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Comparative Study between the Dried Fruits by Solar Dryers with or Without Reflective Mirrors as Utilization of Renewable Solar Energy and Conventional Dryers

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ABSTRACT

The objective of this investigation was aimed to study the effect of four drying methods such as natural sun drying and electric hot air drying method compared with solar drying with or without reflective mirrors as utilization from renewable solar energy, environmentally friendly technology, on the physical, chemical and sensory properties of dried grapes and apricot fruits as well as cost of operation. Results indicated that, drying rate of tested samples by using solar drying with reflective mirrors and electric hot air drying methods wear faster than those for drying rate of solar drying without reflective mirrors and natural sun drying because the inclusion of reflective mirrors to dryers increases the drying potential considerably. The useful temperature rise of about 10 ºC was achieved with mirrors, which reduced the drying time by 12, 6 h for grapes and apricot respectively, which was leading to reduce the drying time, and thus lead to a reduction cost of the dried products. Also, to reach the adequate moisture content in the final product of dried grapes 18.0, 16.6, 16.4 and 17% and apricot 17.4, 17.2, 17.0 and 17.0% under the limit of maximum permissible level of moisture content in Egyptian standard by drying methods under investigation the elapsed drying time were 52, 36, 24 and 24 drying hours for grapes and 34, 24, 18 and 18 drying hours for apricot to reach the adequate moisture content. The grapes and apricot samples dried by using solar drying with or without reflective mirrors were the best for the most of physicochemical quality properties such as color, rehydration ratio and shrinkage rate when compared with the similar samples dried by electric hot air drying and natural sun drying method, which needed the long time. The tested samples dried by using solar drying with or without reflective mirrors were found to be the high retention of *L*-Ascorbic acid. Also, solar drying with reflective mirrors and electric hot air drying methods were a highly retention of β- carotene and total phenolic compounds. The solar drying with reflective mirrors drying process caused, in general, more retention of total flavonoids in dried grapes and apricot samples as well the ability to quench the DPPH radical obviously than those found in the samples dried by other drying methods. The grapes and apricot samples dried by using both solar drying with or without reflective mirrors exhibited good sensory properties and better acceptability when compared with the samples dried by other tested drying methods, especially by solar drying with reflective mirrors-related drying can meet the four major requirements in drying of foods: short time of operation, drying efficiency, cost of operation, and quality of dried products.

***Key words*:** Renewable solar energy, Solar drying with reflective mirrors, antioxidant compounds, antioxidant activity and sensory quality.

Introduction

The sun is probably the most important source of renewable energy available today. Traditionally, the sun has provided energy for practically all living creatures on earth, through the process of photosynthesis, in which plants absorb solar radiation and convert it into stored energy for growth and development. Scientists and engineers today seek to utilize solar radiation directly by converting it into useful heat or electricity.

The main advantages of solar energy are that it is clean, able to operate independently or in conjunction with traditional energy sources, and is remarkably renewable. Renewable energy resources will play an important role in the world's future Demirbas, (2000). Renewable energy sources are those resources which can be used to produce energy again and again, e.g. solar energy, wind energy, biomass energy, geothermal energy, etc. and are also often called alternative sources of energy Panwar, (2007). The sources of renewable energy that meet domestic energy requirements have the potential to provide energy services with zero or almost zero emissions of both air pollutants and greenhouse gases. Renewable energy system development will make it

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possible to resolve the presently most crucial tasks like improving energy supply reliability and organic fuel economy; solving problems of local energy and water supply increasing the standard of living and level of employment of the local population; ensuring sustainable development of the remote regions in the desert and mountain zones; implementation of the obligations of the countries with regard to fulfilling the international agreements relating to environmental protection Zakhidov, (2008).

Egypt has received average solar energy of 7 kWh/ m^2 day. This solar energy is sufficient, especially in summer; to me*et al*l the energy demands for drying of the agricultural products therefore, using solar energy can considerably reduce energy costs Chedid and Chaban, (2003). Egypt is one of the countries having solar energy in abundance. The solar energy incident on the Egyptian land has a magnitude of 12- 30 MJ/m^2 /day, and the sunshine duration is between 3500- 4500 hr per year. Solar energy can solve apart of energy demand problem however the use of solar energy in Egypt could play a useful role in satisfying energy requirements of most urban areas in appropriate circumstances. El-Metwally, (2005).

The easiest way to dry food is by sun drying. The advantage of this technique is that one basically doesn't need any specific equipment, so it is a low cost way of handling the products. The disadvantages are many, and one of the main problems is spoilage of the products due to weather conditions as rain, wind and dust. The hygiene is difficult to maintain, with contamination from the soil. Animals, insects and birds, are also a source for contamination of microorganisms, and they also cause losses by eating the products if they get the chance. The direct sunlight could lead to deterioration of the nutritional value, and also cause color changes. The long drying time needed for drying the products could allow fungi and other microorganisms to grow on the products (Sharma *et al*. 2009).

Open sun drying, where the product is exposed directly to the sun allowing the solar radiation to be absorbed by the material is one of the traditional and oldest methods employed using solar energy, for food preservation. The sun's free energy for drying in open-air is counterbalanced by a multitude of disadvantages, which reduce not only the quantity but also the quality of the final product. Belessiotis and Delyannis, (2009).

The color of the dried products often comes out matt and pale compared to the fresh material, due to the dry surface reflects the light in another way. In vegetables, carotenoid and chlorophyll pigments goes through chemical changes caused by heat and oxidation. Residual polyphenol oxidase enzymes could lead to browning during storage. Blanching the products before drying could prevent this (Fellows 2000).

Solar dryers are very environment friendly and will enhance energy conservation. As an alternative to open sun drying, solar drying system is one of the most attractive and promising applications of solar energy systems. It is renewable and environmentally friendly technology, also economically viable in most developing countries Fudholi *et al*. (2010).

The use of solar energy in recent years had reached a remarkable edge. The continuous research for an alternative power source due to the perceived scarcity of fuel fossils is its driving force. It had become even more popular as the cost of fossil fuel continues to rise. Of all the renewable sources of energy available, solar energy is the most abundant one and is available in both direct as well as indirect forms. Also, one of the most important potential applications of solar energy is the solar drying of agricultural products. Losses of fruits and vegetables during their drying in developing countries are estimated to be 30–40% of production. The postharvest losses of agricultural products in the rural areas of the developing countries can be reduced drastically by using well-designed solar drying systems El-Sebaii, and Shalaby, (2012).

The solar driers can in regions with stable warm and sunny weather, be a good alternative to mechanical driers. Especially in areas with no access to electricity, or unstable power supply, this could be an important method for preserving food. Compared to primitive sun drying, the advantages are protection from unstable weather conditions, no direct sun exposure and protection from animals, insects and birds. A solar dryer will also dry the products in a shorter time, because of collection of heat from the sun, which gives less time for microorganisms to establish and grow. The fact that the process is environmental friendly, because no fossil fuel is used makes it even a better method in the future (Sharma *et al*. 2009).

Fruits and vegetables have higher water contents, which limits their shelf life and limits wider distribution. This has led to an increase in the production of processed fruits and vegetables, including dehydrated fruits and vegetables. Dehydrated products have low water contents, which prevents the development of microorganisms that deteriorate fresh fruit and vegetables. However, these drying processes can have a negative effect on the nutrients within the food product (Morris and Brady, 2003).

