Zagazig J.Agric. Res., Vol .31 No.(6) 2004 **3047 - 3059**

UTILIZATION OF WIND ENERGY FOR POST HARVESTING TECHNOLOGY

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Accepted 18/9/2004

ABSTRACT: The aim of the present study is to develop and evaluate a simple device for drying some agricultural products (mint and onion) by solar-wind energy. The evaluating experiments were carried out during 1 September 2002 to 12 November 2002 at Rice Mechanization Center, Meet El-Dyba, Kafr El-Shiekh Governorate. The device was constructed at Rice Mechanization Center. It consists of three main parts: solar collector, drying chamber and chimney and fan combination unit. The objectives of the investigation are to :- Develop a simple device for drying by using solar-wind energy, Determination of the optimum conditions for drying mint and onion products using the developed device, Comparing the developed device with the direct sun drying (by trays) from the economic point of view. The obtained results recommended for using the developed solar-wind dryer for drying mint and onion under the following conditions:- Using fan combination unit with 8blades (diameter 12.5cm), Using air inlet gate 960cm^2 and proper mass product of 1764 and 4333g for drying mint and onion respectively.

INTRODUCTION

Egypt is considered one of the countries that enjoys a plentiful ratio of energy sources which are renewable especially the solar and wind energy. In fact, wind energy is one of the most flexible of all renewable energy sources. It can be used in different purposes such as, irrigation, electricity generating, crop drying, grain grinding and also many other purposes and that after converting wind power to mechanical power by windmills, Ushiyama (1992). Because Egypt locates between the tropics and semi tropics, hence there are vast areas can use the wind energy sources to work beside the solar energy in drying some agriculture crops and making suitable environment conditions inside the grain stores. Drying of agricultural crops one of the projects of using the renewable energy sources in the agricultural fields. It aims mainly to making designs which have the best performance and high efficiency to suit working in the newly-reclaimed places which need traditional sources of energy. The renewable energy such as solar-wind energy Sabbah et al. (1998).

There are many investigators agreed with the previous opinion they stated the effective ranges for air velocity on the drying rates of some crops and fruits. El-Sahrigi et al. (1970), reported that for proper the air velocity three Egyptian onion varieties were (2.9, 3.9 and 5.6m/s), Bains et al. (1989), showed that for apple pure was faster at the from 2.0 m/s to 4.1 m/s, Abd El-Latif and Helmy (1992), promised to use air flow rate of $0.28m^3/s.m^2$ for drying of grain and Sabbah et al. (1998), recommended used air velocity from 0.6 to 0.9m/s for the drying of agricultural crops.

On the other hand some investigators found little effect of air velocity and airflow rate on the drying rate, such as : Li and Morey (1987) stated that for ginseng from 0.3 to 0.5 $m^3/s.m^2$; Yusheng and Poulsen (1988) recommended that for potatoes the range from 0.6 to 3.1 m/s, and Ibrahim (1994) for potato cubes and apple rings.

Sukhatme (1984) classified the various methods of solar utilization. He reported that the energy from the sun can be used directly and indirectly. The direct means include thermal and photovoltaic conversion, While the indirect means include the use of water–power, the winds, biomass and the temperature differences in the ocean.

Jay (1986) found that the temperature rang from 60 to 63 °C are suitable for drying many vegetables. In addition Kordylas (1990) mentioned that the rate of drying depends upon the relative humidity of the air. Also, many investigators found the effect of increasing it or decreasing the thin-layer drying rate on the drying rate of some crops.

Fohr and Arnaud (1992) used a laboratory dryer the drying rate of grape and found the drying air temperature range of 20 to 70 ^{0}C make explicit influence on the drying rate.

Ghanem (2002) mentioned that the production costs of drying one ton of the onion slices (4mm) using an auxiliary type dryer was 361.69LE/ton compared to for 1185.69 LE/ton using the traditional type dryer.

MATERIALS AND METHODS

1- The developed solar-wind dryer.

Three identical developed dryer were constructed from local materials. They were orientated to East-West direction facing south in order to capture the maximum possible solar incident on them. It consists of three main parts, as shown in Figs (1 and 2). These parts are:- Solar collector, Drying chamber and Chimney and fan combination unit.

