Prospects of Modern Technology in Agricultural Engineering and Management of Environmental Problems: 193 - 212

DEVELOPMENT AND EVALUATE A SOLAR COOKER TO BE USED FOR COOKING AND DRYING SOME AGRICULTURAL PRODUCTS

*Mona M. A. Hassan

ABSTRACT

Solar drying and cooking are interrelated activities which have been studied for several years. However, successful use of solar energy should always be accompanied by scientific and technical analysis of each application. In this study a solar cooker with one reflector was provided, to enhance the incident solar radiation on the glass cover during the course of the sun exposure experimented and testing it as a solar dryer to make this system multi purposes. .This study was constructed in faculty of agriculture, Zagazig University (2012). The obtained data showed that, the standardized cooking power was found to be inversely proportional to temperature difference (T_w-T_{amb}). The values of the utilization thermal efficiency are 45.3,67.6 and 74.47% for 1,1.5 and 2 kg of water respectively. The cooking time taken for the different materials were 70,80 and 95 minutes for rice, potatoes slices and cake. The moisture content of onion and apricot reached to 25 and 10.31 % dry basis in 9 and 14 h of drying in the solar dryer respectively. Both of the examined models (Simple and Page's model) could satisfactory describe the change in onion and apricot moisture content during the drying process.

***Keywords**: solar energy, solar cookers, solar dryers.*

INTRODUCTION

In developing countries where access to power grids or reliable sources of energy is cumbersome and sometimes difficult, solar energy has proven time and time again to satisfactorily meet the energy needs of communities around the world. Flat-plate collectors are in wide use for domestic household hot-water heating and for space heating. Solar drying and cooking are interrelated activities which have been studied for several years. Solar cooking presents an alternative energy source for cooking.

*Lecturer of Agricultural Engineering, Faculty of Agriculture, Zagazig University

It is a simple, safe and convenient way to cook food without consuming fuels, heating up the kitchen and polluting the environment. It is appropriate for hundreds of millions of people around the world with scarce fuel and financial resource to pay for cooking fuel. Solar cookers can also be used for boiling of drinking water, providing access to safe drinking water to millions of people thus preventing waterborne illnesses. Solar cookers have many advantages, on the health, time and income of the users and on the environment. In tropical countries, the solar energy is plenty and therefore it becomes a reliable and sustainable source of energy. There are still critical issues yet to be resolved in order to make that technology acceptable for wider dissemination. The principle of solar cooking is that rays of sun are converted to heat and conducted into the cooking pot. The ability of a solar cooker to collect sunlight is directly related to the projected area of the collector perpendicular to the incident radiation. ***Funk(1999)*** found that the resulting solar cooker power curve is a useful device for interpreting the capacity and heat retention ability of a solar cooker, the two parameters most important to performance. The cooking power curve found by using the international test standard appeared to be independent of location and date provided the protocol could be followed (clear skies, low wind). The proposed international standard for testing solar cookers and reporting performance was applied to historical solar cooker test data to show that it is a useful tool for evaluating the relative performance of different designs. ***Nahar (2003)*** reported that, the performance of a flat plate collector depends on it's design parameters included type of absorber, type of cover, thickness and type of insulation. Beside these the performance also depends on the metrological and operating conditions. ***Kassem et al.(2006)***concluded that the solar drying method is comparable with the natural drying regarding the percentage of water loss from the plant material, however the solar drying is supposed to be faster than the natural drying. plants dried by this method kept their essential oil content as high as possible and better regarding the chlorophylls content in the dried herb. ***Gbaha et al. (2007)*** found that the drying rate increases with drying air temperature and drying air mass flow

Kimambo(2007) found that the reflector cooker with glass reflector achieved highest temperatures and accordingly shortest cooking times than any other cookers tested under sunny days with no cloud cover.
The objectives of this work are to: (a)Evaluate the thermal performance of a solar cooker with a reflector. (b)Carry out Water boiling tests and conduct controlled cooking tests (c) Test the cooker as a solar dryer to dry vegetables like onion and fruits like apricot.

MATERIALS AND METHODS

This study was conducted in the faculty of agriculture, Zagazig University (longitude =35° 30° and latitude =31° 31°) in June 2012, to fabricate and develop a solar cooker with a reflector and test it as a solar dryer to dry some agricultural products .

Description of the solar cooker before development:

Solar cooker used for the experiment is a commercially available single glazed conventional box type. It was made of wood with thickness of 1.5 cm and 70 x 60 x 24, outer dimensions , 55 x 48 x 20 cm inner dimensions and on the top there is a groove 1.5 x 1 cm along the four sides prepared to fit the glass cover. The cross-section of the cooker is shown schematically in Figure(1,2). Commercially available 0.1 cm thick iron sheet was used as the absorber plate 50 x 45 x 6.5 cm. It was painted with matt black paint to improve its absorptivity. Iron satisfies the desirable absorber plate characteristics of good thermal conductivity. Glass wool insulation was used on the bottom and sides of the cooker to minimize the heat losses. The gap between outer and inner box of the cooker was filled with 4 cm glass wool. The glazing material was commercially available 5 mm thick tempered glass which satisfies the desirable cover properties of high optical transmittance, low reflectivity and absorption of solar radiation. The cooking vessel was made of black painted aluminum pot in cylindrical shape having 21 cm diameter and 10 cm depth. It has a flat base for obtaining good thermal contact with the absorber plate. It was placed in the center of the absorber plate inside the cooker. The corners and edges of the box were well covered with silicon sealant to prevent any air leakage or infiltration. The box of the cooker receives the solar radiation both directly and by reflection. The plane mirror reflector was suitably fixed on a wood framework 70x 60 cm. The plane reflector was made of a commercially available mirror, which has the desired property of high optical reflectivity. The plane reflector can opened at any angle using a tilt angle with horizontal 80° at 9:00 am and 110° for the end of the day .

Description of the solar cooker after development:

To work as a solar dryer:

Nine holes each 1 cm in diameter were added to increase air flow. The inlet air holes were positioned at the front wooden sheet and the outlet air holes 5 cm from the top edge of the back wooden sheet of the solar dryer. The air flows into dryer at the air inlet holes, passes through the product and brings the moisture into the air stream, which then flows out into the atmosphere through the air outlet holes. The dryer has one perforated tray with net surface area of 0.12 m^2. With dimensions of 35x35 cm . The tray consists of a frame made from wood bars and the bottom from plastic mesh.

The experimental procedures:

The experiments were carried out to evaluate a simple design of a box solar cooker with one reflector and testing it as a solar dryer under Egyptian conditions during the summer of 2012.

1- The cooker:

A simple type solar cooker was constructed and its thermal performance was evaluated. The ambient temperature, absorber plate temperature, pot water temperature, inner air temperature, and the solar radiation intensity were measured. The cooker was not loaded for the first day, and loaded with different quantities of water 1.0 , 1.5 and 2.0 kg of water, and different cooking materials(0.5 kg of rice , 0.5 kg of potatoes slices(5 mm) , and 0.5 kg of cake).

2- The experimental procedures for the cooker as a dyer:

The experiments were carried out to test the cooker as a dryer for drying onion slices(1.5 mm) and half apricot fruit. The product was spread out over the tray in a single layer in the dryer. The glass cover was opened from front side about 1 cm height from 11:00 am to 14:00 pm to keep the temperature inside

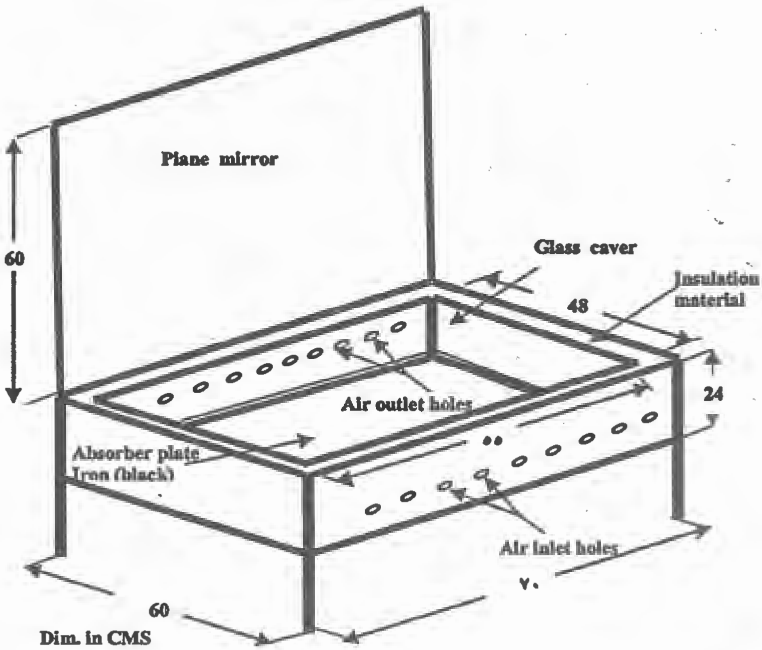


Figure (1) Isometric view of constructed box cooker

Figure(2):The components of the box-type solar cooker the dryer under 70°C. The ambient temperature, absorber plate temperature, weight loss of the samples and the solar radiation intensity were measured.

Measurements were taken at intervals of 1.0 hour during the effective sunshine period from 9:00 am to 17:00 pm.

Temperature measurements were taken with K-type thermometer with an accuracy of 0.1 °C range (-50-1300°C ± 0.5%+1°C). The solar radiation intensity on horizontal surface were measured by "Watchdog" weather station model 900 ET. The weather station measures wind speed (0-175 mph) ± 5%, wind direction (2° 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).

Measurements:

Solar cookers:

Thermal Figures of Merit:

Figures of merit are reference numbers that are assumed to be determined for all cookers in a consistent manner.

There are four thermal figures of merit defined by this framework.