Grapes are one of the most popular and palatable fruits in the world. According to FAO data, grape production was about over 70 million tons all over the world. Preservation of grapes as raisins is the key operation in many parts of the world where grapes are grown. Raisins are a source of carbohydrates and contain a large amount of iron, vitamins (A, B_1, B_2, B_3 and B_6), minerals and antioxidants (Breksa *et al.,* 2010).

Grapes and grape products have been shown to be good sources of phenolic antioxidants (Teissedre, *et al*, 1996).

Apricot is a climacteric fruit with a very short storage life due, in part, to a high respiration rate and a rapid ripening process. To extend the shelf life of apricot, different preservation methods have been developed including canning, freezing, drying and packing in controlled atmospheres (Jiménez *et al.,* 2008).

Apricot fruits can be considered as a good source of phytochemicals such as polyphenols, carotenoids and vitamins, which significantly contribute to their taste, colour and nutritional and functional values. Currently there is a considerable interest in these biologically active components because of their antioxidant properties and ability to alleviate chronic diseases (Gardner, *et al,* 2000). In addition the growing demand for healthy and nutritive foods in the world today has made nutrient analyses a major area in quality control studies. Dietary phenolic intakes, in particular, are known to reduce coronary heart diseases and cancer, as well as to act as anti-microbial, anti-allergic, anti-mutagenic and anti-inflammatory (Kim, and Lee, 2003).

So, the objective of this research was to study the effect of drying methods (natural open sun drying, and electric hot air drying compared with solar drying with or without reflective mirrors) on total cost per unit of products, quality characteristics of dried grape and apricot such as physiochemical, antioxidant compounds, antioxidant activity and sensory quality properties of dried grape and apricot.

Materials and Methods

Samples of grapes *(Vitis vinifera* L.*)* variety (Thompson seedless) were procured from Mustafa Hendy farm, Misr Ismailia desert road, El-tal El-kabir, Ismailia, Egypt. Whereas Apricot *(Prunus armeniaca* L.*)* variety (Caneno) was procured from El Tahany farm, Kilo 80 Misr Alexandria desert road, Cairo, Egypt. Both were obtained during the summer season of 2014.

Preparation of raw material:

Fresh seedless grapes used in this study were washed by tap water and dipped in hot alkaline Solution 0.1% (1 g \ L NaoH) for 20 sec. at 90°C, and immediately immersed in cold fresh water to stop the heat effective and removal of NaoH residual, then they were sulphureted by sodium metabisulfite solution 0.5% (5 g\L) for 30 min.

Apricot fruits were washed thoroughly with tap water, pitted, blanched in hot water at 90°C for 40 sec. then sulphurized by immersing in 1% (10 g\L) sodium metabisulfite solutions for 30 min. After that, the apricots were drained. Then all grapes and apricot samples they divided into four batches. Each was carefully set up as a single layer on the drying trays and they were dried by four methods natural sun drying (M1), solar dryer without reflective mirrors (M2), solar dryer with reflective mirrors (M3) and electric hot air dryer (M4).

The details of four methods used for drying:

In present work four methods were used for the dehydration of tested materials. The first method of drying is using direct natural sun rays (open drying method). The second and third methods used indirect solar energy new design thus named renewable energy (alternative energy). They differ only in use of reflective mirrors means with and without mirrors. The fourth method is using electric energy (oven of dehydration air hot drying method) both first and fourth methods was used for comparison with second and third methods of renewable and alternative energy (indirect solar dryers with and without mirrors)

Natural open sun drying method:

Prepared raw materials were distributed uniformly as a one layer on to the stainless steel trays of size 3 × 1.2 m and height on aboveground 1 m and dried under direct sunlight at temperatures between 27 and 38° C in July and August 2014 in the roof of the Faculty of Agricultural Engineering, Al-Azhar University, Nasr city, which located at (30° 2\ N and 31° 12\ E).

Renewable energy "indirect solar energy dryers":

With or without reflective mirrors methods:

The solar collector was made of a wooden box having gross dimensions of 1.5 m long, 0.75 m width (1.125 m^2 area). The walls and bottom was constructed of wooden panels (0.8 cm thick), frame of a wood with a cross section (10 x 5) cm^2 connected to the flat plate collector, the absorber plate was made of light-gauge steel sheet of 0.7 mm thick and the space between the bottom and the flat plate collector are insulated by foam layer (0.03 m thick), this box (collector) painted from inside by a blackboard paint mixed with 50% by weight of a talc powder i.e. (too fin zinc oxide, nontraditional paint) (Ghanem, 2003).The solar collector was covered with one layer of a clear glass, 3 mm thick to reduce the reflection of radiation and heat losses by convection. The solar collector was attached with the drying chamber by an air duct. The air duct has a cross section area 0.144 m^2 it was insulated by two layers of insulating materials from foam 0.03 m thick and glass wool thick 3 cm.

Drying chamber:

Drying chamber was constructed of wooden panels (0.05 m thick), the side walls and bottom of drying chamber were insulated by foam layer (3 cm thick). Drying air inters the chamber after leaving the solar collector through an air duct from the bottom to the top of the dryer bin. The dryer door was made of wooden panels with gross dimensions of 0.52 m long and 0.52 m wide, the door was connecting to drying chamber by two hinges the door was tightly sealed by a rubber gasket during the drying process. The drying chamber was mounted on a wooden stand 0.80 m higher from the ground.

Chimney:

The chimney was installed in the air outlet of the drying chamber for removing the moist drying air. It was constructed of 0.5 m long galvanized steel sheet of cylindrical shape and covered with a conical steel sheet cowl.

Air blower:

The air centrifugal fan of 750W, 220 V, made in China, was used to supply the air flow rates. This blower was connected to the solar collector by PVC pipes of 100 mm diameter by special connections,(T and elbows) these pipes passes the air through the solar collector, with gates, for controlling the air flow rates.

With reflective mirrors method:

In the present study two similar solar dryers wear used as depicted pictures, Fig (1) were designed and manufactured by (Ghanem, 2003) in the roof of the Faculty of Agricultural Engineering, Al-Azhar University, Nasr city, one of these two solar dryers wear modified by adding three stainless steel number 304 reflectors in order to concentrate solar radiation and magnifying energy collected that directly affecting drying time. One of the three previously characterized reflectors has dimension of 0.75×1 m and is supported due to south with an inclination angle tracing the sun manually. The other two reflectors were supported east and west of the solar collector. Each of them has the dimension of 1×1.5 m. Drying experiments were carried out in summer season of 2014 in July. Solar and sun drying methods from 8 Am to 5 Pm During the night dried products is rehydrated due to higher relative humidity. Solar intensity relative humidity, drying and ambient air temperatures were recorded.

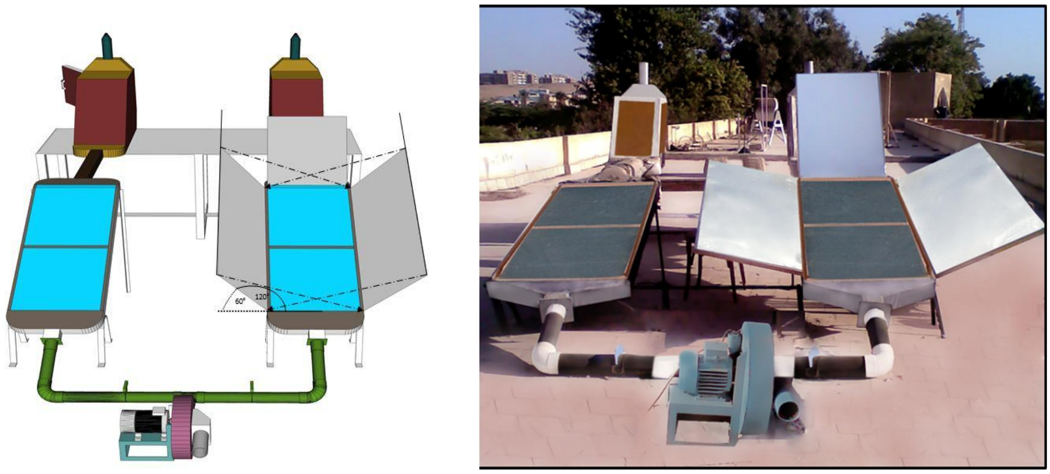

Fig. 1: Solar drier with or without reflective mirrors.