1.1- Solar collector:

An air-type solar collector was designed with an adjustable tilt angle of (30^0 $40^/$). It had an absorber plate surface area of 20640cm^2 (120 x172cm). The absorber plate was formed from iron sheet 3mm thickness. Its upper face was painted using matt black to absorb the maximum amount of the solar energy, the surface area was covered using fibrous glass 3mm thickness and 24000cm^2 area (120 x 200cm).

1.2- Drying chamber

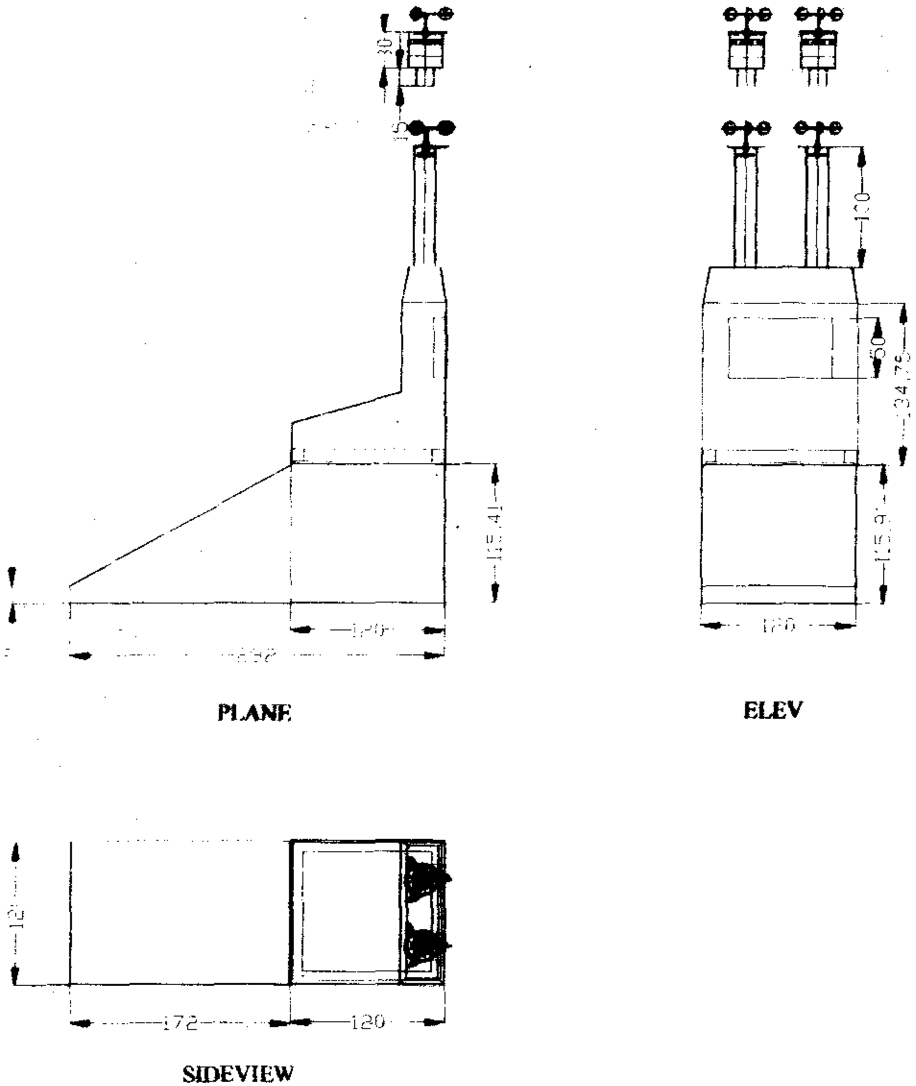
The drying chamber was covered using fibrous glass of 3mm thickness and 12240cm^2 area (102 x 120cm), with tilt angle (30^0 $40^/$) and the internal surface was covered using iron soft screen to put the product in it, and with the surface area 13265 cm^2. (115x115cm).

1.3- Chimney

Each dryer hade two chimney each chimney was formed from iron sheet of 1mm thickness its upper was painted using matt black.