1. Standard Stagnation Temperature
2. Standard Cooking Power
3. Standard Sensible Heating Time
4. Unattended Cooking Time

-Standard Stagnation Temperature(SST):

It is a measure of the maximum air temperature reached inside the cooking vessel under normalized conditions. To conduct this test, the cooker is oriented towards the sun with an air filled cooking vessel. Temperature measurements are taken as the air inside the cooking vessel is heated by the incident solar energy. Testing is concluded when temperature stabilizes at a constant value (within 2-3%) or when 2 hours have passed. This value is normalized to a total irradiance of 850 W/m^2.

$$SST = \frac{T_{ps} - T_a}{I_{measured}}, \qquad c^{\circ} m^2 / W$$

Where, T_{ps} = Plate stagnation temperature(°C), Ta = Ambient air temperature(°C), $I_{measured}$ = Horizontal insolation(W/m^2), when stagnation temperature reached .

-Standard Cooking Power(P):

is a measure of how much power is delivered, under normalized insolation, to the contents of the cooking vessel. The cooking pot is filled with a mass of distilled water equal to 1.0 , 1.5 and 2.0 kg and oriented to face the sun. Testing is concluded when the water temperature reaches 95°C or when 4 hours have passed, whichever occurs first. The obtained temperature over time curve is reduced to a single measure of performance by dividing the testing period into 1 hour intervals. ***ASAE Standards S580(2003)***

$$P = \frac{MC(T_2 - T_1)}{3600} \quad ,W$$

Where, M = Mass of water in cooking vessel(kg), C = Specific heat of water(J/kg°C), T_2 = Water temperature at end of interval(°C) and T_1 = Water temperature at beginning of interval(°C).

This cooking power is then normalized to 850 W/m².

$$P_n = p\left(\frac{850W/m^2}{I_{measured}}\right) \quad ,W$$

Where, $I_{measured}$ = Measured insolation averaged over the interval(W/m²). Finally, these equations must be reduced to a single measure of performance. This is done by plotting P_n against ΔT and performing a linear regression, where ΔT refers to T_{water}-$T_{ambient}$ (recorded for each interval). The Standard Cooking Power is taken from this regression for a ΔT value of 50°C. The R^2 value for this regression fit should be reported and the data must be taken until a fit can be made with a R^2 of at least 0.75. The length of time taken for this test should be 4 hours, beginning in the morning or the length of time taken for the pot contents to reach 95°C, whichever occurs first.

- Standard Sensible Heating Time(t_0):

Perhaps more important than power and temperature, is the time taken to perform a cooking function. Therefore, this figure of merit indicates how long it will take the cooker under investigation to heat a known quantity of water to 50°C above ambient temperature under a horizontal insolation of 850 W/m^2.

$$t_e = \left(\frac{I \Delta T_e t}{I_e \Delta T}\right) \quad ,hours.$$

Where, ΔT_0 = 50(°C), I_0 = 850 (W/m^2) ,I = Horizontal irradiance averaged over entire interval (W/m^2), t = Length of measured interval(hours) ΔT = Temperature difference over measured interval(°C).

- Unattended Cooking Time($t_{c,s}$):

Describes how long a cooker can retain cooking temperatures unattended while the user performs other activities. To perform this test, the cooker is oriented towards the sun and left there, while water temperature is monitored. This test should be conducted directly after the test for Standard Sensible Heating Time and Standard Cooking Power so that the water is initially at a high temperature. The test is conducted until the temperature of the water decreases by 20°C from its starting temperature.

$$t_{c,s} = t_c \left(\frac{I_e}{I}\right) \quad ,hours.$$

Where, $t_{c,s}$ = Cooling time standardized(hours) t_c = Cooling time measured(hours) and I = Horizontal insolation, averaged over test period(W/m^2).

- The utilization thermal Efficiency(η_u):

El-Sebaii and Ibrahim(2005) defined the utilization thermal efficiency

$$\eta_u = \frac{m_w C_w \Delta T}{I_{avg} A_c \Delta t} \quad \text{as:} \qquad , \text{decimal}$$

Where: m_w, C_w are the mass (kg) and specific heat (J/kg°C) of water, respectively. ΔT is the temperature difference between the maximum temperature of water and the mean ambient air temperature during the interval Δt, (°C), I_{avg} is the solar intensity during the time interval (W/m^2) and A_c is the aperture area (m^2) of the cooker.

Solar dryer:

- The moisture ratio (*MR*) and drying rate :

The moisture ratio (*MR*) and drying rate were calculated by using the following equations:

$$MR=\frac{M_t-M_e}{M_i-M_e}\text{, decimal}$$

$M_e=(M_f+M_f)-(Mm)^2/(Mi+M_f)-2(Mm)$ *(O,Callaghan and Nellist,1971)*

$$Drying\ rate=\frac{M_{t-dt}-M_t}{dt}\text{, kg water/min}$$

Where: M_i, M_f are Initial and final moisture contents (db%), *Mm* is moisture content at half time(db%), M_e is Material moisture content in equilibrium with the drying air(db%), M_{t-dt} and M_t are the moisture contents at t-dt and *t* , respectively(db%), and *dt* is the drying time period(min.).

