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SOLAR DRYING OF PEANUT PODS USING TWO DIFFERENT TYPES OF SOLAR DRYERS

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ABSTRACT

The objective of the present study was to investigate and evaluate two different drying methods of peanut (forced convection solar drying and natural convection solar drying) under three different layer thicknesses of (5, 10 and 15 cm) and two different stirring conditions (with stirring and without stirring). The studied drying methods were compared with sun drying method practiced by farmers. For the traditional drying method, the average peanut pods moisture content at different layer thicknesses of 5, 10 and 15 cm was decreased from an initial level of 54.39% (w.b.) to a final level of about 13±1% (w.b.) in 52, 56 and 66 h, respectively. Meanwhile, for the natural convection solar dryer, the recorded drying time for the unstirred peanut pods with different layer thicknesses were 48, 56 and 62 h, and the corresponding drying time for the stirred treatments were 44, 50 and 54 h, respectively. Under condition of forced convection greenhouse type solar dryer, the recorded drying times for the unstirred treatments at different layer thickness were 40, 48 and 56 h, and the corresponding drying times for the stirred treatments were 36,40 and 46 h, respectively. The thermal efficiency of the forced convection solar dryer was (46%) while it was 23.93% for the natural convection solar dryer. The quality evaluation tests showed that, the acid value decreased from 0.74 to 0.4 and the peroxide value decreased from 3 to 1.33. These values are in the range of the quality standards for peanut.

INTRODUCTION

Peanut is the third major oilseed crop in the world followed by soybean and cotton (FAO, 1990). The planted area of peanut in Egypt was 150767 feddan in 2001, which yielded 205066 ton with an average of 1.36 ton/feddan (Agricultural Statistics, 2001).

About two-thirds of world peanut production is crushed for oil and the remaining (one-third) is consumed as food. Arlington (2002) reported that, eating food with vitamin E, like whole grain, peanuts, nuts, peanut butter, vegetable oil and seeds can help to reduce the risk of Alzheimer.

The peanut plant is pulled from the ground, inverted, and left to dry in the open field. It may take up to 2 weeks and the crop is at risk from losses, aflatoxin and over drying. Therefore, peanut drying is the most important processes before shelling and handling to provide peanuts with good quality. Due to the steep increase in the price of energy, alternative energy sources have become more attractive. Solar energy is one of these alternative energy sources. The solar energy application is dependent upon the development of systems that have optimum performance, good reliability and economic characteristics that compare favorable with conventional energy systems and other energy sources (Abdellatif, 1985).

The use of solar dryers significantly reduces drying time and prevents mass losses; furthermore, product quality can be improved compared with traditional sun drying methods (Lutz and Muhlabauer, 1986).

Freshly harvested peanut pods have a moisture content in the range of 40 to 55% (w.b). These pods carry not only an undesirable additional weight of excess water during transpiration but also an additional weight due to soil sticking onto their outer shell (Srivastava *et al.*, 1982).

Leaving peanut to dry down to the desired level of moisture content in the field is risky. It may take long time and the crop is at risk from aflatoxin, rain, birds and over drying. Golasangi *et al.*, (2000) reported that, the quality of the dried peanut seeds decreased with increasing drying temperature and time.

The combining solar energy and natural wind in a drying system is a promising system for drying agricultural products on small scales (Sabah, 1985). Also, Abdellatif and Helmy (1992); and Helmy *et al.* (1995) stated that solar energy could be used for drying the grain in the greenhouse under Egyptian conditions without malfunction and with high effectiveness. El-Awady *et al.* (1988) found that the temperature inside the tent dryer rises about (3 to 5°C) and for the tray dryer over the ambient temperature. The prediction of the temperature by the equations showed be reasonably accepted (Shoukr *et al.*,1986).

The objective of the present work was to study and evaluate two different drying methods of peanut namely, forced convection solar drying, natural convection solar drying. The studied solar drying methods would be compared with the traditional sun drying methods under three different layers thickness and two different stirring conditions (with stirring and without stirring).

MATERIALS AND METHODS

The experimental work was conducted at the Department of Agricultural Engineering, Faculty of Agriculture, Suez Canal University, Ismailia during peanut harvesting season throughout the period from 1 to 10 October 2000.

Peanut pods (Giza-5 variety) freshly harvested at moisture content of about 55% (w.b) was used for the experimental work. Three different systems of peanut pods drying were investigated and evaluated in this study. These methods included: a natural convection solar drying, a forced convection solar drying and traditional sun drying. The description of these methods is shown as follows:

Natural convection solar dryer

The dryer consists of the first solar collector, the drying chamber and the secondary solar collector as shown in Fig. (1). The first collector was constructed of a flat absorber plate made of black painted iron-sheet (2 m X 1 m) rested on the ground and completely covered by a vinyl sheet over a wooden frame.

The drying chamber constructed of a wooden frame having a gross dimensions of 1 m X 1 m X 0.2 m (L.W.H) and a perforated floor made of iron mesh (10 % opening) to allow passage of hot air and to prevent the pods falling through. The total area of the drying chamber floor was divided into two equal sections each of 0.5 m^2. The drying chamber was followed by a secondary solar collector. The secondary solar collector was made of vinyl plastic cover supported on wooden frame. The absorber surface of the secondary collector was formed of perforated black plastic material covering the surface of the drying chamber. The function of the secondary collector is to raise up the temperature of the air and flow it out naturally from the drying chamber. This process occurs due to the resulted difference in the density of air across the upper part of the drying chamber. A window with dimensions of 0.1 m X 0.2 m was fitted at the back side of the drying chamber for loading and unloading the peanut pods and also for pods stirring. The dryer was sited to face a southern direction so that maximum amount of solar insolation could be collected, as compared with other directions .

Forced air solar dryer (greenhouse type)

Fig. (2) shows the greenhouse solar dryer used during the experimental work. The dimensions of the vinyl house are 0.80 m wide, 1.25 m long and 1 m high and the dimensions of the drying chamber are 0.80 m wide, 1.25 m long and 0.2 m high.

he dryer constructed from iron frame in the circumference of four wooden walls forming a batch and the frame is covered by a clear plastic film similar to that used for the natural convection dryer. Wire netting constitutes a floor at the bottom of the batch and a plenum chamber is constructed under the wire netted floor. An axial type suction fan and a duct for air suction were stetted at the back side of the dryer and a window for air inlet is opened at the front side. Whenever the fan is rotated, the window must be opened suspending with strings. To prevent the direct exposure of the peanut pods to sunrays and to increase the collection efficiency of solar radiation, a black net cloth was used for covering the surface of the drying chamber similar to that one used in the natural convection dryer.

Traditional drying method

The traditional drying system used in this study was similar to that used by farmers to dry peanut pods in the field. The freshly harvested peanut pods were spread on the floor and stirred by farmers at several times until it reaches the desired level of moisture content. During the experimental work, a wooden frame of 1m X 1m X 0.25 m (L W H) divided into two identical sections was used to investigate the three layer thicknesses of peanut pods (5,10 and 15 cm).

Experimental treatments and measurements

Experimental treatments

The experimental treatments included three different drying methods (natural convection solar drying, forced convection solar drying and traditional sun drying). Three different layers thickness (5, 10 and 15 cm) and two different stirring conditions (stirring at two hours intervals and without stirring) were investigated.

Experimental Measurements

Temperature and relative humidity

The universal digital measuring system (Model Kaye Dig. 14) connected to 32 channels scanning box with thermocouple sensors distributed at different points was used to measure the air temperature outside and inside the dryers and also to measure the bulk and pods temperature of each drying method.

