger
17	13	12	Pepper
14	13	12	Mint

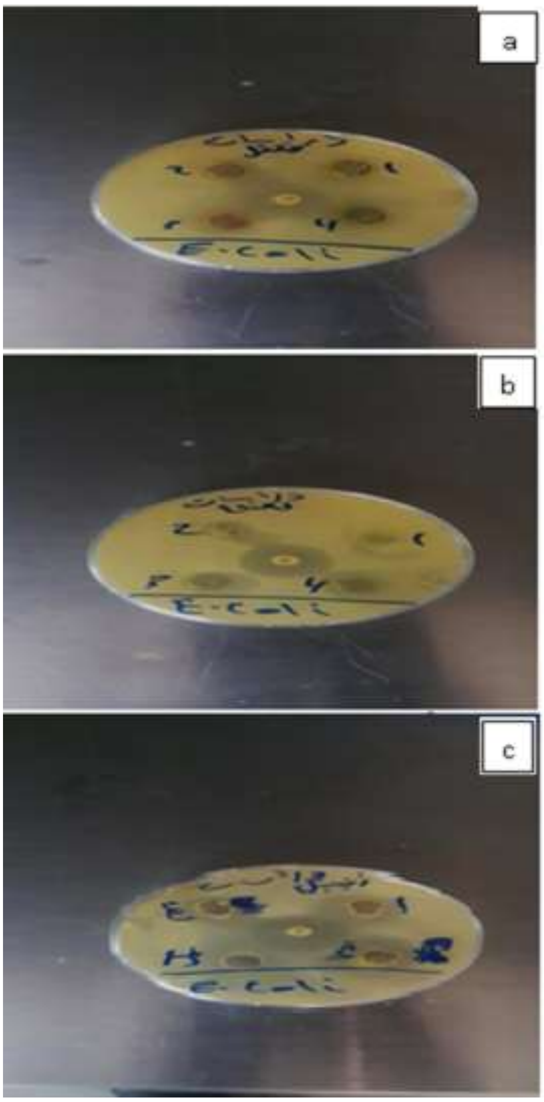


Figure 2. a: Effect of the alcohol extract of the pepper on the E. colib bacteria.b: Effect of the alcohol extract of the mint on the E. colic bacteria. C:Effect of the alcohol extracts of the ginger on the E. coli bacteria

Table 5 shows the effect of the type of material and the rate of air flow and their interaction on *E.Coli* bacteria (inhibition diameters). There was a significant effect of the material type on the diameters of the bacteria inhibition of the intestinal. This is due to the difference in the active substances found in these plants as well as the difference in their concentrations. The double interaction between the material type and the air flow rate has a significant effect. The highest diameter of the inhibition of 25 mm, (Ginger) and speed (0.065). The lowest diameter of the inhibition was obtained from the double interference between the peppers, peppermint and speed (0.056) and the amount of (12) mm. There was no significant effect of the air flow rate on diameters.

Table 5. Effect of material type and air flow rate on E.Coli bacteria

Type of dehydrated substance	Air flow rate (m^3/s) (0.056)	(0.065)	(0.101)	mean
Pepper	12	13	17	14.00
Ginger	20	25	22	22.33
Mint	12	13	14	13.00
mean	14.67	17.00	17.67	---
LCD Values: to substance type: 3.079 *, to Air flow * 6.183rate: 3.079*, interaction:				

Table 6. Effect of alcohol extracts of ginger, peppers and mint on the diameter of the inhibition area (mm) of the *Staphy.aureus* bacteria

0.101)	(0.065)	(0.056)	Type of dehydrated substance
11	11	11	Ginger
11	17	15	Pepper
10	10	10	Mint

The effect of the alcohol extract of ginger, peppers and mint on the diameter of the inhibition area of the *Staphy.aureus* bacteria are given in table (6). It was found that the extract of the peppers is more effective than the rest of the extracts. The diameters ranged from 11-17 mm to contain the capsaicin which affects the bacteria. The peppers had diameters of 11 mm and mints 10 mm.