- Thin layer Drying Equations:

1- The simple exponential equation *(Hukill, 1947):*

$$MR=\frac{M-M_e}{M_O-M_e}=\exp(-kt)$$

Where :MR: Moisture ratio(db%), dimensionless, M : Material moisture content,(db%), t: Time, (h) and k : the drying rate constant, (min^{-1}).

The simple exponential model has been applied to fit the drying data of the date . After converting its form to the logarithmic form relating the moisture ratio(MR) of the tested sample with the elapsed drying time "t" as follows:

$$Ln\ MR=(-kt)$$

2- Page's model *(Page, 1949):*

$$MR=\frac{M-M_e}{M_O-M_e}=exp(-kt^u)$$

The page's model has been applied also to fit the drying data after converting its form to:

$$Ln(-Ln(MR))=Ln(K)+u.Ln(t)$$

u : the drying rate constant,(min^{-1}).

RESULTS AND DISCUSSION

The obtained results of this study will be discussed under the following headings:

Solar cooker:

-Effect of loading Density on the Cooker Temperatures:

Figure (3) showed the effect of load on the cooker temperatures. it was seen that the temperatures of the cooker increase during the day until they achieve their maximum values at 13:00 PM. Therefore; the best time for cooking is around solar noon at high solar radiation. It was noticed also that the maximum water temperatures of 95.2 and 93.6 °C were obtained at 13:00 pm with 1 and 1.5 kg load respectively and reached to 92.9 °C at 14:00 pm with 2 kg load. That means when the load increased, it needs more time to reach the maximum value of the temperature.

-Thermal Figures of Merit:

1- Standard Stagnation Temperature:

The results showed that the value of SST was 0.087 °C m^2/W at stagnation plate temperature of 113 °C ,ambient air temperature of 33 °C and insolation on a horizontal surface of 915 W/m^2 that means the cooker can be used twice a day for consecutive cooking.

2- Standard Cooking Power:

The results presented in Figures (4), (5) and (6) showed A linear regression relationship between (P_n) and ($T_w - T_{amb}$). The linear regression equations and the values of the coefficient of determination (R^2) of the equations were $p_n = -2.205(T_W - T_{amb}) + 428.41$, (0.9331) for 1 kg of water, $p_n = -3.4561(T_W - T_{amb}) + 647.73$,(0.9368) for 1.5 kg of water and $p_n = -5.2583(T_W - T_{amb}) + 866.47$,(0.7131) for 2 kg of water .The standardized cooking power was found to be inversely proportional to temperature difference (T_w-T_{amb}).From the previous data, it can be referred that, there were a highly positive relation with high (R^2).

3- Standard Sensible Heating Time:

The cooker took about 1.42,1.51 and 3.09 hours for 1,1.5 and 2 kg of water respectively to heat water 50°C above ambient temperature. When the load increased, it needs more time to reach water temperature 50°C above ambient temperature .

4- Unattended Cooking Time:

The cooker took about 4.37, 4.66 and 5.37 hours for 1,1.5 and 2 kg of water respectively to decreases by 20°C from its maximum temperature. When the load increased, it needs more time for water to lose about 20°C from its maximum temperature.

-Effect of loading density on the utilization thermal efficiency:

From figure (7) the results indicated that the value of η_u increased when the load increased. The values of η_u were 45.3,67.6 and 74.47% for 1,1.5 and 2 kg of water respectively.

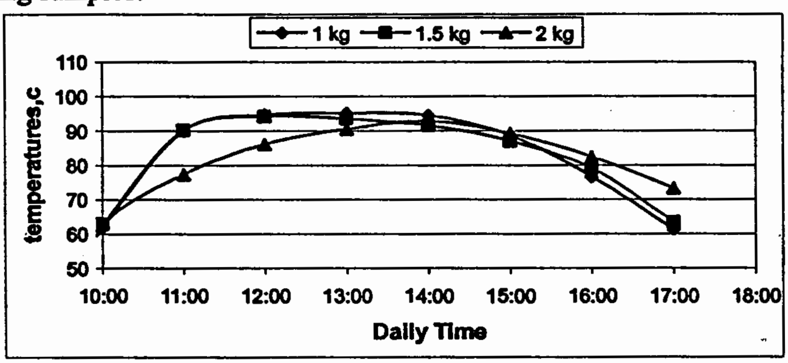
- The Cooking Time:

Three cooking tests with different cooking raw materials were conducted for determining cooking time. The materials were rice, potato and cake. The cooking time taken for the different materials were 70,80 and 95 minutes for rice, potatoes slices with water and cake respectively.