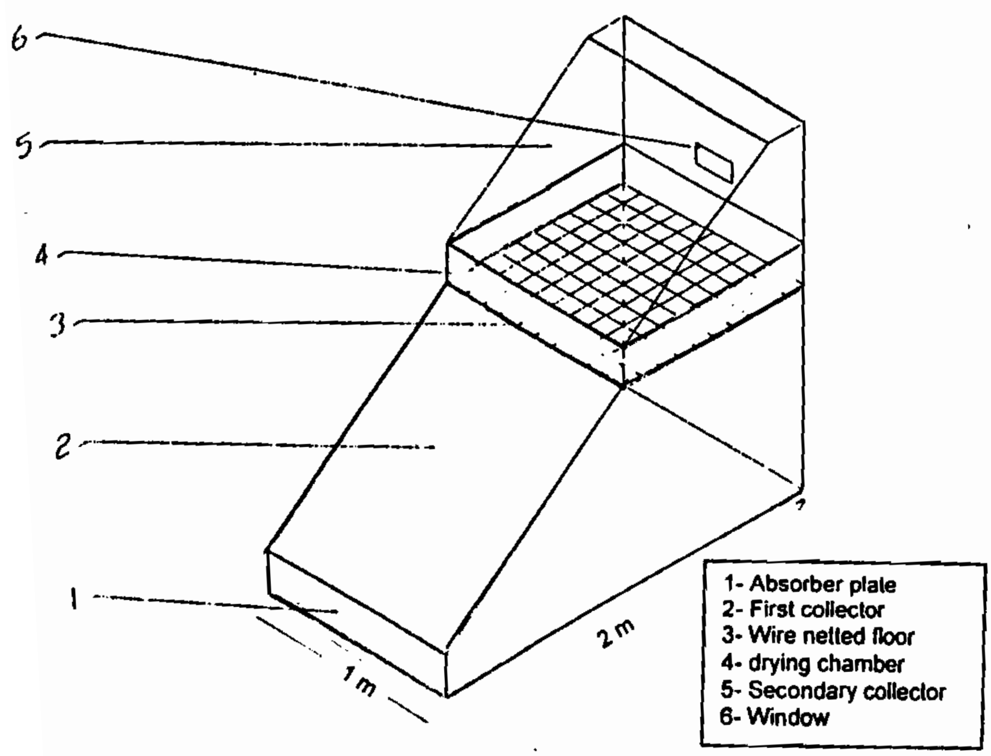


Fig. (1): Schematic diagram of the natural convaction solar dryer.

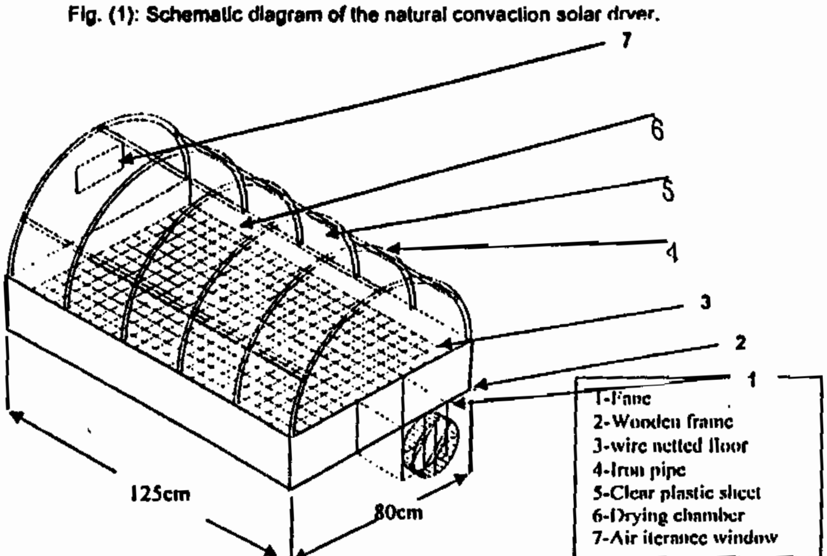


Fig. (2): Schematic diagram of the greenhouse solar dryer.

The relative humidity meter (Model Secumed) was used to measure the air relative humidity.

Air velocity

A hot type anemometer (Model ATESCO 40S-V1) was used to measure the velocity of air flow at different points represent the air movement through the two type of solar dryers (natural and forced convection) and the speed of air outside the dryers.

Pods moisture content

Pods moisture content was measured using electrical oven, at 105°C (378 K) for 24 hour. The moisture content was calculated according to Hemeada (1974) as follows:

Pods moisture content = AC +BD

Where:

A: Moisture content of seed, %,

B: Moisture content of hull, %,

C: Percentage of seeds in pods, %and

D: Percentage of hulls in pods, %.

Thermal efficiency of the dryer

Thermal efficiency of the dryer is defined as the heat of evaporation of the moisture removed from the peanut pods divided by the solar radiation falling on the dryer during the drying time. The thermal efficiency of both natural convection and forced air dryers was calculated according to Jindal and Reyes, (1987) as follows:

$$\eta = \frac{W_w \, X L}{Q \, X 3600} X 100$$

Where:

η = Thermal efficiency, %;

W_w = Water evaporated from grain, kg;

L = Latent heat of vaporization of water, kJ/kg, and

Q = Total solar energy available, kW.

The solar radiation flux incident (w/m^2) was calculated according to the computer program developed by El-Sayed *et al.* (2005).

Quality Evaluation:

Determination of acid value (A.V)

Acid value was measured according to the method descried by A.O.A.C. (1975). Mix 25 ml diethyl ether with 25 ml alcohol and 1 ml of phenolphthalein solution (1%) and carefully neutralise with 0.1 M sodium hydroxide. Dissolve1-10 g of the oil or melted fat in the mixed neutral solvent and titrate with aqueous 0.1 M sodium hydroxide shaking constantly until a pink color which persists for 15 sec is obtained . The titration should preferably not exceed about 10 ml or otherwise two phases are liable to separate. This does not occur however if hot neutral alcohol is used as solvent or if the acidity is titrated with alcoholic alkali. The acid value was calculated according to the following equation.

$$\text{Acid value} = \frac{V.N.56.1}{W}$$

Where:
V = Volume of alkali required to naturalize the free fatty acids, ml;
N = Normality of KoH, dimensionless and
W = Mass of sample, g.

Determination of peroxide value:

Peroxide value was measured according to the method descried by A.O.A.C. (1975). Add 10 ml of chloroform and 10 ml of glacial acetic acid to the flask and, using a micro gas flame close to the flask, boil the mixture to the top of the tube where it is condensed by the water jacket . When the mixture is boiling steadily pour 1 g of potassium iodide dissolved in 1.3 ml water slowly down the condenser so that the refluxing is not interrupted . Redissolve any precipitated iodide by adding not more than 0.3 ml water .Then 1 g (or less) of the sample down the condenser, again without interrupting the refluxing, and turn off the condenser water so that the sample is washed into the flask. Boil the mixture fore a further 4 min. Then remove the flask , cool rapidly , add 50 ml water and titrate the liberated iodine with 0.01 M sodium thio-sulphate using starch. The following equation was used to calculate the peroxide value of lipid samples under study.

$$Peroxide\ value = \frac{S.N.1000}{W}$$

Where:
S = Titration of sample, ml;
N = Normality of sodium thiosulphate, dimensionless and
W = Mass of lipid sample, g.

Cost Analysis

A comparison study between the forced air convection solar dryer (greenhouse type) and the natural convection solar dryer under study is made to indicate the least expensive dryer for drying peanut pods consideration according to El-Awady *et al.* (1988). In general, the total cost is broken down into initial and operating costs.