Electric oven (hot air dryer) method:

The air drying unit which used in this investigation in Food Science and Technology Department, Faculty of Agriculture, Cairo, Al-Azhar University. Was constructed as rectangular cabinet approximately 55 x 60 x 140 cm. and contains a five perforated trays for placed the material to be dried. It contains two electric heaters, Motor airs push (Air blower) 1 horse, and Organizer adjusted the temperature oven. Temperature rang 60-250º C It was set oven temperature during a dehydration period on (60±1) Cº.

Chemicals, reagents:

All chemical reagents used in present study were analytical grade. Folin-Ciocalteu, Gallic acid**,** Mediums (plat count agar**,** Potato dextrose agar (PDA)**.** All chemicals were purchased from El- Gamhouria Trading for Chemicals and Drugs Company, Egypt.

Cost analysis:

El- Awady *et al*. (1988) reported that the total cost per unit product is broken down into:

1) Fixed costs:

a) Depreciation = cost now – salvage value / total expected life in years.
(Salvage = 10% of cost now)
b) Interest on investment = (0.5(Depreciable cost) + estimated savage)
x interest rate (Interest rate is assumed 0.11)
c) Taxes and insurance = (0.5(Depreciable cost) + estimated savage)
x combined rate (Combined rate =1.5%)

2) Operating costs:

a) Fuel, power and utilization
b) Maintenance and labor (maintenance = 3% cost now)

Gross Chemical Composition:

Moisture, protein (N × 6.25), ether extract, and ash of fresh and dried grapes and apricot fruits were determined using the methods described by the A.O.A.C., (2005) Total carbohydrates content was calculated by differences as followed: total carbohydrates(%) =100 - [protein + fat + water + ash + alcohol] in 100 g of food). Kraisid, *et al*. (2003) and BeMiller (2010).

It should be clear that carbohydrate estimated in this fashion includes fibre, as well as some components that are not strictly speaking carbohydrate, e.g. organic acids (Merrill and Watt, 1973),

Determination of sugars:

Total, reducing and non-reducing sugars in fresh and dried grapes and apricot fruits, were determined by A.O.A.C., (2005). The fruit extract sample was clarified by lead acetate and excess of lead acetate was precipitated by sodium oxalate. The reducing sugars and total sugars were determined in the clarified solution and the non-reducing sugars were calculated from the difference between the percentage of reducing and total sugar.

Colour :(Optical density measurement):

Colour was determined as the optical density of the diluted centrifuged extracts water of fruit flesh. 1g of the prepared samples were extracted with distilled water (200 ml) and the absorbance was measured at 360 nm for grapes and 320 nm for apricot using Perkin Elmer Lambda UV/VIS Spectrophotometer according to Hilphy *et al*. (2008).

Total Soluble Solids (T.S.S):

Total soluble solids (T.S.S) for fresh and dried samples were determined by using a refractometer, Carl Ziess, Jena (Germany) at 20°C. A correction was made for different temperatures and the results were calculated as Brix° at 20°C. A according to the method described by the AOAC, (2005).

Titratable Acidity (TA):

The titratable acidity (TA) for fresh and dried grapes and apricot fruits were determined according to the method described by A.O.A.C., (2005) TA was analyzed in triplicate and expressed as citric acid equivalents.

The pH Value:

Fresh and dried samples was homogenized and then evaluated as the method described by A.O.A.C., (2005) pH value determination was carried out by a Jenway 3505 pH Meter (UK) with a combined pH electrode at 25°C.

Rehydration Ratio (RR):

The rehydration capacity was used as a quality characteristic of the dried product (Velić *et al.* 2004) expressed in the rehydration rate – RR (Lewicki, 1998). Approximately 2 g (± 0.01 g) of the dried sample was placed in a 250 ml laboratory glass box (two analyses for each sample), 150 ml distilled water was added and the glass box was covered and heated to boil within 3 minutes. The content of the laboratory glass box was then gently boiled for 10 more min and then cooled. The cooled content was filtered for 5 min under vacuum and weighed. The rehydration ratio was calculated as:

$$RR = \frac{Wr}{Wd}$$

where:
Wr - drained weight (g) of the rehydrated sample.
Wd - weight of the dry sample used for rehydration.

Shrinkage (%):

Shrinkage is expressed by the volume ratio of sample before and after drying.A few researchers have expressed shrinkage as a function of the change of selected dimensions of the samples, measured with vernier or digital callipers (Hatamipour and Mowla, (2003), Karathanos *et al.* (1996) and Mayor and Sereno, (2004). Mostly, it was expressed in terms of the apparent volume (Eq. 1). This volume can be measured by the Archimedes principle or by a number of displacement techniques.

$$S = \frac{V_0 - V_d}{V_0} \times 100$$

Where, S (%) of shrinkage, V_d is the apparent volume of the sample after drying, cm3 andV0 is the apparent volume of the raw sample, cm3. Initially covered with paraffin oil then Volume changes due to sample shrinkage were measured by a water displacement method as described by Sjoholm and Gekas, (1995). Measurements were made as quickly as possible (less than 30 s) to avoid water uptake by samples. to displace sample in order to estimate sample volume gravimetrically.

Determination of antioxidant compounds:

1-Determination of ascorbic acid:

Ascorbic acid content was estimated in fresh and dried grapes and apricot fruits according to A.O.A.C., (2005) using 2, 6 dichlorophenol-indophenols by titratable method. Result was expressed as mg ascorbic acid per 100 g samples.

2-β-Carotene content:

The β-carotene content of dried samples (grapes and apricot) was analyzed using high performance liquid chromatography (HPLC) as described by Wang and Xi, (2005). The wavelength of the detector was set at 470nm. A Vydac 5 µm 210TP54column 250cm × 4.6cm (Anspec, Ann Arbor, MI) and a solvent system, methanol-BHT stabilized tetrahydrofuran (THF) 90/10 (v/v), were used for the reverse phase separation of carotenes. The β-carotene of dried samples were calculated by comparison with carotene standards and expressed as micrograms of carotene per gram of sample on a dry weight basis.

3-Extraction and determination of total phenolic compounds (TPC):

One gram of each samples were mixed with 25 ml of 50% ethanol and stirred at room temperature for 1 h then filtered through Whitman filter paper No.1. TPC was calculated in the eththanolic extracts, according to the Folin–Ciocalteu method with slight modifications (Jaramillo-Flores *et al.,* 2003). A 100 µL aliquot of ethanolic extract was mixed with 900 µL of 10 fold Folin–Ciocalteu phenol reagent (diluted 1:10 with distilled water) and was allowed to stand for 5 min at room temperature; 0.75µL of 7.5% sodium bicarbonate solution was added to the mixture and vortexed for 30 s, and allowed to stand for 90 min at room temperature. The absorbance was measured at 725 nm using a spectro-photometer (6405 UV/Vis, Jenway LTD., Felsted, Dunmow, UK). A calibration curve of gallic acid (ranging from 0 to 1.00 mg/mL) was prepared and tested under similar conditions. All values were expressed as mean (mg of Gallic acid equivalents/g of dray weight) ±SD for 3 replications.