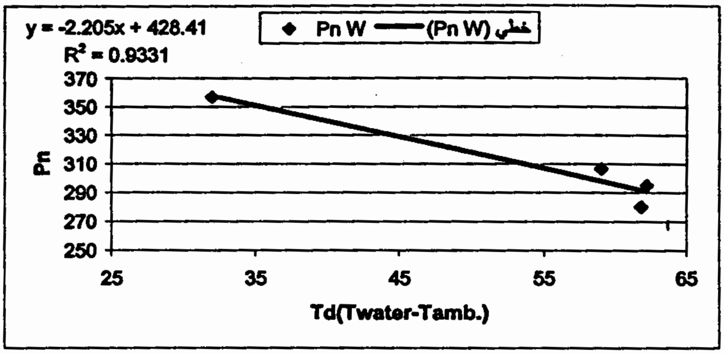
Solar Dyer:

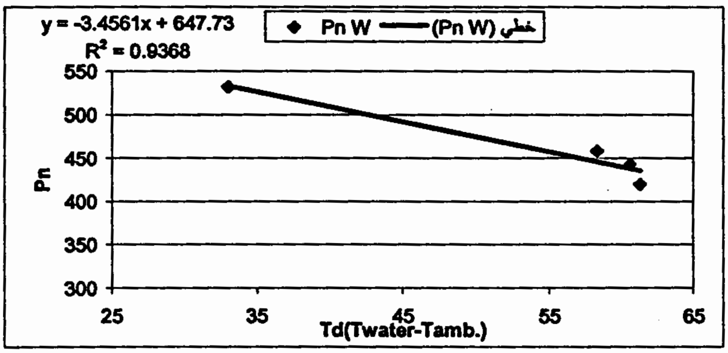
-Drying Kinetics of onion and apricot:

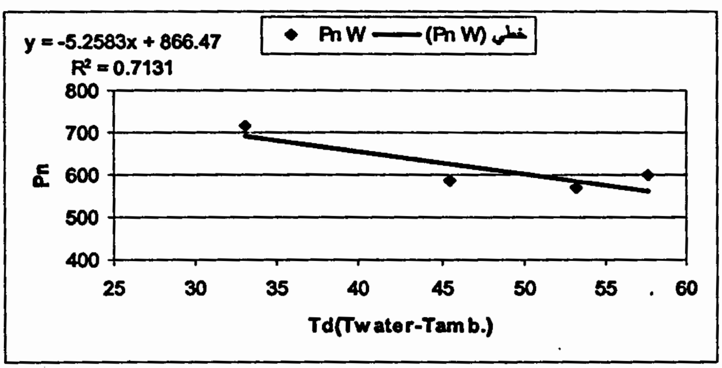
From the experimental data, the moisture contents of onion and apricot for the solar dryer at any time are represented in Figure (8). It was clearly evident from these curves that the moisture content of onion and apricot reached to 25 and 10.31 % dry basis in 9 and 14 h of drying in the solar dryer respectively, This can explained that the main factor influencing drying rate was the drying air temperature. solar dryer can generate higher air temperature and significantly affected the increasing of evaporation rate of water and then led to lower final moisture content of drying samples.



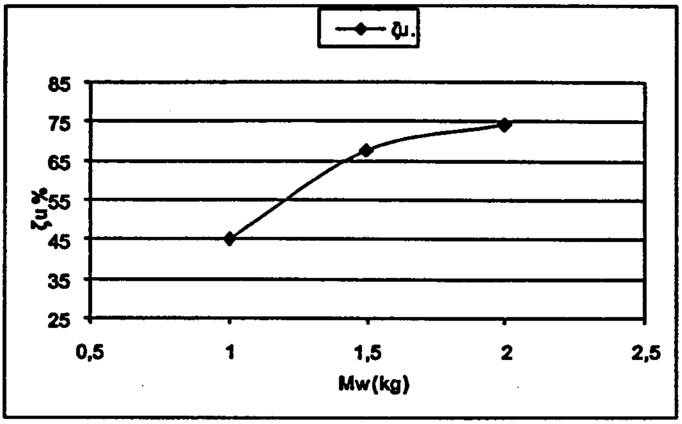
Figure(3): Effect of loading density on the Cooker Temperatures







Figure(4,5,6): The standardized cooking power as a function of (Tw-Tamb) for 1,1.5,2 kg of water respectively.



Figure(7): Effect of loading density on the utilization thermal efficiency.

Figure (9) shows the variation of the drying rate with drying time of onion and apricot , obtained by calculating from experimental data. The initial adjustment period of rise in temperature is ignored in the analysis of drying time. The drying rate for solar dryer comprises 2 distinct drying periods, that is, the constant-rate period and falling-rate period. In the constant-rate period, the onion and apricot surfaces is wet and a continuous film of water exists on the surface having temperature approximately that of wet bulb temperature in the solar dryer. The energy received by the product is entirely used for vaporization of the surface water. For the falling-rate period, the surface is no longer wetted. The evaporation zone is then inside the product.

- Modeling of the Drying Curve:

In order to determine the appropriate drying equation, the drying constants of the drying models were estimated from the experimental results using a nonlinear regression method.