1-Initial costs:

a- Depreciation = (cost new - salvage value) / total expected life (years)
Salvage value = 10% cost (new)

b- Interest on the investment = 0.5 (Depreciable cost+ estimated salvage) X interest rate (4%)

c- Taxes and insurances = 0.5 (Depreciable cost + estimated salvage) X Combined rate (1.5%)

2-Operating cost:

a- Electrical cost.
b- Maintenance and labour (maintenance = 3% of initial cost)

RESULATS AND DISCUSSION

Moisture Reduction of Peanut Pods:

The reduction in pods moisture content was varied under different drying methods and it was affected by the drying air temperature, relative humidity, pods layer thickness and stirring process.

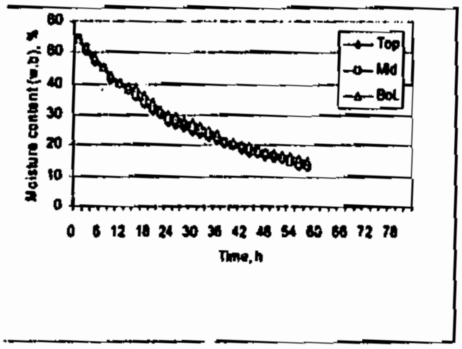
For the traditional drying method, Fig. (3) and Fig. (4) show the reduction in average pods moisture content as related to drying time for different pods layer thickness and stirring process. As shown in the figures, the average peanut pods moisture content was decreased from an initial level of 54.39% (w.b.) to a final level of about 13±1% (w.b.) within 52, 56 and 66 h for the peanut pods dried with stirring process at layer thicknesses of 5, 10 and 15 cm, respectively. The corresponded drying time for the pods dried without stirring process was 56, 64 and 78 h, respectively.

The above mentioned results revealed that, the reduction rate of pods moisture content was affected by the drying air temperature and relative humidity, and the corresponded pods and seeds bulk temperature. Also, the stirring process give more chance for pods to receive equal amount of heat and thereby faster moisture reduction and more homogeneous drying at different layers.

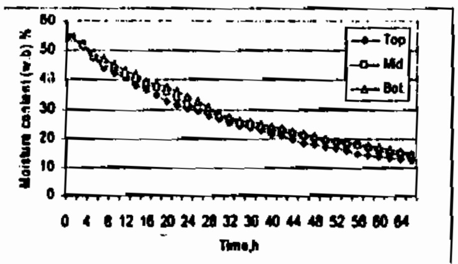
For the natural convection solar dryer, Fig. (5) and Fig. (6) show, the change in pods moisture as related to drying time for different pods layer and stirring process. As revealed in the figures, the recorded drying times without stirring peanut pods at layer thicknesses of 5, 10 and 15 cm were 48, 56 and 62 h, respectively. The corresponding drying times for the stirred treatments were 44, 50 and 54 h, respectively. When comparing the reduction in pods moisture content at different layers for both stirred and unstirred treatments, the unstirred treatments dried fastest at the bottom layers followed by top and middle layers due to the upward movement of drying air. However, for the stirred treatments, a uniform pods moisture reduction at all layers and a faster drying process was observed as compared with the unstirred treatments.

For the greenhouse type solar dryer, Fig. (7) and Fig. (8) illustrate the reduction in average pods moisture content as related to drying time for different pods layers thickness of (5,10 and 15cm) and stirring process. As shown in the figures, the average pods moisture content was decreased in a higher rate with the decreasing of layer thickness and stirred treatments as compared with the unstirred treatments.

For the unstirred treatments at layer thicknesses of 5, 10 and 15 cm the recorded drying times were 40, 48 and 56 hours and the corresponded drying times for the stirred treatments were 36, 40 and 46 h, respectively. When comparing the pods moisture reduction at different layers of each studied treatment, it was found that, without stirring treatments the pods moisture reduction at the surface layer was the fastest followed by middle and bottom layer.



At 5 cm thickness



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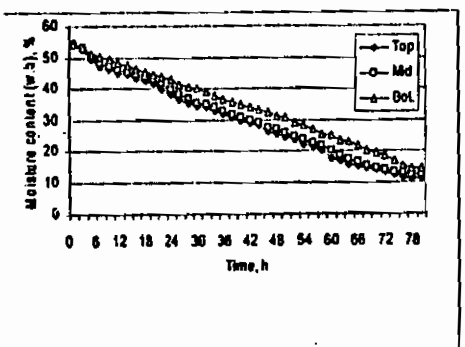
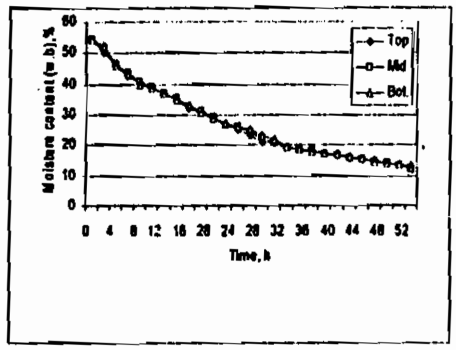
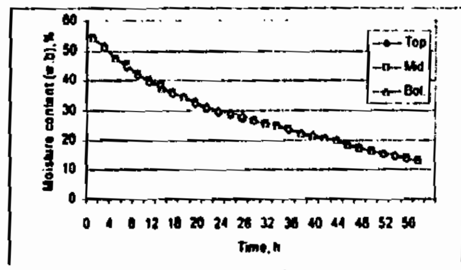


At 15 cm thickness

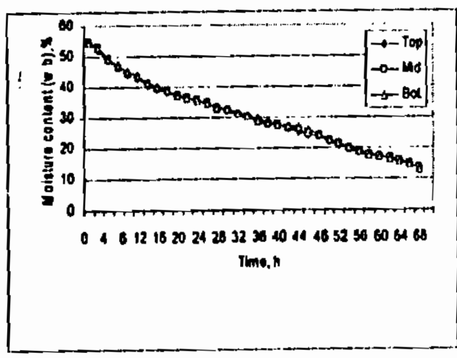
Fig. (3): Moisture reduction of peanut pods under traditional drying method without stirring at different pods layer thickness



At 5 cm thickness

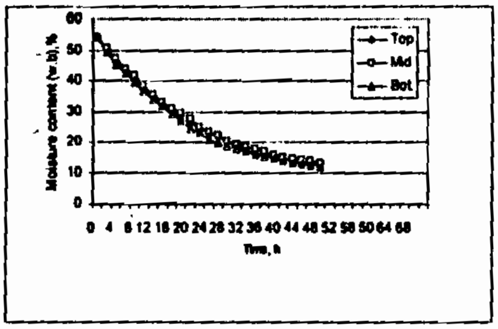


At 10 cm thickness

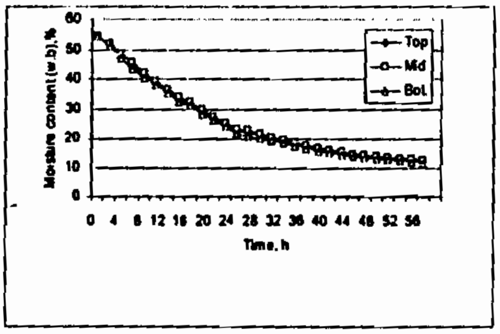


At 15 cm thickness

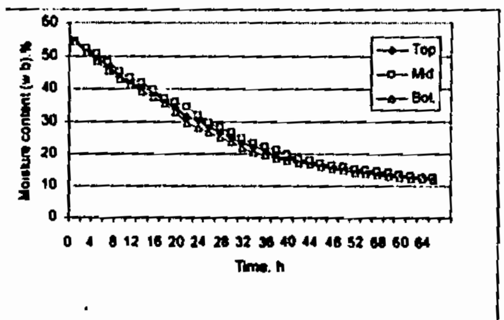
Fig. (4): Moisture reduction of peanut pods under traditional drying method with stirring at different pods layer thickness