1.4- Fan combination unites:

Six identical types of fan combination units were constructed from local material. The unit is turning with a vertical axis and accept wind from any direction without adjustment. It similer to cup anemometer, whereas this device rotates by drag force. The shape of this cup produces is a nearly have relationship between rotational frequency and wind speed as shown in Fig (3)



Fig(1), sketched view of solar-wind

No	Part name
1	Air inlet gate
2	Solar collector
3	Fibrous glass
4	Drying chamber
5	Chimney
6	Fan combination unite

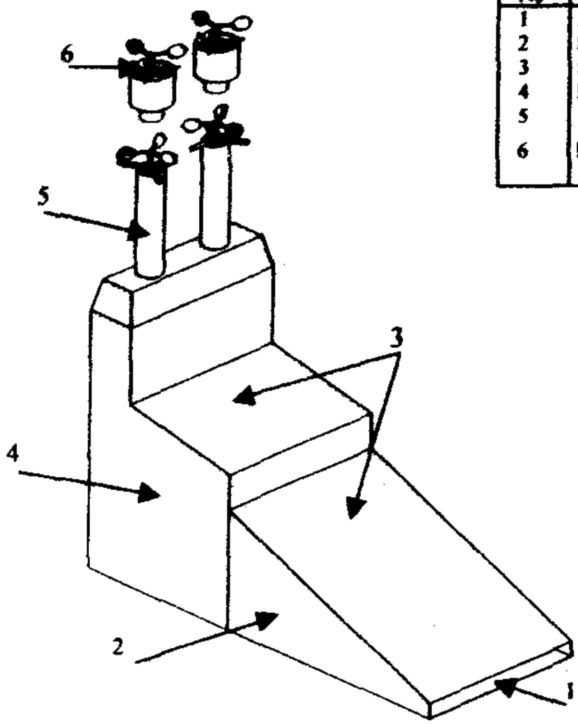
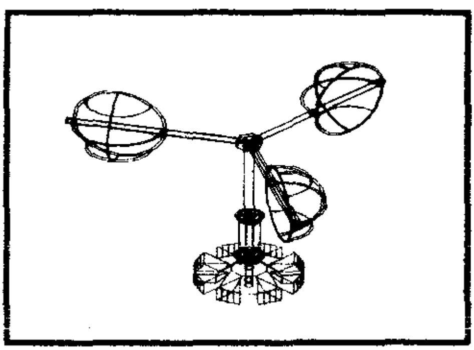


Fig (2) sketched view of solar-wind dryer



Fig(3) general view of the fan combination unit

2- The dryer products

2.1- Onion product

Onion bulbs were sorted cleaned and the outer dry layers removed. The peeled bulbs were cut into rings with thickness of 3mm and dipped for approximately six minute in 0.3% Solution of Sodium Meta Bisulphite ($Na_2S_2O_2$), after dipping onion rings were selected and put in the drying chamber on each the three dryer and the same mass spread under direct sun .

2.2- The green mint

Green mint sorted and cleaned by the fresh water, selected and put in the drying chamber on each of the three dryer and the same mass spread under direct sun .

The Studied Variables:

The deduced treatments include the following:

Three types fan combination unit namely:- fan with 8blades (12.5cm diameter) (F_1), fan with 6 blades(25cm diameter) (F_2) and without fan (F_0), Three levels of air inlet gate area namely:- 480, 960 and 1440cm^2 for onion and mint product and, different product mass levels namely:- for onion product, two product mass were selected to be deduced 4333 and 8666g., while for mint product. Three product mass were selected to be deduced 588, 4476 and 1764g. The obtained result were evaluated in terms of :- The rate of water removal , moisture content, drying coefficient and cost of drying .

Measurements And Estimations:

1- Moisture Content (%) :

Mass of product was measured by using electric balance before and after drying. Then moisture content (%) was estimated on dry (d. b) and wet (w.b) basis according to the following equation:

$$M_d = (w - d)100/d \qquad (1)$$

$$M_w = (w - d)100/w \qquad (2)$$

M_d = Percentage moisture content (dry basis).

M_w = Percentage moisture content (wet basis).

W = mass of the wet sample.

D = mass of the dry sample.

2- Determination of drying coefficient:

The following formula was used to determine the drying coefficient (k) from the moisture content time curve.

$$M - Me/Mo - Me = e^{-kt} \qquad (3)$$

Where: **Mo** =Moisture content, (dry basis) at the beginning of the drying period at time (Zero).

M = Moisture content, (dry basis) at any time (t).

Me = Equilibrium moisture content, dry basis(its values were selected as 5 and 6 (%) for mint and onion product respectively).

k = Drying coefficient.

t = Time.