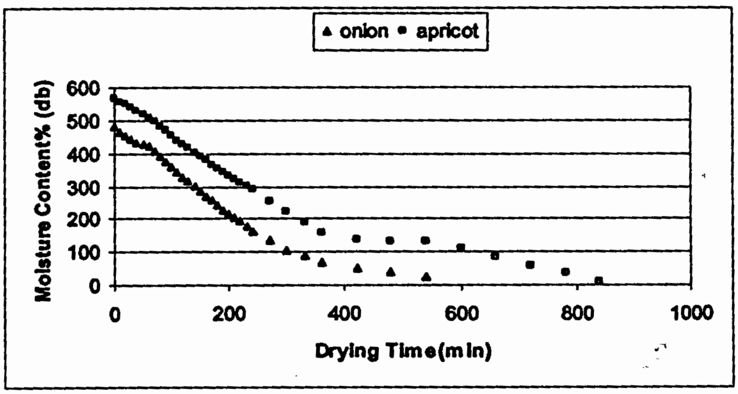
- Simple exponential equation:

The obtained experimental data were analyzed using the simple exponential equation. The best fitted result of the model was shown in Figures (9,10,11). The linear regression equation are y=-0.0089x+0.479 and y=-0.0046x+0.1905 and the values of the coefficient of determination (R^2) of the equation are (0.8262,0.9689) for onion and apricot respectively.

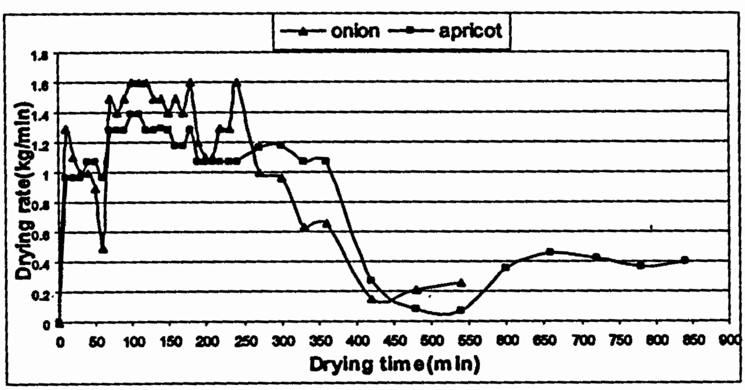
- Page's model

The obtained experimental data were analyzed using the Page's model. The best fitted result of the model was shown in Figures (12,13,14). The linear regression equations are y=1.3153x-6.905 and y=1.2592x-7.105 and the values of the coefficient of determination (R^2) of the equation are (0.9558,0.9937) for onion and apricot respectively.

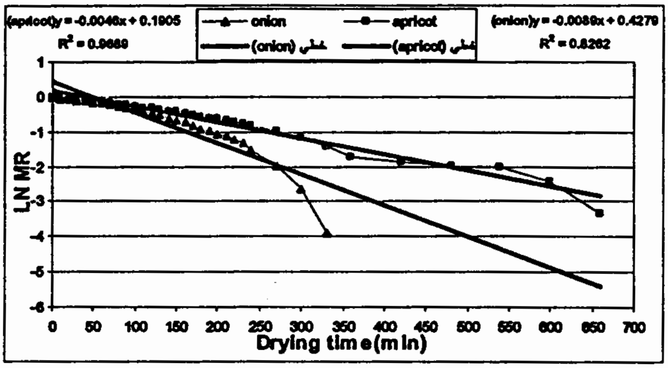
Both of the examined models (Simple and Page's model) could satisfactory describe the change in onion and apricot moisture content during the drying process. While the, Page's model could predict the change in moisture content of onion and apricot more adequately than the simple model.



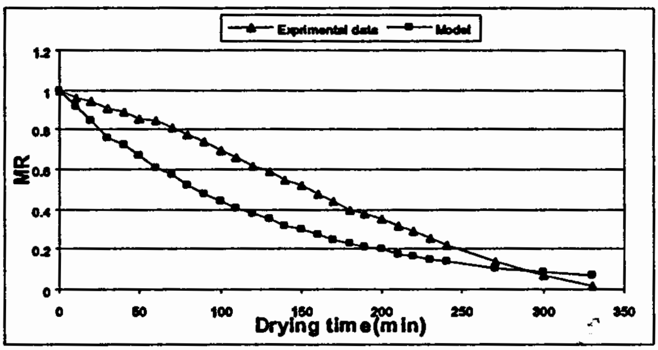
Figure(8): The moisture contents of onion and apricot for the solar dryer



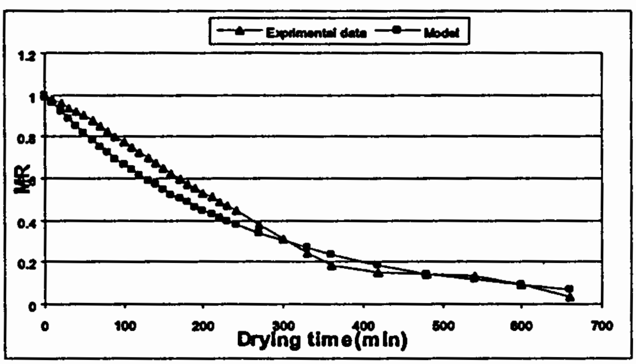
Figure(9): The drying rate with drying time of onion and apricot