At 5 cm thickness

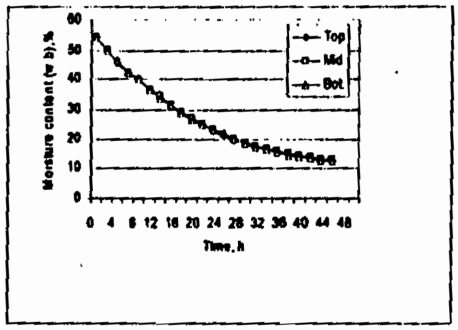


At 10 cm thickness

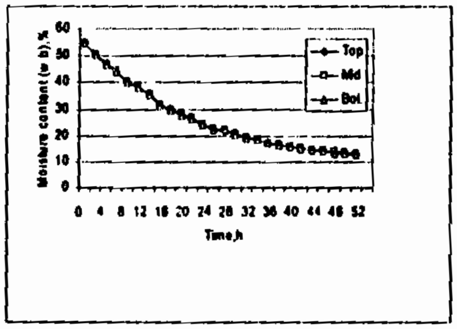


At 15 cm thickness

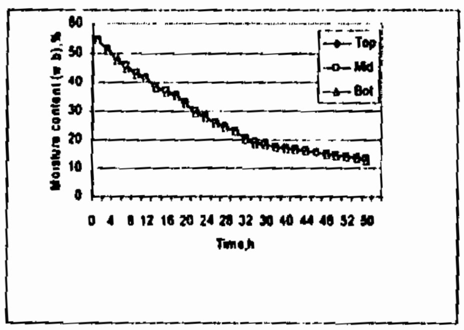
Fig. (5): Moisture reduction of peanut pods using natural convection solar dryer without stirring at different pods layer thickness



At 5 cm thickness

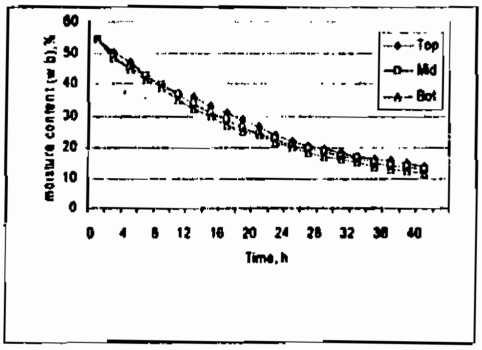


At 10 cm thickness

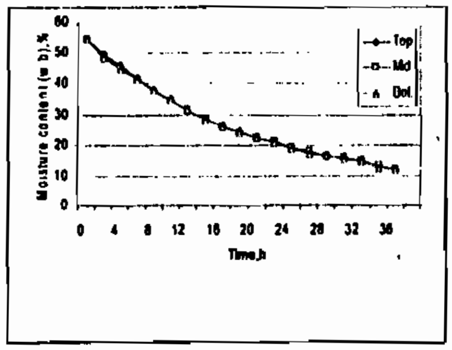


At 15 cm thickness

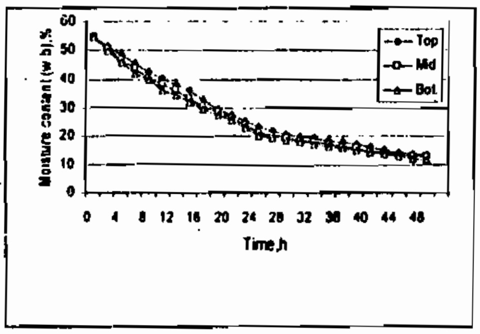
Fig. (6): Moisture reduction of peanut pods using natural convection solar dryer with stirring at different pods layer thickness



At 5 cm thickness



At 5 cm thickness



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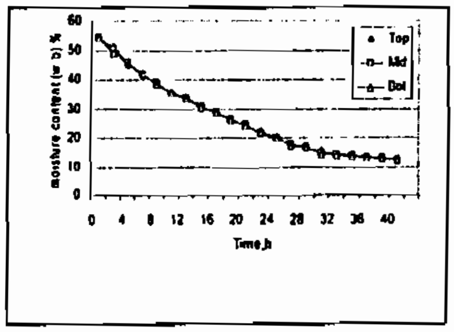
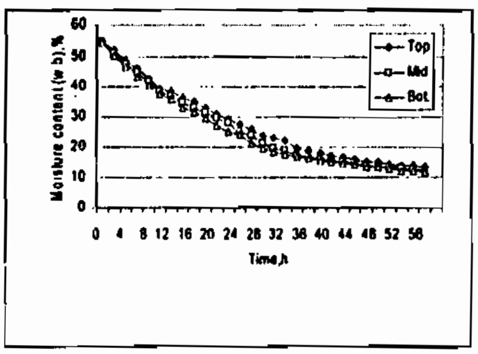
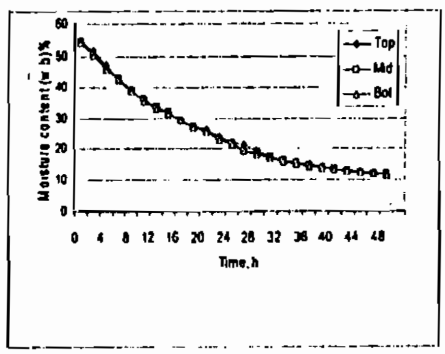


At 10 cm thickness



At 15 cm thickness



At 15 cm thickness

Fig. (7): Moisture reduction of peanut pods using forced convection solar dryer without stirring at different pods layer thickness

Fig. (8): Moisture reduction of peanut pods using forced convection solar dryer with stirring at different pods layer thickness

This may be attributed to the up-down flow of drying air of this type of dryers. Also, the figures show that the pods moisture reduction was higher and uniform for the stirred treatments as compared with the unstirred treatments.

To explore, the above mentioned results, it can Le found that, as compared with the widely used traditional drying method of peanut pods the greenhouse type solar dryer could decrease the total drying time by 29.57, 25 and 23.20% with layer thicknesses of 5, 10 and 15 cm without stirring process while, the corresponded reduction percentages with stirred treatments were 30.76, 28.57 and 28.78%, respectively.

On the other hand, the reduction percentages in drying time with natural convection solar dryer was 14.20, 12.51 and 20.51% for the unstirred treatments at layer thicknesses of 5, 10 and 15 cm and the corresponded reduction percentage for the stirred treatments was 15.39, 10.71 and 18.18%, respectively. This means that, the greenhouse type solar dryer showed a highly effective percentage of reduction in drying time for all layers under study. Also, increasing the layer thickness to 15 cm is recommended to gain more benefits of using both the greenhouse type and the natural convection solar dryers.

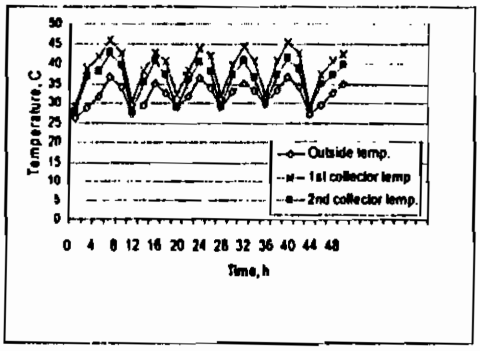
Air Temperature and Relative Humidity

The drying air temperature and relative humidity were recorded during the period of the experimental work every two hours intervals. The average drying air temperature and relative humidity for the traditional sun drying method at layer thicknesses of 5, 10 and 15 cm were 31.63, 32.05 and 32.06°C, respectively and the corresponded values of air relative humidity were 44.96, 44.42 and 44.46%.