3.3- Temperature:

Every one hour the dry and wet air temperature measured in different position in solar collector, drying chamber and the out side of dryer by using thermocouple.

4- Relative humidity:

The air relative humidity were calculated using humidity table in the same above mentioned position.

5- Cost of drying:

The hourly drying cost of the developed dryer as well as sun drying by trays was calculated according to **Awady (1978)** as follow

C = P/H [1/E + I/2 +T +R] + [0.9 HP* F*S] + w/144 (4)

Where:-

C: Hourly drying cost (L.E./hr).

P: Capital investment (L.E.).

H: Yearly operation hours (hr).

E: Life expectancy of equipment in year (%).

I: Interest rate(%).

T: Taxes and over heads ratio (%).

R: Repairs ratio of the total investment (%).

0. 9: A factor including reasonable estimation of oil addition to fuel.

HP: Horse power of engine (hp).

F: Brake specific fuel consumption (liter/hp.h).

S: Price of fuel per liter (L.E./liter).

W: Labor wage rate per month in (L. E.).

144: Reasonable estimation of monthly working hours.

While, the cost per unit of production could be determined by using the following formula:

Cost per unit production (L.E./ton) = Hourly cost(L.E./h)/Productivity (ton / h). (5)

RESULTS AND DISCUSSION

The main obtained results from the collected data could be summarized under the following four heading:-

1- The best performance operation of the developed dryer comparing with direct sun drying.

Tables (1 and 2) illustrate the amount of the rate of removed water.

Table (1): The best performance of developed dryer for ment.

Product mass				
Inlet area	m1	m2	m3	A-MEAN
		F = f1		
a1	125.080	166.350	165.813	152.414
a2	125.430	166.550	167.650	153.210
a3	124.950	165.770	167.407	152.709
		F = f2		
a1	59.600	97.637	146.400	101.212
a2	95.520	97.700	154.400	100.837
a3	59.447	98.067	146.000	101.171
		F = f3		
a1	87.800	132.500	161.500	127.267
a2	88.050	132.800	161.131	127.328
a3	88.000	132,600	160.567	127.056
M-MEAN	90.875	132.219	175.986	127.027

Table (2): The best performance of developed dryer for onion product.

M Product mass				
Inlet area	m1	m2	A-MEAN	DIFF
		F = f1		
a1	247.400	190.600	219.000	56.800**
a2	247.600	190.043	218.822	57.557**
a3	246.300	189.920	218.110	56.380**
		F = f2		
a1	153.600	222.300	187.950	-68.700**
a2	151.100	223.600	187.350	-72.500**
a3	152.533	223.033	187.783	-70.500**
		F = f3		
a1	202.300	183.400	192.850	18.900**
a2	204.500	183.900	194.200	20.600**
a3	202.400	183.500	192.950	18.900**
M-MEAN	200.950	198.922	199.891	1.937

The results showed that, the best performance operation of dryer was obtained at using the developed solar-wind dryer for drying mint and onion under the following conditions:- Using fan combination unit with the 8 blade, Using air inlet gate 960 cm^2 and proper mass product of 1764 and 4333 g for drying mint and onion respectively .

2- The effect of developed solar-wind dryer on moisture content comparing with direct sun drying.

Fig (4 and 5) illustrate the reduction of moisture content.

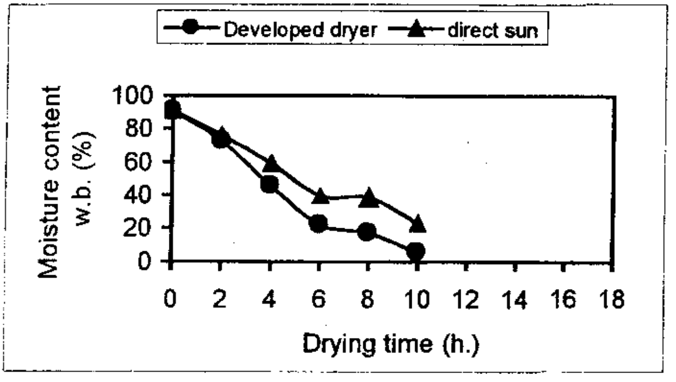


Fig (4) The effect of developed solar-wind dryer on moisture content comparing with direct sun drying for mint product.