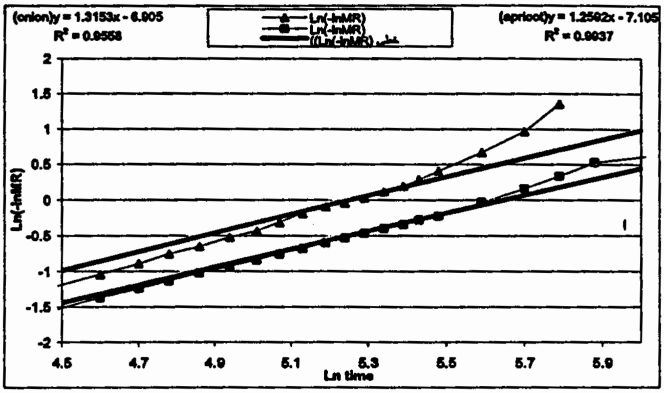
Figure(10): Determination of the drying constant; (K) of the simple equation for onion and apricot



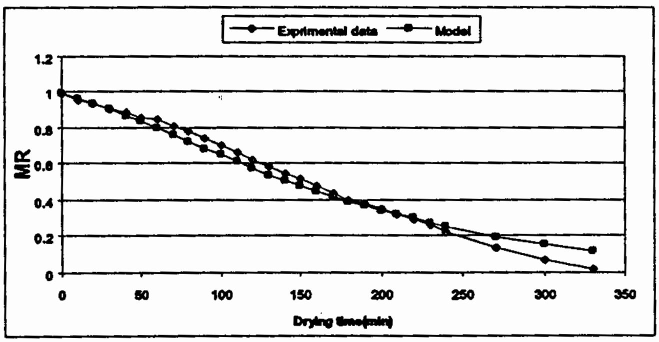
Figure(11): Comparison of the moisture ratio between experimental data and calculated values according to Simple exponential equation for onion.



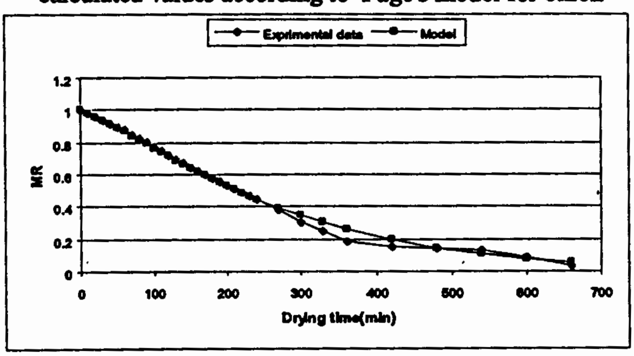
Figure(12): Comparison of the moisture ratio between experimental data and calculated values according to Simple exponential equation for apricot.



Figure(13): Determination of the drying constants; (K and u) of Page equation for onion and apricot



Figure(14): Comparison of the moisture ratio between experimental data and calculated values according to Page's model for onion



Figure(15): Comparison of the moisture ratio between experimental data and calculated values according to Page's model for apricot

CONCLUSION

The concluded results from this study were as follows:

1- When the load increased on the cooker, it needs more time to reach the maximum value of the temperature.

2- The results showed that the value of SST was 0.087 °C m^2/W at stagnation plate temperature of 113 °C ,ambient air temperature of 33 °C and insolation on a horizontal surface of 915 W/m^2.

3- The standardized cooking power was found to be inversely proportional to temperature difference (T_w-T_{amb}).From the previous data, it can be referred that, there were a highly positive relation with high (R^2).

4- When the load increased, it needs more time to reach water temperature 50°C above ambient temperature .

5- When the load increased, it needs more time for water to lose about 20°C from its maximum temperature.

6- The values of the utilization thermal efficiency increased when the load increased.

7-The cooking time taken for the different materials were 70,80 and 95 minutes for rice, potatoes slices with water and cake.

8- The moisture content of onion and apricot reached to 25 and 10.31 % dry basis in 9 and 14 h of drying in the solar dryer respectively.

9- Both of the examined models (Simple and Page's model) could satisfactory describe the change in onion and apricot moisture content during the drying process. While the, Page's model could predict the change in moisture content of onion and apricot more adequately than the simple model.

10- The cooker has a good reliability for cooking food, boiling water and drying some agricultural products.

REFERENCES

ASAE Standards S580(2003). "Testing and Reporting Solar Cooker Performance" Structures and Environment Division Standards Committee.

El-Sebaii, A. A., and A. Ibrahim (2005). "Experimental testing of a box-type solar cooker using the standard procedure of cooking power" Renewable Energy, 30(12):1861-1871.

FUNK p. a. (1999). Evaluating the international standard procedure for testing solar cookers and reporting performance. USDA Agricultural Research Service, P.O. Box 578, Mesilla Park, NM 88047, USA. Solar Energy Vol. 68, No. 1, Published by Elsevier Science Ltd Printed in Great Britain.

Gbaha. P., H. Andoh, J. Saraka,B. Koua, S. Toure (2007).Experimental investigation of a solar dryer with natural convective heat flow. Institut National Polytechnique Fe´lix Houpho¨uet-Boigny, B.P. 1526 Yamoussoukro, Co^te d'Ivoire Renewable Energy 32 (2007) 1817–1829.