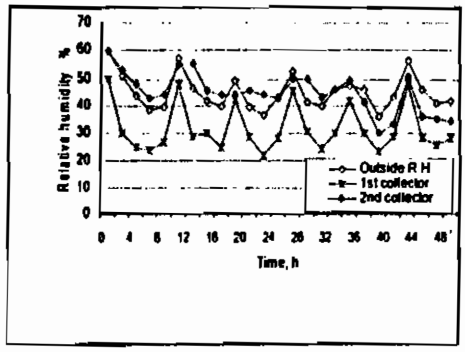
For the natural convection solar dryer, Fig. (9) and Fig. (10) show that, the first collector of the dryer could increase the average air temperature outside the dryer by 6.9, 6.88 and 6.89°C and decrease the air relative humidity by (13.04, 13.10 and 13.28%) at the layers thicknesses of 5, 10 and 15 cm, respectively. Also, the drying air temperatures inside the second collector was decreased by about 2.97, 3.39 .and 3.91°C at the layer thicknesses of 5, 10 and 15 cm, respectively. The corresponded values of air relative humidity was increased by 13.18, 14.14 and 15.11%, respectively, compared with the air inside the first collector.

For the forced convection solar dryer (greenhouse type), Fig. (11) and Fig. (12) show that, the average drying air temperature outside the dryer was 32.21, 32.01 and 32.06°C at the layer thicknesses of 5, 10 and 15 cm and the corresponded values for relative humidity were 44.76, 45.02 and 44.48%, respectively. On the other hand, the average drying air temperature inside the solar collector of the greenhouse dryer was 36.34, 36.15 and 36.18°C at layer thicknesses of 5, 10 and 15 cm and the corresponded relative humidity values were 36.25, 36.54 and 36.06%, respectively.

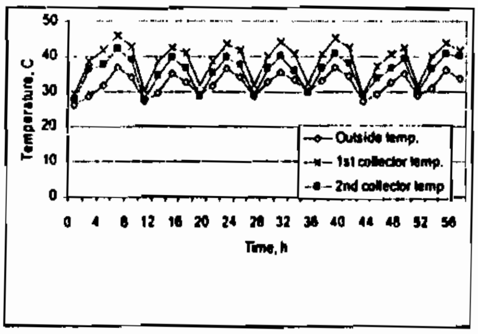
This means that, the solar collector of the dryer could increase the outside air temperature by 4.13, 4.14 and 4.12°C at pods layer thicknesses treatments of 5, 10 and 15 cm, while decreased the air relative humidity by 8.51, 8.48 and 8.42 %, respectively.



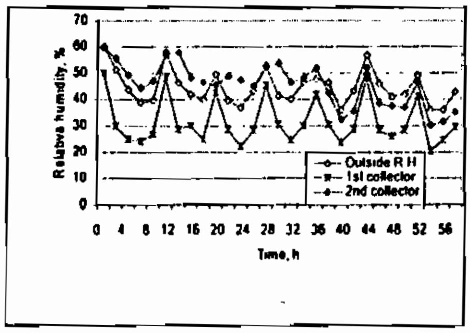
At 5 cm thickness



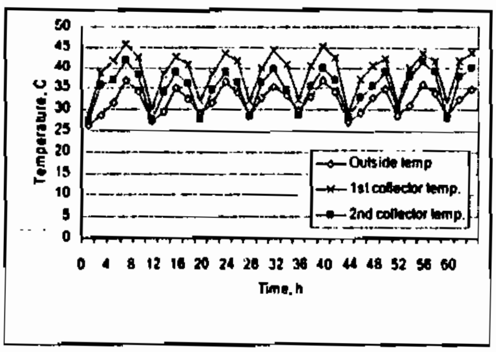
At 5 cm thickness



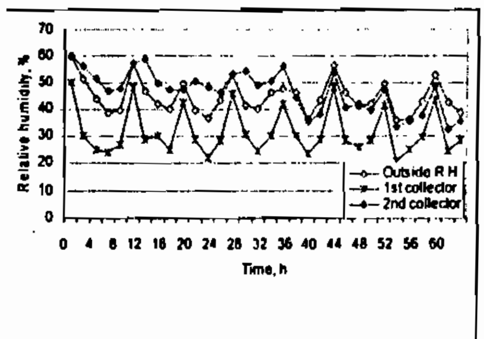
At 10 cm thickness



At 10 cm thickness



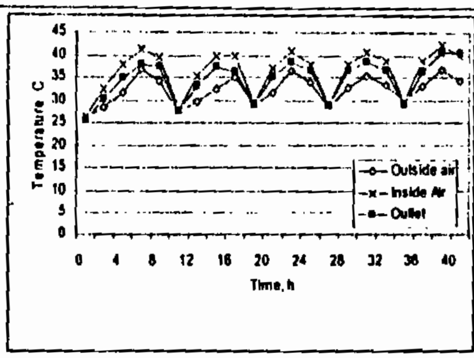
At 15 cm thickness



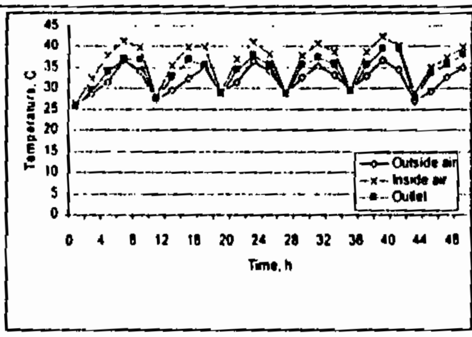
At 15 cm thickness

Fig. (9): Air temperature (outside and inside) the Natural convection solar dryer at different peanut pods layer thickness

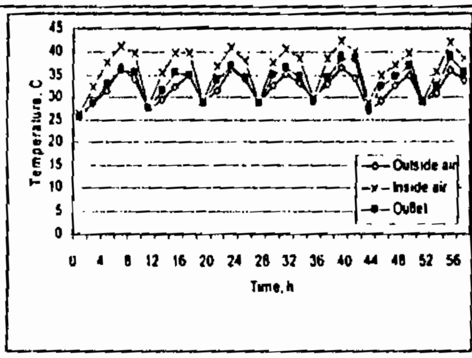
Fig. (10): Air relative humidity (outside and inside) the Natural convection solar dryer at different peanut pods layer thickness



At 5 cm thickness

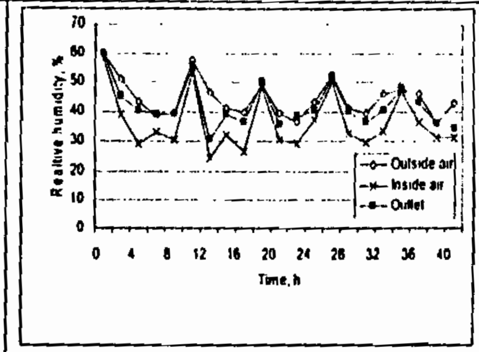


At 10 cm thickness

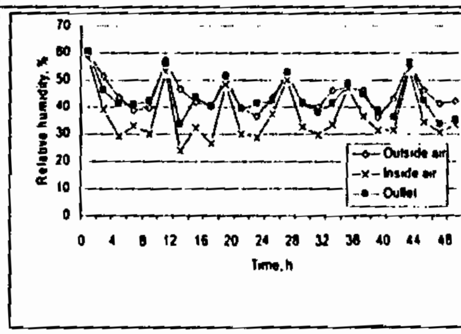


At 15 cm thickness

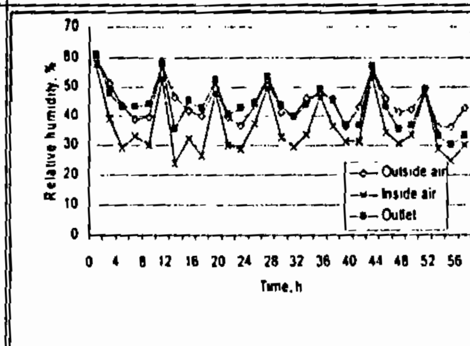
Fig. (11): The outside, inside and outlet air temperature for the forced convection solar dryer at different peanut pods layer thickness



At 5 cm thickness



At 10 cm thickness



At 15 cm thickness

Fig. (12): The outside, inside and outlet air relative humidity for the forced convection solar dryer at different peanut pods layer thickness

Bulk and seed temperatures of peanut pods:

In general, both bulk and seed temperatures of all treatments were decreased during the first period of drying and starts to fluctuate until reaching the drying air temperature at the end of drying process.