4-Total Flavonoids:

Total flavonoids were analyzed for fresh and dried grapes and apricot fruits according to the method reported by Toor and Savage, (2006). And Zhishen *et al.* (1999). The samples absorbance was measured at 510 nm on a spectrophotometer (Spekol11, No. 849101,) against the blank (water) and the total flavonoids was determined from the standard curve. Flavonoid content was expressed as mg Rutin equivalents/ 100 g DM

Antioxidant Activity:

Antioxidant activity was determined by 2, 2-diphenyl-1-picrylhydrazyl (DPPH) method according to Lee *et al.* (2003). The stock reagent solution ($1\times10^{-3}M$) was prepared by dissolving 22 mg of DPPH in 50 ml of pure methanol and stored at -20 ºC until use. The working solution ($6\times10^{-5}M$) was prepared by mixing 6 ml of the stock solution with 94 ml of methanol to obtain an absorbance value of 0.8 ± 0.02 at 515 nm, as measured using a spectrophotometer. 0.1 ml extract was vortexes for 30 sec with 3.9 ml of DPPH solution and left to react for 30 min, after which the absorbance at 515 nm was recorded. A control with no added extract was also analyzed. Scavenging activity was calculated as follows:

DPPH radical = scavenging activity (%) = $(A_{control} - A_{sample}) / (A_{control}) \times 100$

Organoleptic evaluation:

Organoleptic evaluation was used to differentiate between the grapes and apricot samples dried by different drying methods under this study. Sensory evaluation was carried out by 10 panels from educational organization members of Food Science and Technology Department, Faculty of Agriculture, Cairo, Al-Azhar University. Organoleptic test of dried samples were given to the panelists for quantitative expression of the quality and sensory parameters. The sensory technique was carried out by using a hedonic test ten-point scale according to Gallali *et al*. (2000).

Statistical Analysis:

All data of dried samples fruit were analyzed using SPSS (version 16.0 software Inc. Chicago, USA) of completely randomized design as described by Gomez and Gomez, (1984). Treatment means were compared using least signification differences (LSD) at 0.05 levels of probability and standard error.

Results and Discussion

Effect of different drying methods on the falling rate period (Elapsed time) of moisture content in produced dried grapes and apricot fruits:

The relation between moisture content and elapsed time to reach the required moisture content (drying curves) of dried tested fruits (grape and apricot)by natural sun drying (M1), solar dryer without reflective mirrors (M2), solar dryer with reflective mirrors (M3) and electric hot air dryer (M4) are shown in Table (1).

From the obtained data listed in Table (1). it could be indicated that to reach the adequate moisture content in the final product of dried grapes (18.0, 16.6, 16.4 and 17%) and apricot (17.4, 17.2, 17.0 and 17.0%), under the limit of maximum permissible level of moisture contents in The Egyptian standard by drying methods under investigation (natural sun drying, solar drying without reflective mirrors, solar drying with reflective mirrors and electric hot air dryer) the elapsed drying time were 52, 36, 24 and 24 hours for grapes and 34, 24, 18 and 18 hours for apricot to reach the adequate moisture content.

From Table (1) it can be seen that the moisture content of the samples under investigation decreased with the increased of drying time. In the beginning of drying cycle, the rate of moisture evaporation gradually loses and decreases as the drying proceeds. The incorporation of reflective mirrors in the solar drying unit advanced

Table 1: Effect of different drying methods on the falling rate period of moisture content (%) for tested dried grapes and apricot fruits.

Moisture content of tested fruits during drying by different drying methods									
Drying time (S.h)	Grape				Drying time (S.h)	apricot			
	M1	M2	M3	*M4		M1	M2	M3	*M4
0	80.0	80.0	80.0	80.0	0	83.3	83.3	83.3	83.3
2	78.45	78.0	77.30	76.85	2	81.80	81.0	80.0	79.0
4	77.0	74.30	70.0	68.30	4	76.0	73.65	71.45	68.45
6	70.0	61.50	58.75	58.0	6	68.50	53.80	49.90	51.0
8	67.65	48.68	42.0	41.87	8	57.90	46.30	43.85	44.60
10	62.45	42.0	40.45	39.66	10	48.75	44.70	37.50	38.25
12	59.0	40.32	38.0	37.0	12	40.0	36.0	24.0	24.50
14	54.80	38.75	31.70	33.0	14	38.50	29.45	19.40	19.80
16	53.25	37.0	28.0	29.90	16	36.75	26.75	18.20	18.36
18	52.0	36.50	25.90	27.50	18	34.90	22.0	17.0	17.0
20	50.30	34.76	20.0	21.0	20	31.92	19.90	-	-
22	49.44	30.0	17.70	18.45	22	27.60	18.38	-	-
24	48.12	26.90	16.4	17.0	24	24.90	17.2	-	-
26	46.50	24.0	-	-	26	21.65	-	-	-
28	42.36	22.50	-	-	28	19.86	-	-	-
30	39.0	21.0	-	-	30	18.60	-	-	-
32	34.50	18.0	-	-	32	18.0	-	-	-
34	30.75	17.20	-	-	34	17.4	-	-	-
36	29.0	16.6	-	-					
38	28.70	-	-	-					
40	27.85	-	-	-					
42	26.10	-	-	-					
44	24.0	-	-	-					
46	22.80	-	-	-					
48	20.0	-	-	-					
50	19.20	-	-	-					
52	18.0	-	-	-					

*S.h: sun hours, M1: natural sun drying, M2: solar dryer without reflective mirrors, M3: solar dryer with reflective mirrors M4: electric hot air drying. *drying time by hours*

the drying process by12 h (33.33%) for grapes and 6 h (25%) for apricot when compared with the same materials dried by solar drying without reflective mirrors method. A reflective mirrors give rise to increase the concentration of solar radiation on the stage of drier and the blower circulate the drying air inside the drying chamber. These results are in accordance with the data obtained by Badgujar, (2012). Who reported that the average temperature of the desiccant material with the reflective mirrors reaches a maximum of 80˚C at the noon, which is about 10˚C higher than that of without reflective mirrors. This shows that the drying potential of the desiccant material is increased and maintains the temperature level well above the ambient temperature even on the next day in the morning. The decrease in temperature of desiccant after the peak is mainly due to the fall in solar radiation and heat losses to the ambient air circulated through the desiccant.

These results may be due to increase the temperature of drying media in case of solar drying with reflective mirrors and electric hot air drying methods which was higher than that found in other drying methods (Natural sun drying and solar drying without reflective mirrors methods). The reflective mirrors which assisted to solar dryer led to increase the reflected waves from sun light to the stage of solar dryer and then perform to increase the temperature of drying media which was decrease the drying time (rapid in the drying rate) according to Shanmugam and Natarajan (2006) and Shanmugam and Natarajan (2007). From the previous discussion, it could be concluded that the drying rate of all tested samples by using solar dryer with reflective mirrors and electric hot air drying methods was faster than those for drying rate of natural sun drying and solar dryer without reflective mirrors. The elapsed drying time to reach the adequate moisture content in the final dried tested samples by using natural sun drying requires a much longer drying time, in all tested dried fruits flowed by samples produced by solar drying without reflective mirrors While, the same tested samples were required

A shorter time to reach the desired moisture content in the final products when used the solar drying with reflective mirrors and electric hot air drying methods. Where the solar drying with reflective mirrors and electric hot air drying methods were need to the same time to reach adequate moisture content in all tested samples. It should be noted that the fruits dried by solar drying with reflective mirrors characterized with Low-cost and energy-saving as compared with electric hot air drying method (Sharma *et al.,* 2009).