Hukill, W.V. and J.L. Schmidt,(1960). Drying rate of fully exposed grain kernels. Transaction of ASAE. 3(2): 71-77,80. (cited by Lalit,1985).

Kassem, A.M.,I.E. El-batawi and Mahassen M.A.Sidky(2006).Effect of Solar Energy and Other Drying Methods on Quality of Some Medicinal Plants. Misr J. Agric. Eng. 23(4): 766-782.

Kimambo,C.Z.M.(2007). Development and performance testing of solar cookers. Department of Energy, University of Dar es Salaam. Journal of Energy in Southern Africa • Vol 18 No 3.

Nahar, N.M. (2003). Year round performance and potential of a natural ciculation type of solar water heater in India. Energy Buildings, 35: 239-247.

O,Callaghan,J.R.and Nellist,M.E.(1971).The measurement of drying rates in thin layers of rye grass seed.J.Agric.Eng.Res.16(3):192-212.

Page, G.E. (1949). Factors influencing the maximum rates of air drying corn in the layers. Unpublished M.Sc. Thesis. Dept. Mech. Eng. Purdue Univ.

الملخص العربي

تطوير و تقييم الأداء الحراري لطباخ شمسى ليعمل فى طبخ وتجفيف بعض المنتجات الزراعية

منى محمود عبد العزيز حسن*

يهدف هذا البحث إلى تطوير طباخ شمسى من النوع الصندوقى ليعمل كمجفف شمسى لزيادة معدلات استخدامه. تم تصنيع الطباخ من مواد خام متاحة ومتوفرة ويتكون من صندوق خارجى من الخشب بسمك(١.٥ سم) وابعاد خارجية: (٧٠*٦٠*٢٤سم)و ابعاد داخلية(٥٥*٤٨*٢٠سم) يوضع بينهما عازل من الصوف الزجاجي بسمك (٤سم),السطح الماص من الصاج بسمك(١مم)و ابعاده(٥٠*٤٥*٦.٥سم)و يتم وضع السطح الماص بداخل الصندوق الداخلى و يغطى الصندوق بلوح زجاجي بسمك (٥مم).تم تزويد الطباخ مرآة تعمل كعاكس للاشعة .تم استخدام إناء للطبخ من الالومنيوم أبعاده (٢١*١٠سم).

تم عمل تعديلات على الطباخ ليعمل كمجفف سمشى و هى كالاتى:
فى احد جوانب المجفف من أسفل تم عمل مجموعة من الفتحات لدخول الهواء بقطر ١ سم و مجموعة اخرى فى اعلى الجانب الاخر لخروج الهواء الساخن. والمجفف مزود بصينية لوضع المنتج مصنوعة من إطار من الخشب و القاع من البلاستيك المثقب. وتجريبه بدون حمل ثم مع ثلاث احمال هى (١.٥ ،١ ,٢ كجم من الماء) و فى طبخ(الارز، شرائح البطاطس،الكيك) و فى تجفيف البصل كنوع من الخضروات و المشمس كنوع من الفاكهه .

وتم دراسة بعض العوامل المؤثرة على أداء الطباخ وأوضحت النتائج ما يلى:

١. وصلت درجة حرارة الماء إلى 95.2 و 93.2 درجة مئوية و هى اعلى معدلاتها عند الساعة الواحدة ظهرا مع (1.5,١ كجم من الماء) على التوالي .اما مع ٢ كجم من الماء وصلت الحرارة الى 92.9 درجة مئوية عند الثانية ظهرا.
٢. زادت قدرة الطبخ مع زيادة الحمل ووجدت علاقة عكسية مع درجتي حرارة الماء والهواء الخارجي مع قدرة الطبخ.

* مدرس الهندسة الزراعية - كلية الزراعة- جامعة الزقازيق

٣. مع زيادة الحمل يزيد الوقت الذي يأخذه الطباخ للوصول لدرجة حرارة الماء أعلى من حرارة الجو ب ٥٠ درجة مئوية.

٤. وأيضا مع زيادة الحمل يزيد الوقت الذي يأخذه الطباخ ليفقد حرارته حوالى ٢٠ درجة مئوية.

٥. كفاءة الاستخدام زادت مع زيادة الحمل فكانت 45.3,67.6, 74.47 % .

مع(2,1.5,1 كجم من الماء)على التوالى.

وقد أوضحت نتائج التجفيف ما يلي :

١. وصلت نسبة رطوبة البصل الى ٢٥% وزن جاف بعد ٩ ساعات تجفيف أما المشمش وصلت رطوبته الى ١٠% تقريبا بعد ١٤ ساعة من التجفيف.

٢. معدلات التجفيف استخدم فى وصفها (Simple and Page's model) ولكن Page's model كان اكثر دقة فى وصفها.

٣. الطباخ اعطى كفاءة عالية فى غلى الماء,طبخ الطعام و تجفيف بعض المنتجات الزراعية.