For the traditional sun drying method, Fig. (13) and Fig. (14) show that, the recorded average pods bulk temperatures at the pods layer thicknesses of 5, 10 and 15 cm were 30.38, 30.32 and 30.15°C, respectively. The corresponded values for the treatments without stirring process were 31.34, 31.23 and 31.02°C, respectively. On the other hand, the recorded seed temperature at the pods layer thicknesses of 5, 10 and 15 cm with stirring process were 30.37, 30.19 and 29.75°C and the corresponded values for the unstirred beds were 30.84, 30.43 and 30.16°C, respectively.

For the natural convection solar dryer, Fig. (15) and Fig. (16) show that, the recorded average pods bulk temperatures at layer thicknesses of 5, 10 and 15 cm with stirring process were 33.98, 32.74 and 31.72°C, respectively. While, the corresponding values for seed temperature were 33.3, 31.77 and 30.75°C, respectively. However, for the unstirred beds, the recorded bulk temperatures were 34.83, 33.57 and 32.48°C, respectively, and the corresponding values for seed temperatures were 33.67, 32.24 and 31.18°C, respectively.

Meanwhile, for the greenhouse type forced convection solar dryer, Fig. (17) and Fig. (18) show that, the recorded average bulk temperatures with stirring process were 36.33, 34.62 and 33.23°C at the layer thicknesses of 5, 10 and 15 cm, respectively. While, the corresponded values of seed temperature were 34.12, 32.95 and 32.11°C, respectively. On the other hand, the recorded bulk temperatures at the layer thicknesses of 5, 10 and 15 cm without stirring were 37.19, 35.47 and 33.95°C and the corresponded values for seed temperature were 34.65, 32.56 and 32.18°C, respectively.

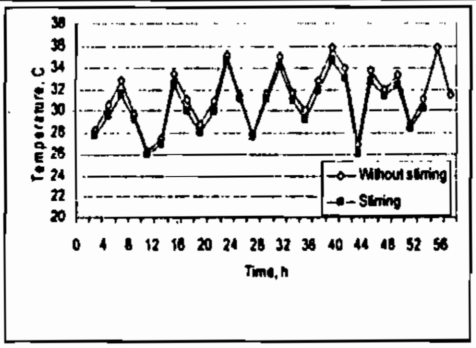
In general, for all studied drying methods the pods bulk temperature and seed temperature were increased with increaseing of drying air temperature and decrease of pods layer thicknesses. Also, for all treatments, the stirring was decreased both pods bulk temperature and seed temperature due to heat loss from the pods bulk during the stirring process. So that, the stirring process shows more uniform drying and also could accelerate the drying process.

Solar Energy Flux Incident:

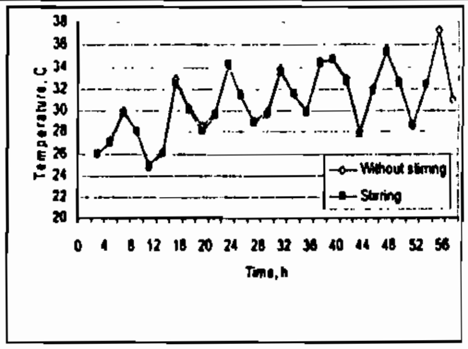
Fig. (19) presents the calculated solar energy flux incident during the overall period of experimental work (from 1 to 10 October 2000). In general, the solar radiation gradually increased from sun rise till it reaches the maximum value at noon, it then decreased gradually until it reached the minimum value at sunset.

Dried Peanut Quality:

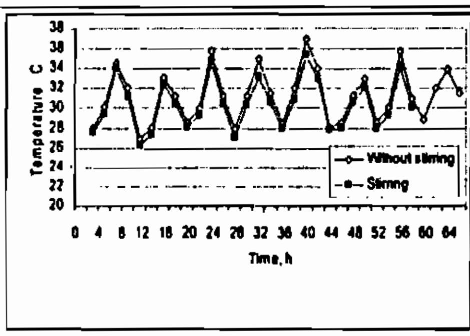
Dried peanut quality was evaluated by measuring acid value (A.V.) and peroxide value in the beginning and in the end of the drying time for the three drying methods. The results showed that, the acid value decreased from 0.74 to 0.4 and the peroxide value decreased from 3 to 1.33. These values are in the range of the quality standards for peanut oil according to Patterson (1989).



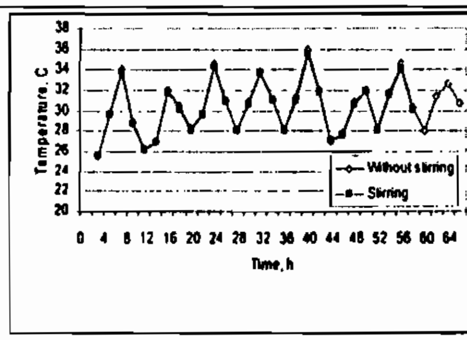
At 5 cm thickness



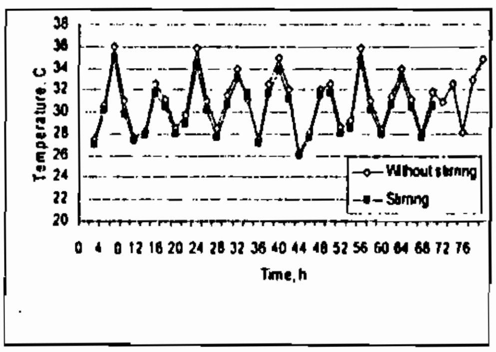
At 5 cm thickness



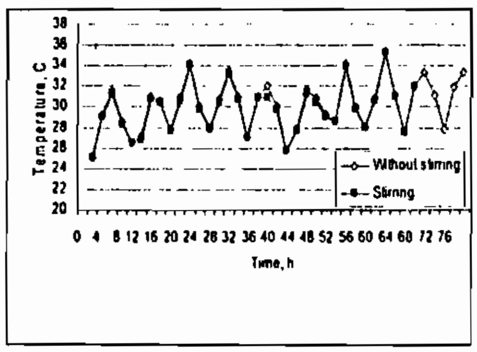
At 10 cm thickness



At 10 cm thickness



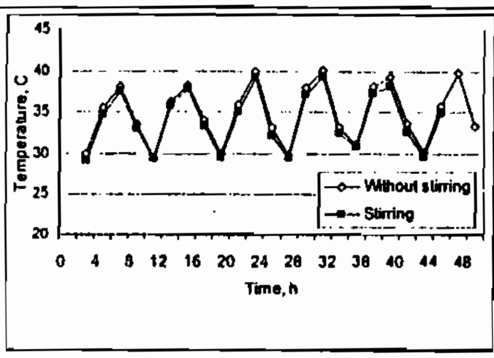
At 15 cm thickness



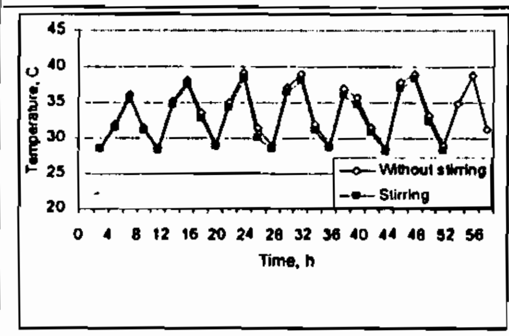
At 15 cm thickness

Fig. (13): Bulk temperature for peanut pods dried by traditional drying method at different pods layer thickness