Drying time and temperature of dried fruits by using different drying methods:

The required drying time for dehydration of fruits (grapes and apricot) by using natural sun drying, solar drying without reflective mirrors, solar drying with reflective mirrors and electric hot air drying methods and the average of temperature during the dehydration process are exhibited in Table (2).

From the obtained data, in Table (2). it could be appeared that the much longer drying time was obtained by using the natural sun drying method in all tested samples, whereas it was 52 hr. of dried grapes and 34 hr. of dried apricot. As well as drying time of the same tested samples it took 36-24 hr. when dried by solar drying without reflective mirrors and 24-18 hr. when using of both solar drying with reflective mirrors or electric hot air drying methods.

Table 2: Drying time and temperature of dried tested fruits using natural sun drying, solar drying without reflective mirrors, solar drying with reflective mirrors and electric hot air drying.

Drying methods		Drying time and temperature	Dried fruits	
			Grape	Apricot
Natural Sun Drying.		Time by sun hours	52	34
		Temperature (ºc)	37	37
Solar drying	Without reflective mirrors.	Time by sun hours	36	24
		Temperature (ºc)	50	50
	With reflective mirrors.	Time by sun hours	24	18
		Temperature (ºc)	60	60
Electric hot air drying.		Time by (hours)	24	18
		Temperature (ºc)	60	60

The clear observation noted in present work is the solar dryer with reflective mirrors drying system could produce final dried products (grapes and apricot) moisture throughout short time not exceeded than 24 and 18 hr. respectively. As well as the electric hot air drying method typically took the same time for reached to final dried products (all tested sample). As regards the average temperature during drying process of tested fruits (grape and apricot) were 37 ºC for sun drying method, 50 ºC for solar drying without reflective mirrors and 60 ºC for solar drying with reflective mirrors or electric hot air drying methods.

Also from the same Table (2). it could be also illustrated that the lower average temperature obtained during drying of fruits (grape and apricot) were recorded by sun drying methods (37ºC), followed solar drying without reflective mirrors (50ºC) and the higher average temperature obtained during drying of the fruits were recorded by solar drying with reflective mirrors and electric hot air drying methods (60 ºC). These results reflect the elapsed drying time to reach the adequate moisture content in the final dried tested samples which was explain that tested fruits dried by sun drying methods need to prolonged time than that other investigated drying methods especially solar drying with reflective mirrors and electric hot air drying methods where recoded the higher temperature and shorter time (table 5 and 6) was observed with dried fruits. A comparison between the solar drying with reflective mirrors and electric hot air drying methods in terms of energy consumption there are undoubtedly that the solar drying with reflective mirrors saving the energy more than electric hot air drying methods whereas incorporation the reflective mirrors give rise to increase the concentration of solar radiation on the stage of drier and increased the temperature which was led to drying time can be reduced. These results are in agreement with Bal *et al*. (2010) they reported that The inclusion of reflective mirrors increases the drying potential by 20%. The useful temperature rise of about 10 ºC was achieved with mirrors.

The economical evaluation of different drying methods for dried tested grapes and apricot fruits:

The cost per LE/kg of dried product for grape and apricot dried by different drying systems namely: open sun drying, solar dryer without reflective mirrors, solar dryer with reflective mirrors and electric hot air drying, are shown in Table (3). Comparing the production cost of the electric hot air drying system for all dried products, the costs per Kg for the grapes, and apricot were 12.30 and 9.20 LE/Kg respectively, it is clear that electric hot air drying were the highest drying costs for all dried products and system studied.

On the other hand, the production costs LE/Kg for the open sun drying were the lowest of drying costs for all drying systems and dried products studied. The production cost for all dried products in the open sun drying systems for grapes and apricot were 0.76, and 0.50 LE/Kg respectively. Meanwhile the quality of product dried by this method was the lowest quality of all drying systems and dried products. Whereas the good quality for all dried products were for solar dryer with reflective mirrors method lower elapsed time, and also lower production cost. The production cost for solar dryer with reflective mirrors method of grapes and apricot, are 5.73 and 4.30LE/Kg respectively.

It is also clear that the divergence between the production costs of different dried products for the same drying method may be due to the physical, chemical, and size reduction pretreatment (whole or slices) and can be related to the difference of moisture migration mechanism that directly proportional to drying time

Table 3: Cost estimation for natural sun drying (M1), solar drying without reflective mirrors (M2), solar drying with reflective mirrors (M3) and electric hot air drying (M4) for dried tested grapes and apricot fruits

Items		Natural sun drying	Solar drying		Electric hot air drying
			Without reflective mirrors	With reflective mirrors	
Depreciation.		27 LE/year	189 LE/year	189 LE / year	558 LE/ year
Interest on investment.		4.78LE/year	33.49LE/year	33.49 LE/year	98.89 LE/ year
Taxes and insurance.		6.52LE/year	45.67LE/year	45.67 LE/year	134.85LE/year
Maintenance and labor.		9 LE / year	63 LE / year	63 LE / year	186 LE / year
Electricity costs oven		-	335.7LE/year	335.7 LE/year	1342.8LE/year
Heater		-	-	-	750 LE/ year
Reflective Mirrors		-	-	50 LE / year	-
Total costs LE / year		47. 30	667.0	717.0	3071.0
Total production ton / year	Grape	0.0624	0.0937	0.125	0.25
	Apricot	0.0937	0.125	0.1666	0.333
Total costs LE / ton	Grape	758	7118	5736	12282
	Apricot	505	5336	4303	9220
Total costs LE/ kg	Grape	0.76	7.11	5.73	12.30
	Apricot	0.50	5.33	4.30	9.20

Effect of different drying methods on chemical composition of dried samples:

The effect of natural sun drying, solar drying without reflective mirrors, solar drying with reflective mirrors and electric hot air dryer drying methods on chemical composition of investigated dried grapes and apricot samples are listed in Table (4 and 5).

Table 4: Effect of different drying methods on chemical composition of produced dried grape fruits (Means± SE).

Composition (%)	Fresh grapes		Dried grapes fruits by different drying methods			
	WW	DW	Natural Sun drying	Solar drying		Electric hot air drying
				without reflective mirrors	with reflective mirrors	
Moisture	80.0	-	-	-	-	-
Protein	0.9	4.50^{a}±0.011	3.81^{e}±0.017	4.0^{c} ±0.023	4.08^{b} ±0.011	3.90^{d} ±0.028
Lipids	0.18	0.90^{a}±0.028	0.79^{d}±0.011	0.84^{bc}±0.011	0.85^{b} ±0.011	0.81^{c} ±0.011
Ash	0.62	3.10^{a}±0.017	3.07^{a}±0.011	3.09^{a} ±0.023	3.10^{a} ±0.017	3.05^{a} ±0.017
Total carbohydrates	18.30	91.50^{d}±0.028	92.33^{a}±0.017	92.07^{b}±0.017	91.97^{c}±0.011	91.2^{e} ±0.011
Total sugars	17.50	87.50^{a}±0.017	83.26^{d}±0.017	86.63^{c}±0.017	86.84^{b}±0.023	82.53^{e}±0.011
Red. Sugars	14.0	70.0^{a} ±1.15	66.26^{b}±0.577	69.12^{a}±0.069	69.34^{a}±0.196	65.26^{b}±0.500
Non-red. sugars	3.50	17.50^{a}±0.028	17.0^{c} ±0.023	17.50^{a}±0.014	17.50^{a}±0.011	17.27^{b}±0.011
Other carbohydrates	0.80	4.0^{e} ±0.023	9.07^{a}±0.017	5.44^{c} ±0.023	5.13^{d} ±0.011	8.71^{b} ±0.017