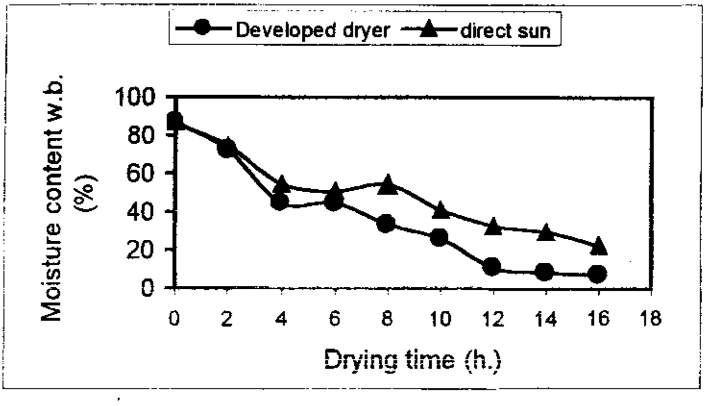


Fig (5) The effect of developed solar-wind dryer on moisture content comparing with direct sun drying for onion product.

Result showed that the reduction of moisture content is greatly affected by developed dryer comparing with direct sun drying .

Concerning mint, Fig (4), show that, after ten drying hours, moisture content decreased by 94.15 %, and 75.16 % under solar-wind dryer and direct sun drying respectively at the same product mass.

Relating to onion Fig (5), shows that after fifteen drying hours, moisture content decreased by 92.09 % and 74.43 % under solar-wind dryer and direct sun drying respectively at the same product mass .

3- The effect of developed solar-wind dryer on drying coefficient comparing with direct sun drying.

Fig (6 and 7) illustrate the reduction of drying coefficient.

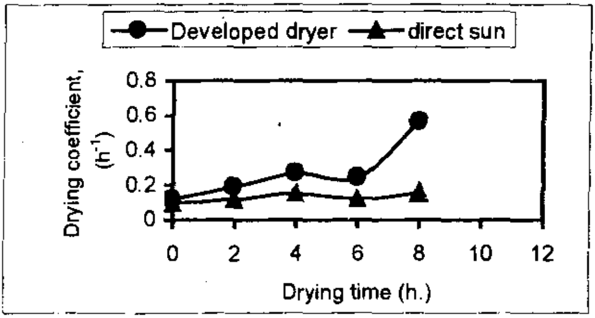


Fig (6) The effect of developed solar-wind dryer on drying coefficient comparing with direct sun drying for mint product.

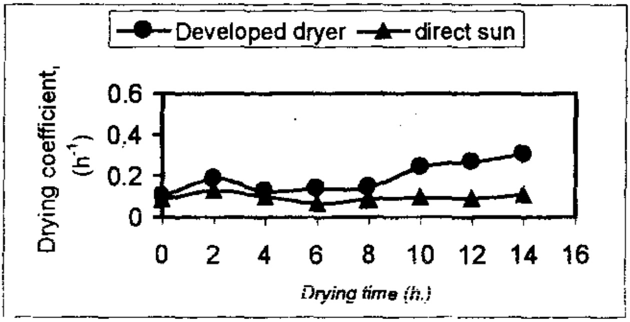


Fig (7) The effect of developed solar-wind dryer on drying coefficient comparing with direct sun drying for onion product.

Concerning mint Fig (6), show that, after ten drying hours, drying coefficient were 0.563 (h^{-1}), and 0.154 (h^{-1}), under solar-wind dryer and direct sun drying respectively at the same product mass.

Relating to onion Fig (7), show that, after fifteen hours drying coefficient were 0.303(h^{-1}), and 0.107(h^{-1}), under solar-wind dryer and direct sun drying respectively at the same product mass .

4- Cost requirement for different drying products.

The cost of different drying system is dependent on many factors due to drying conditions and drying system.

The houry cost for dryer and sun drying by trays were 0.14 and 0.12(L.E./ton).

Cost values of drying mint were 3.31 and 5.97(L.E./ton) under developed dryer and sun drying by trays. Relating to cost of drying onion, cost values were 2.0 and 2.54(L.E./ton) under developed dryer and sun drying by trays .

Summary And Conlusion:

The present investigation is mainly carried out to developed and evaluate a solar-wind energy dryer for drying some agriculture products: The performance of the developed device was evaluated under different processing conditions. The device variables include three different types of fan combination unit, and three levels of air inlet gate area (480, 960 and 1440cm^2). In addition three levels of mint product mass (588, 1176 and 1764g) and two levels of onion product mass (4333 and 8666g) were proposed to be investigated .