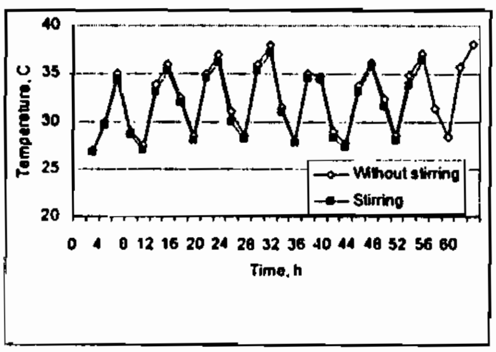
Fig. (14): Seed temperature for peanut pods dried by traditional drying method at different pods layer thickness



At 5 cm thickness

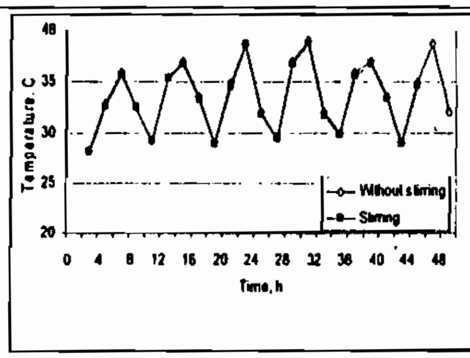


At 10 cm thickness

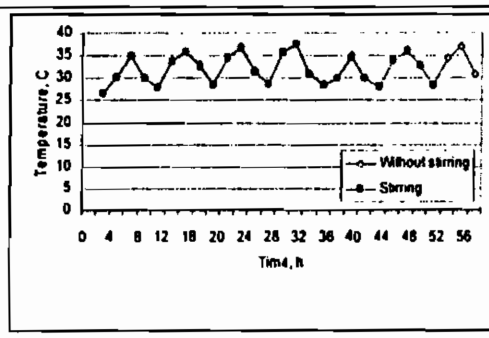


At 15 cm thickness

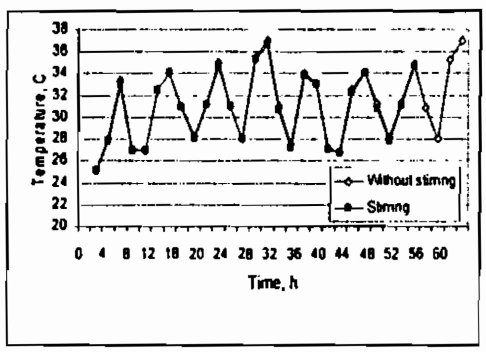
Fig. (15): Bulk temperature for peanut pods dried by natural convection dryer at different pods layer thickness



At 5 cm thickness

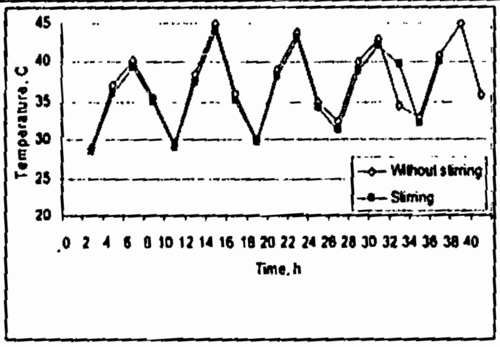


At 10 cm thickness

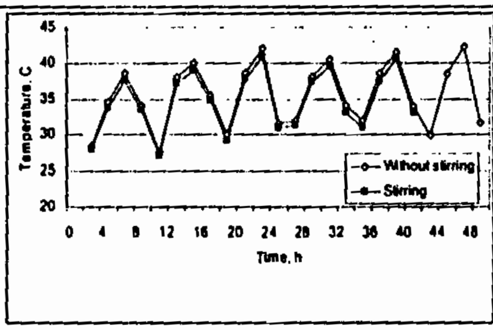


At 15 cm thickness

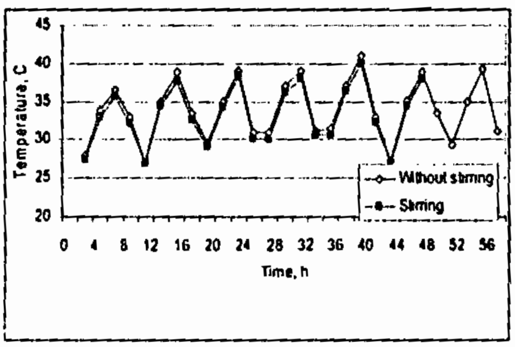
Fig. (16): Seed temperature for peanut pods dried by natural convection dryer at different pods layer thickness



At 5 cm thickness

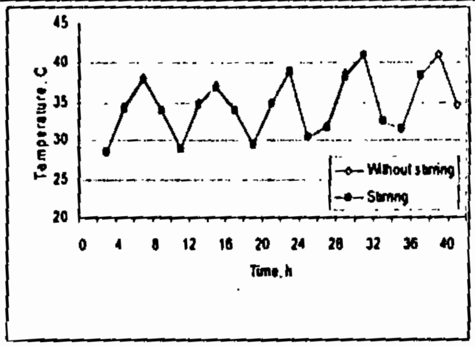


At 10 cm thickness

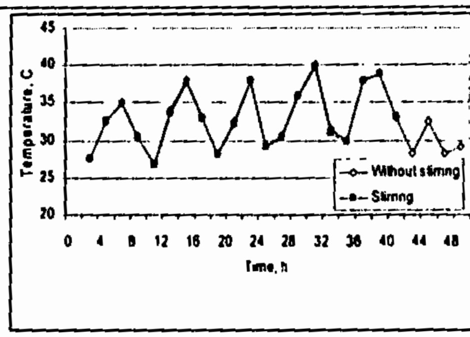


At 15 cm thickness

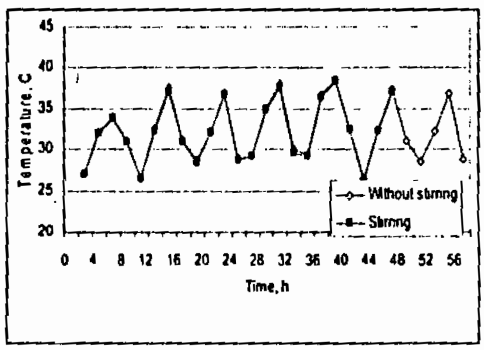
Fig. (17): Bulk temperature for peanut pods dried by forced convection dryer at different pods layer thickness



At 5 cm thickness



At 10 cm thickness



At 15 cm thickness

Fig. (18): Seed temperature for peanut pods dried by forced convection dryer at different pods layer thickness

Cost Estimation.

The cost analysis for the drying costs of the forced air convection solar dryer (greenhouse type) and the natural convection solar dryer indicated that, the drying cost of peanut pods was 0.27 L.E /kg for forced air convection dryer in comparison with 0.19 L.E./kg for the natural air convection dryer. This means that, the natural convection solar dryer is more economic under Egyptian conditions in comparison with the forced air solar dryer. The drying cost could be less than this amount when using the dryer for drying several crops throughout the year.

Thermal Efficiency of the Dryers

The results of calculating thermal performance for both natural convection and forced air dryers showed that, the overall thermal efficiency of natural convection dryer was 23.93% and the corresponding result for forced air dryer (greenhouse) was 46%.