Values are means of three replicate ± standard error of mean (SEM); Values with different letters are significantly different at p<0.05. M1: natural sun drying M2: solar drying without reflective mirrors M3: solar drying with reflective mirrors. M4: Electric hot air drying methods

From the obtained data, in Table (4 and 5), it could be noticed that the moisture content of fresh tested seedless grapes and apricots was found to be as 80.0 and 83.3 % respectively. In addition, the fresh grapes and apricot contained 91.5 and 86.3 % of total carbohydrates on dry weight basis, reducing sugars was the predominant components found in fresh seedless grapes, which was presented about 70.0 % of the total carbohydrates compared with 17.5% for non-reducing sugars on contrast the reducing sugars contents in apricots was lower (31.13 %) than non-reducing(48.87%). Furthermore, the fresh seedless grapes contained 4.5% protein, 0.9 % lipid and 3.1 % ash on dry weight basis. The same values of fresh apricot were 6.58% protein, 5.74% ash and 1.31% lipid on dry weight basis. These results are in accordance with the data obtained by Hussain *et al*. (2012); El-kassas *et al*. (2014) and Jogaiah *et al*. (2014).

As illustrated in the obtained data in Table (4 and 5), it could be observed that the moisture content in all tested seedless grapes and apricot fruits dried by different drying methods under investigation was found ranged between 16.4 to 18.0 % and17.0 to 17.40 % respectively. These results are in agreement with those obtained by Dev. *et al*. (2008).

In relation to the effect of different drying methods under investigation on the chemical composition of produced dried seedless grapes (raisin) and apricots as shown in Table (4 and 5), it could be noticed that, the contents of protein, lipid, ash, total carbohydrates, reducing sugar and non-reducing sugar was at range 3.81-

4.08, 0.97-0.85, 3.05- 3.10,91.24-92.33,65.26-69.34 and 17.00-17.50 % for dried grapes (raisin) and 6.44-6.54,1.24-1.30,5.35-5.40,86.76-86.94,23.50-29.00 and 48.00-48.11% for dried apricots; respectively, on dray weigh basis. As well as in the light of these data listed in Table (4 and 5) it could be exhibited that reducing sugar was the major component in dried grapes(65- 69 %) on contrary the non-reducing sugar was found to be the major component in dried apricot in all tested drying methods which was represented about 48.0 - 48.11 %. Statistically, no significant differences was observed between dried grapes samples in ash content as well no significant differences between dried apricot samples in non-reducing sugar as affected by using different drying methods (natural sun drying, solar drying without reflective mirrors, solar drying with reflective mirrors and electric hot air dryer). Also it was noted that there were significant differences was observed between dried grape samples by investigated drying methods in crude protein content, lipid content, total carbohydrates, total sugars and reducing sugars (Table 4). Likewise in dried apricot samples was noticed significant differences between dried apricot processed by natural sun drying, solar drying without reflective mirrors, solar drying with reflective mirrors and electric hot air drying in total and reducing sugar (Table 5).

Table 5: Effect of different drying methods on chemical composition of produced dried apricot fruits (Means± SE).

Composition (%)	Fresh apricot		Drying methods			
	WW	DW	Natural Sun drying	Solar drying: without reflective mirrors	Solar drying: with reflective mirrors	Electric hot air drying
Moisture	83.3	-	-	-	-	-
Protein	1.1	6.58^{a} ±0.017	6.48^{b}±0.011	6.53^{a} ±0.011	6.54^{a}±0.023	6.44^{b}±0.011
Lipids	0.22	1.31^{a} ±0.017	1.24^{b}±0.011	1.30^{a} ±0.011	1.30^{a} ±0.017	1.27^{ab}±0.023
Ash	0.96	5.74^{a} ±0.005	5.38^{c}±0.011	5.39^{b} ±0.011	5.40^{b} ±0.017	5.35^{c} ±0.017
Total carbohydrates	14.42	86.37^{c}±0.017	86.90^{a}±0.028	86.78^{b}±0.017	86.76^{b}±0.011	86.94^{a}±0.023
Total sugars	13.50	80.0^{a} ±0.023	74.45^{d}±0.017	76.30^{c}±0.017	77.0^{b} ±0.034	71.50^{e}±0.023
Red. Sugars	5.20	31.13^{a}±0.023	26.45^{d}±0.017	28.30^{c}±0.011	29.0^{b} ±0.028	23.50^{e}±0.011
Non-red. sugars	8.30	48.87^{a}±0.017	48.0^{b} ±0.028	48.0^{b} ±0.017	48.11^{b}±0.028	48.0^{b} ±0.023
Other carbohydrates	0.92	6.37^{e}±0.017	12.45^{b}±0.028	10.48^{c}±0.017	9.76^{d} ±0.011	15.44^{a}±0.011

Values are means of three replicate ± standard error of mean (SEM); Values with different letters are significantly different at $p<0.05$. M1: natural sun drying M2: solar drying without reflective mirrors M3: solar drying with reflective mirrors. M4: electric hot air drying methods

It is noteworthy also that no significant differences noticed in non-reducing sugar content of grapes dried by natural sun drying and electric hot air drying. As in the case of apricots no significant differences noticed in protein content, lipid content, ash content and total sugar content in dried apricots also by the same drying methods. As is the case for natural sun drying and electric hot air drying the same behavior was exhibited no significant differences between solar drying without reflective mirrors or solar drying with reflective mirrors in non-reducing sugar content of grapes and protein content, lipid content, ash content and total sugar content of dried apricots.

The losses in both amino acids and reducing sugars in the samples dried by using natural sun drying and electric hot air drying when compared with the samples dried by the other drying methods (solar drying with or without reflective mirrors) may be due to the much longer drying time of this method (10 hr) as compared to the other drying methods may cause the reaction of these components together to form the browning reaction which called the Millard browning reaction or non-enzymatic browning which creating distinctive the brown pigments. These results are in accordance with the data obtained by Kim *et al* (2014).

Effect of different drying methods on physicochemical properties of produced dried grape and apricot:

The physicochemical properties of dried fruit (seedless grapes and apricot) produced by different drying methods such as total soluble solid (TSS%), pH value, titratable acidity (as citric acid), rehydration ratio, percentage of volumetric shrinkage and color index (measuring by optical density (OD) at 360nm for grapes and 320 nm for apricot), are played an important role in assessing their quality and palatability as well as the consumer acceptability of these products. The quality characteristics of dried grapes and apricot produced by natural sun drying, solar drying without reflective mirrors, solar drying with reflective mirrors and electric hot air drying methods are shown in Table(6).

The obtained data in Table (6) exhibit that the physicochemical quality properties of fresh seedless grapes fruit such as pH value, titratable acidity % (as citric acid), total soluble solid (TSS %), and color index(OD) at 360nm were found to be as18.00%, 3.62,0.94 % and 0.291 for grapes; respectively. These results are in agreement with the data obtained by Ahmed and Masoud (2012) and Panceri *et al*. (2013). Also the same determined characteristics in apricots were as follow 14.5 %, 3.48, 0.98 % and 0.497; respectively Milošević, *et al.* (2012), Türkyılmaz *et al*. (2013) and Evrendilek, (2016).