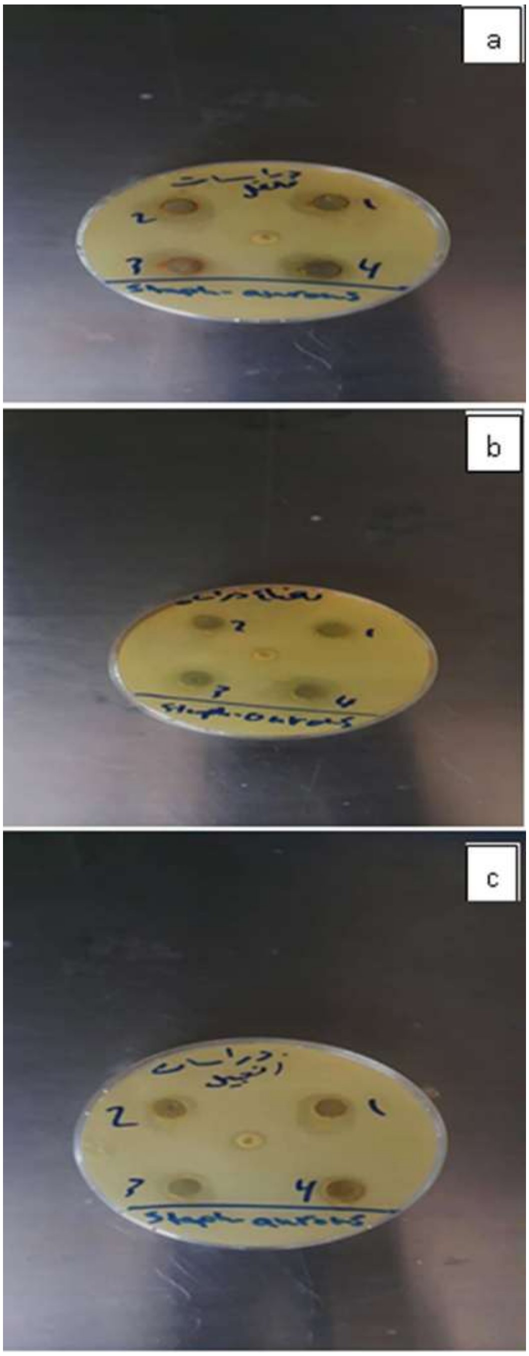


Figure 3. a. Effect of the alcohol extract of the pepper on the Staphy.aureus bacteria. b: the Effect of the alcohol extract of the mint on the Staphy.aureus bacteria. c: the Effect of the alcohol extract of the ginger on Staphy.aureus bacteria

Table 7 shows the effect of the type of material and the rate of air flow and their interaction on the *Staphy.aureus* bacteria (diameters). There was a significant effect of the type of material on the diameters of the bacteria inhibition of the bacteria. This effect is due to the difference in the active substances in these plants as well as the difference in concentrations. The binary interaction between the material type and the airflow rate has a significant effect, with the highest diameter of 17 mm, (Pepper) and speed (.0650). The lowest diameter of the inhibition was obtained from the double interaction between the type (mint) and the first, second, and third velocity (10). There was no significant effect of the air flow rate on the diameters.

Table 7. Effect of material type and air flow rate on *Staphy.aureus* bacteria

Type of dehydrated substance	Air flow rate (m^3/s) (0.056)	(0.065)	(0.101)	mean
Pepper	15	17	11	14.33
Ginger	11	11	11	11.00
Mint	10	10	10	10.00
mean	12.00	12.67	10.67	---
LCD Values: to substance type: : 2.263 *, to Air flow rate: * 4.2942.263 *,interaction:				

The results showed that when the air flow rate increased, the daily theoretical efficiency and daily operation of the solar collector increased. Increasing the intensity of the sun's falling radiation results in a decrease in the efficiency of the solar dehydrator. The interaction between the material type and the air flow rate had a significant effect on the daily efficiency of the solar collector, the daily efficiency of the solar collector, the efficiency of the dehydrating chamber, The alcohol extract of ginger was more effective against the growth of *E.Coli* bacteria than the rest of the extracts where the diameters ranged 20-25 mm. The alcohol extract of the pepper was effective against the growth of the *Staphy.aureus* bacteria better than the rest of the extracts where the diameters ranged (11-17) mm.

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