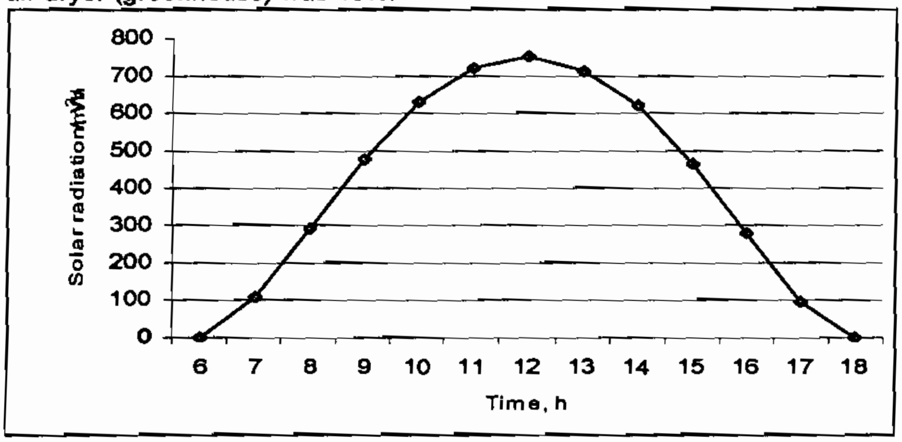


Fig. (19): Hourly average daily solar energy flux incident (calculated).

Conclusion

The obtained results could be summarized as follows:

1- As compared to the traditional drying method, The greenhouse type solar dryer could decrease the total drying time by 29.57, 25 and 23.20% at layers thicknesses of 5, 10 and 15 cm without stirring process while, the corresponded reduction percentages for the stirred treatments were 30.76, 28.57 and 28.78%, respectively. The reduction percentages in drying time for the natural convection solar dryer were 14.20, 12.51 and 20.51% for the unstirred treatments at layers thicknesses of 5, 10 and 15 cm and the corresponded reduction percentages for the stirred treatments were 15.39, 10.71 and 18.18%, respectively.

2- The stirring process could give more chance for pods to receive equal amount of heat and thereby faster pods moisture reduction.

3- The overall thermal efficiency of natural convection dryer and forced air dryer were 23.93% and 46%, respectively.

4- The acid value decreased from 0.74 to 0.4 and the peroxide value decreased from 3 to 1.33. These values are in the range of the quality standards for peanut.

5- The drying cost of peanut pods was 0.27 L.E /kg for forced air convection dryer in comparison with 0.19 L.E./kg for natural air convection dryer. This means that, the natural convection solar dryer is more economic under Egyptian conditions in comparison with the forced air solar dryer.

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التجفيف الشمسى لقرون الفول السودانى باستخدام نوعين مختلفين من المجففات الشمسية

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الغرض من هذه الدراسة هو تقييم لطريقتين من طرق التجفيف لقرون الفول السودانى (جيزة ٥) وتشمل طريقة التجفيف بالدفع الجبرى للهواء، وطريقة التجفيف بالحمل الطبيعى للهواء ومقارنتها بطريقــة التجفيف الشمسى الطبيعى. وقد تم تصنيع ستة مجففات شمسية، ثلاثة منها تعمل بالحمل الطبيعــى للهــواء والثلاثة الأخرى تعمل بالدفع الجبرى للهواء وقد قسم كل مجفف إلى قسمين متساويين أحــدهما تــم تقليــب القرون به كل ساعتين والأخر تركت القرون به بدون تقليب كما تم قياس المحتوى الرطوبى للقــرون كــل ساعتين وقيست أيضا درجة حرارة كتلة القرون ودرجة حرارة الحبوب داخل القرون وذلك للطبقات ا لثلاث من القرون (العليا والوسطى والسفلى) كما تم أيضا قياس سرعة الهواء خارج وداخل المجففات.وقد اشتملت أهم النتائج على:-

١- بالنسبة لطريقة التجفيف الشمسى الطبيعى، تناقص المحتوى الرطوبى للقرون من ٥٤,٣٩% إلى ١٣% فى ٥٢، ٥٦،٦٦ ساعة للقرون التى جففت على أسماك ٥، ١٠، ١٥ سم على الترتيب فى حالة التقليب كل ساعتين. أما بالنسبة للمعاملات التى لم تقلب فقد زاد زمــن التجفيــف وبلــغ ٥٦، ٦٤، ٧٨ ســاعة للمعاملات السابقة. وكان التناقص فى المحتوى الرطوبى متأثرا بدرجة حرارة الهواء ورطوبته النســبية وبالتالى درجة حرارة كتلة القرون ودرجة حرارة الحبوب داخل القرون. كما وأن عملية تقليب القــرون تعطى فرصة للقرون لتستقبل كميات متساوية من الحرارة وبالتالى تسرع من عمليــة التجفيــف. كمــا أوضحت التجارب فى عملية التجفيف الشمسى الطبيعى بدون تقليب أن هناك تفاوتا ملحوظا فى الطبقات الثلاث (العليا والوسطى والسفلى) فى المحتوى الرطوبى بالمقارنة بمعاملة التقليب، حيث كانت المحتويات الرطوبية النهائية للسمك ٥ سم هى ١٢,٣٥، ١٢,٩٨، ١٤,٨٥ للطبقات العليا والوسطى والسفلى علــى الترتيب وكانت المحتويات الرطوبية النهائية لنفس الطبقات فى معاملة التقليب لذات الأسماك هى ١٢,٩٥، ١٢,٤٠، ١٢,٣٦ % على الترتيب وكذلك كانت ذات المؤشرات بالنسبة للسمكين ١٠ سم و١٥ سم.

٢- بالنسبة لطريقة التجفيف بالدفع الطبيعى للهواء، تناقص المحتوى الرطوبى للقرون من ٥٤,٣٩% إلــى ١٣% فى ٤٨، ٥٦، ٦٢ ساعة للقرون التى جففت على أسماك ٥، ١٠، ١٥ سم على الترتيب فى حالــة التقليب كل ساعتين. أما بالنسبة للمعاملات التى لم تقلب فقد زاد زمن التجفيف وبلغ ٤٤، ٥٠، ٥٤ ساعة للمعاملات السابقة. وكان نقص المحتوى الرطوبى للقرون لطريقة التجفيف بدون تقليب أسرع فى الطبقة السفلى منه فى الطبقة العليا والوسطى على الترتيب وذلك يرجع لتصميم المجفف نفســه الــذى يســمح باختراق الهواء الساخن للقرون من أسفل إلى أعلى. ويرجع زيادة معدل نقص المحتوى الرطوبى للطبقة العليا عن الوسطى إلى تأثير الشبكة السوداء الموجودة فوق القرون وامتصاصها للحرارة.

٣- بالنسبة لطريقة التجفيف بالدفع الجبرى للهواء، تناقص المحتوى الرطوبى للقرون من ٥٤,٣٩% إلــى ١٣% فى ٦، ٤٠، ٤٦ ساعة للقرون التى جففت على أسماك ٥، ١٠ ، ١٥ سم على الترتيب فى حالــة التقليب كل ساعتين. أما بالنسبة للمعاملات التى لم تقلب فقد زاد زمن التجفيف وبلغ ٤٠، ٤٨، ٥٦ ساعة لذات المعاملات السابقة.

٤- الكفاءة الحرارية لمجفف الدفع الطبيعى للهواء كانت ٢٣,٩٣% بينما كانت ٤٦% لمجفف الدفع الجبرى للهواء.

٥- قيمة رقم الحموضة تناقصت من ٠,٧٤ إلى ٠,٤ وكذلك قيمة البيروكسيد من ٣ الى ١,٣٣ وهذة القيم فى المدى المثالى لجودة الفول السودانى.

٦- تكلفة تجفيف الكيلو جرام الواحد من قرون الفول السودانى كانت ٠,٢٧ جنية مصرى باستخدام مجفــف الدفع الجبرى للهواء بينما كانت ٠,١٩ جنية مصرى باستخدام مجفف الدفع الطبيعى للهواء.