In Table (6) from the obtained results, it could be noticed that, an increase in dried grapes and apricot pH and a decrease in titratable acidity were generally observed. Also, no significant differences were found between solar drying with reflective mirrors or solar drying without reflective mirrors in pH and titratable acidity. Dried grapes and apricot pH were at range 3.51 - 4.19 and 3.42-4.08 respectively, while, titratable acidity was 1.59-1.69 and 1.67-1.74 % (as citric acid). The higher pH value was showed in dried grapes and apricot by electric hot air drying (4.19 and 4.08 respectively). Whilst, the percent of titratable acidity was recorded the highest value in dried grapes and apricot with natural sun drying (Gallali *et al.* 2000) which were 1.69 and 1.74 % respectively. These results are in agreement with the data obtained by Madrau, *et al*. (2009) and Evrendilek, (2016).

Table 6: Effect of different drying methods on physicochemical properties of produced dried grape and apricot (Means± SE).

Physical properties	Fresh	Drying methods			
		Natural Sun drying	Solar drying		Electric hot air drying
			without reflective mirrors	with reflective mirrors	
Grape fruits					
pH value	3.62^{c} ±0.011	3.51^{d} ±0.017	4.06^{b} ±0.017	4.08^{b} ±0.011	4.19^{a} ±0.011
T.A.% (as citric acid)	0.94^{d} ±0.002	1.69^{a} ±0.014	1.63^{b} ±0.011	1.61^{bc} ±0.005	1.59^{c} ±0.011
T.S.S (%)	18.0^{e} ±0.230	79.0^{b} ±0.028	81.78^{a} ±0.011	81.93^{a} ±0.011	77.50^{c} ±0.011
Rehydration ratio (R.R)	-	2.72^{b} ±0.057	2.96^{a} ±0.063	3.02^{a} ±0.057	2.62^{c} ±0.040
Shrinkage (%)	-	34.00^{c} ±0.577	35.50^{b} ±0.011	35.50^{b} ±0.028	37.0^{a} ±0.288
Color (O.D)	0.291^{e} ±0.001	0.908^{a} ±0.001	0.652^{c} ±0.001	0.639^{d} ±0.001	0.721^{b} ±0.001
Apricot fruits					
pH value	3.48^{c} ±0.011	3.42 ^{d}±0.011	3.73^{b} ±0.005	3.71^{b} ±0.005	4.08^{a} ±0.005
T.A.% (as citric acid)	0.98^{c} ±0.005	1.74^{a} ±0.011	1.71^{ab} ±0.011	1.70 ^{ab}±0.028	1.67^{b} ±0.011
T.S.S (%)	14.50^{d}±0.288	69.85^{b} ±0.028	71.56^{a} ±0.011	71.65 ^{a}±0.028	67.31^{c} ±0.011
Rehydration ratio (R.R)	-	3.30^{b}±0.05	3.65^{a} ±0.05	3.72^{a}±0.05	3.0^{c}±0.14
Shrinkage (%)	-	42.80^{a} ±0.011	40.00^{b} ±0.028	39.00^{c} ±0.028	39.00^{c} ±0.577
Color (O.D)	0.497^{e}±0.001	0.623^{a} ±0.001	0.526^{c} ±0.002	0.507^{d} ±0.001	0.538^{b} ±0.001

In relation to total soluble solid (TSS) of grapes and apricot dehydrated by tested drying methods the data listed in Table (6). From the obtained data, it could be mentioned that the effect of natural sun drying, or electric hot air drying as compared to solar drying without reflective mirrors or solar drying with reflective mirrors on total soluble solid (TSS) of dried grapes were at range 77.50-81.93 and 67.31-71.65 % in dried apricots. The higher amount of TSS was found in dried grapes and apricot by using solar drying without reflective mirrors and solar drying with reflective mirrors. However, the highest value of TSS was observed in samples dried by solar drying with reflective mirrors followed by samples dried by solar drying without reflective mirrors in both dried grapes and apricot. In addition, no significant difference showed between solar drying with and without reflective mirrors and the samples dried by natural sun drying, and electric hot air drying found to be significantly lower in both dried grapes and apricot Sen, *et al*. (2015) and Evrendilek (2016).

The removal of moisture content during drying has detrimental effects on their physical and mechanical attributes. The rehydration characteristics of the material are influenced by processing conditions, sample composition, sample preparation and extent of the structural and chemical disruptions induced by drying. In the compression behavior of fruits during rehydration is compared with that during dehydration, using various drying methods (Krokida and Maroulis, 2000).

As illustrated in the same Table, it could be mentioned that the rehydration ratio of the samples dried by solar drying with reflective mirrors had higher rehydration ratio which was 3.02 for dried grapes and 3.72 for dried apricot, then comes next in the order grapes and apricot samples dried by solar drying without reflective mirrors which was 2.96 for grape and 3.65 for apricot flowed by grapes (2.72) and apricot (3.30) samples dried by natural sun drying. While samples dehydrated by electric hot air drying recorded the lowest value of rehydration ratio (Table 6).

From the previous discussion, it could be showed that solar drying with or without reflective mirrors leading to improve the quality criteria of the dried samples when compared with natural sun drying or electric hot air drying such as rehydration ratio, which it widely used as a quality evaluation method after drying. Statistically no significant differences were observed between solar drying with reflective mirrors or without reflective mirrors in rehydration ratio which it was having near values.

When rehydrating a dried product, it will never regain the same condition as before drying. The drying process causes changes in the permeability of the cell walls, loss of osmotic pressure and solute migration. Crystallization of polysaccharides and coagulation of proteins also contribute to irreversible changes of the plant tissue. The less elastic cell walls and the reduced water holding capacity of protein and starch, all decrease the rehydration ratio (RR) of the products. If the drying process is optimal, the negative factors regarding rehydration of the cells will be less than with a poor drying technique (Fellows, 2000).

Shrinking is an important aspect which should be taken into consideration while developing a model for describing drying of foodstuffs. A majority of studies has considered constant size of the product during the drying process and, consequently, the accuracy of the applied models could be seriously affected. Shrinkage during dehydration of fruits and vegetables occurs when the viscoelastic matrix contracts into the space previously occupied by the water removed from the cells (Aguilera, 2003). Shrinkage modifies the shape and dimension of products and is directly related to the loss of water during drying, which in turn affects the mass transport phenomena and case hardening that occurs in some drying processes (Aguilera and Stanley, 1999).

With respect to the volumetric shrinkage of dried seedless grapes and apricot samples as affected by tested different drying methods, as the results given in Table (6) it could be mentioned that significant difference was observed in the volumetric shrinkage of the seedless grape samples dried by natural sun drying or electric hot air drying and solar drying with or without reflective mirrors drying methods whereas solar drying with or without reflective mirrors recorded the same amount of volumetric shrinkage. As well the data of volumetric shrinkage in dried apricots listed in the same Table (6) appeared that, no significant difference was observed in the volumetric shrinkage of the apricot samples was occurred by using solar drying with reflective mirrors or electric hot air drying methods. On contrast, both solar drying with reflective mirrors and electric hot air drying were found significant differences with natural sun drying or solar drying without reflective mirrors. The highest volumetric shrinkage in the dried samples was occurred by using electric hot air drying (37.0%) in dried grapes. Whilst solar drying with reflective mirrors or electric hot air drying were showed had high shrinkage (39.0 %) in dried apricots. These results may be explained by the fact that, shrinkage extent during drying is strongly related to drying conditions. Sun drying has its inherent disadvantages owing to the unpredictable weather conditions, which often lead to quality deterioration especially volumetric shrinkage this mean that, prolonged drying times (slow drying velocity) of the drying method led to increased shrinkage and toughness with reduced hydrophilic properties and hence low rehydration capacity of their products. This situation completely apply to dried apricots by natural sun drying which was recorded the higher values in shrinkage (42.8%) when comparing by other tested drying techniques (Garg, 2001; Murthy, 2009). Therefore, solar drying in some extent helps to solve these problems. However, this is only possible when care is taken during the design, construction and testing of the solar dryer for the target agriculture product. On contrast, volumetric shrinkage of dried grapes by natural sun drying found to be the lower in volumetric shrinkage(34.0 %) these may be related to drying conditions (unpredictable weather conditions) especially, where it was the volumetric shrinkage in dried grapes by natural sun drying was found slight decreased than other tested drying techniques.