The obtained result were evaluated in terms of:- The rate of water removal, moisture content, drying coefficient and cost of drying.

The results may be summarized as follows :-

The obtained results recommended for using the developed solar-wind dryer for drying mint and onion under the following conditions:- Using fan combination unit with the 8 blades, Using air inlet gate 960 cm^2 and proper mass product of 1764 and 4333 g for drying mint and onion respectively.

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استخدام طاقه الرياح في تكنولوجيا ما بعد الحصاد

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أجريت هذه الدراسة بهدف لتطوير جهاز بسيط يعمل بخاصية الدفع الطبيعي باستخدام طاقه الرياح والطاقة الشمسية لتجفيف بعض المنتجات الزراعية (نعناع و بصل) وقد تمت الدراسة في مركز ميكنة الأرز بقرية ميت الديبة محافظه كفر الشيخ. ويتكون الجهاز المطور من ثلاث أجزاء :- المجمع الشمسي وغرفه التجفيف والمدخنة ووحدة المروحة المجمعة.

وشملت الدراسة تطوير جهاز بسيط للتجفيف بالطاقة الشمسية وطاقة الرياح و تحديد الظروف المثلى لتشغيل الجهاز أثناء إجراء عملية تجفيف النعناع والبصل ومقارنة تكاليف تجفيف المنتجات الزراعية بواسطة الجهاز المطور مقابل التجفيف الشمسي بالصواني.

وتضمنت معاملات الدراسة ثلاثة أنواع مختلفة من وحده المروحة المجمعة وهى المروحة ذو ٨ ريش (قطر ١٢,٥ سم) والمروحة ذو ٦ ريش (قطر ٢٥ سم) وبدون مراوح. وأيضا ثلاثة مساحات لفتحه دخول الهواء وهى ٤٨٠ و ٩٦٠ و ١٤٤٠ سم^2 استخدمت هذه المتغيرات لكل من محصول النعناع والبصل. بالإضافة إلى أن كتلة محصول النعناع المختبرة كانت ٥٨٨ و١١٧٦ و ١٧٦٧ جم. بينما كانت كتله المنتج المختبرة لمحصول البصل كانت ٤٣٣٣ و ٨٦٦٦ جم.

وقد تم تقييم النتائج على ضوء المعايير الآتية:- أفضل معدل أداء للمجفف من حيث افضل (معدل أزاحه المياه من المحصول). نسبه الرطوبة. معامل التجفيف و تكاليف تجفيف المنتجات.

وقد تم الحصول على النتائج التالية :-

أولا: أفضل معدل أداء للمجفف المطور على ضوء أفضل معدل أزاحه المياه من المحصول

أ: تحقق أفضل معدل أزاحه للمياه من المحصول عند استخدام وحده المروحة المجمعة ذو ٨ ريش مع مساحة فتحه دخول الهواء ٩٦٠ سم^2 مع كتله المحصول ١٧٦٤ جم لمحصول النعناع و ٤٣٣٣ لمحصول البصل.

ثانيا: نسبه الرطوبة:-

*وجد أن نسبه الرطوبة انخفضت بنسبه ٩٤,١٥% و ٧٥,١٦% لمحصول النعناع وبنسبه ٩٢,٠٩% و ٧٤,٤٣% لمحصول البصل عند استخدام وحده المجفف المطور والتجفيف الشمسي المباشر على الترتيب عند استخدام نفس كتله المحصول.

ثالثا : معامل التجفيف : -

وجد أن معامل التجفيف ٠,٥٦٣ و ٠,١٥٤ (h^{-1}) لمحصول النعناع و ٠,٣٠٣ (h^{-1}) و ٠,١٠٧ (h^{-1}) لمحصول البصل عند استخدام وحده المجفف المطور والتجفيف الشمسي المباشر على الترتيب عند استخدام نفس كتله المحصول.

رابعا: مقارنه تكاليف التجفيف باستخدام المجفف المطور والتجفيف المباشر على الصواني:-

وجد أن تكاليف التجفيف كانت ٣,٣١ و ٥,٩٧ جنيه/طن لمحصول النعناع وكانت ٢,٠ و ٢,٥٤ جنيه/طن لمحصول البصل عند استخدام وحده المجفف المطور والتجفيف الشمسي المباشر.