The characteristics of food color and texture are key to its acceptance, as they are indicative of product quality. Color changes are related to pigment loss and enzymatic and nonenzymatic reactions that take place during fruit and vegetable drying. (Vadivambal and Jayas 2007).

As illustrated in the obtained data in the same Table (6) it could be demonstrated that the color index as (optical density at 360 nm for grapes and 320 nm for apricots) of produce grape and apricots dried by natural sun drying were exhibited obvious significantly higher in color index when compared with the other tested dried samples, which was represented about 0.908 and 0.623nm; respectively, followed by produce grape and apricots dried by electric hot air drying methods which recorded about 0.721 and 0.538 nm as well solar drying without reflective mirrors were 0.652 and 0.526 nm; respectively. While grape and apricots samples dried by solar drying with reflective mirrors found to be recorded the lowest value of color index (0.639 and 0.507nm; respectively)

These results may be due to the increasing of drying time which reached to 52 and 34 hr. when used natural sun drying method in produced dried grape and apricots respectively. As compared with 24 and 18 hr. when used solar drying without reflective mirrors or solar drying with reflective mirrors for the drying grapes and apricot samples, as given in the obtained data of Table (6)

During drying, several chemical reactions take place that lead to the brown color. One important browning reaction in raisins is called the Millard browning reaction or non-enzymatic browning. Certain sugars and proteins react together in a complex series of steps, creating distinctive flavors and brown pigments. A second reaction that leads to browning of raisins are through the enzyme polyphenol oxidase (PPO) contained within the cells. When PPO is exposed to oxygen, as happens when grapes dry and cells break open, the PPO comes into contact with phenolic compounds to form brown color compounds. The combination of Millard browning and enzymatic browning is responsible for color development in raisins. These results are in accordance also with the data obtained by (Christensen and Peacock, 2000).

Effect of different drying methods on antioxidant compounds of produced dried grape and apricot fruit:

Fruits and vegetables, which are rich sources of specific antioxidant groups such as ascorbic acid, carotenoids, flavonoids and phenolic acids, worth special consideration with a significant impact on promoting human health Kamiloglu *et al*. (2015).

The effect of different drying methods such as natural sun drying, solar drying without reflective mirrors, solar drying with reflective mirrors and electric hot air drying methods on antioxidant compounds (such as *L-*

ascorbic acid, *β*-carotene, total phenolic and flavonoids) of produced dried seedless grapes and apricot are presented in Table (7).

Table 7: Effect of different drying methods on antioxidant compounds and total antioxidant capacity of produced dried grape and apricot on dry weight basis (Means± SE).

Antioxidant compounds	Drying methods				
	fresh	Natural sun drying	Solar drying		Electric hot air drying
			without reflective mirrors	with reflective mirrors	
Grape fruits					
Ascorbic acid Content mg/100g	23.88^{a} ±0.011	9.65^{e} ±0.028	14.75^{c} ±0.044	15.10^{b} ±0.017	10.80^{d} ±0.24
β-carotene mg/100g	0.85^{a}	ND	0.40^{c}	0.52^{bc}	0.57^{b}
Total phenolic content mg/100g	387.13^{a} ±0.017	295.60^{e}±0.011	370.75^{d} ±0.028	382.80^{c}±0.028	384.00^{b} ±0.57
Total flavonoid Content mg/100g	136.25^{a} ±0.028	97.85^{e} ±0.028	127.30^{c} ±0.017	132.25^{b} ±1.02	131.88^{b} ±0.017
Apricot fruits					
Ascorbic acid Content mg/100g	38^{a} ±0.028	15.0^{d} ±0.288	18.50^{c} ±0.028	19.25^{b} ±0.028	14.75^{d} ±0.028
β-carotene mg/100g	5.32^{a}	2.50^{d}	3.10^{c}	4.00^{b}	4.00^{b}
Total phenolic content mg/100g	592.50^{a} ±0.057	507.33^{e}±0.017	577.60 ^{d}±0.028	586.90 ^{c} ±0.028	589.65^{b} ±0.028
Total flavonoid Content mg/100g	210.96^{a} ±0.017	156.90^{e}±0.028	198.0^{c} ±0.577	$2.07.43^{b}$±0.017	206.0^{b} ±1.15

Values having similar letters are not significantly different (p<0.05

From these table it could be noticed that fresh grapes and apricot fruit contained A reasonable amount of *L*-Ascorbic acid (23.68 and 38.44 mg/100g, on dry weight basis) and adequate amount of *β*-carotene which was represented about 0.85 mg/100g, for grapes and 5.32 mg/100g, for apricots. In addition, the fresh grapes and apricot fruit contained considerable amounts of phenolics and flavonoids compounds which were found to be 387.13 and 136.25 mg/100g on dry weight basis; respectively for grapes and 592.5 and 210.96 mg/100g on dry weight basis; respectively for apricots. These results are in agreement with the data obtained by Ahmed and Masoud (2012); Carranza-Concha *et al*. (2012); Hussain, *et al*. (2013) and Jogaiah *et al*. (2014). Concerning the effect of different drying methods (natural sun drying, solar drying without reflective mirrors, solar drying with reflective mirrors and electric hot air drying methods) on *L*-ascorbic acid content in dried grapes and apricot was decreased as affected by tested drying methods. The *L*-ascorbic acid content was ranged between 9.65 – 15.1 mg/100g DM in dried grape samples and 15.0 – 19.25 mg/100g DM in dried apricot samples. The grape and apricot samples dried by solar drying with reflective mirrors were found the highest retention of *L*-ascorbic acid (63.23 and 50.66%; respectively), than the other samples dried by other drying methods. On the other side, the retention in *L*-ascorbic acid of grapes and apricot samples dried by solar drying without reflective mirrors was nearly to that found in the grapes and apricot samples dried by solar drying without reflective mirrors, which were the *L*-ascorbic acid retention was found to be 61.76% for grape and 48.68 % for apricot. Moreover, the lowest content of *L*-ascorbic acid was observed in grape and apricot samples dried by natural sun drying which represented about 9.65 and 15.0 mg/100g DM; respectively.

From the previously discussion, it could be concluded that there are significant differences of *L*-ascorbic acid content among all dried grape and apricot samples. These results may be attributed to drying time and drying conditions where the natural sun dried grape and apricot samples had the longest drying time, also due to the *L*-ascorbic acid is more sensitive to the different conditions of drying methods such as heat, oxygen and light. Karatas, and Kamışlı, (2007) Hussain, *et al*. (2013).

As illustrated in the obtained data in the same Table (7), the β-Carotene content of dried grape by different drying methods such as solar drying without reflective mirrors, solar drying with reflective mirrors and electric hot air drying methods were represented about 0.40, 0.52 and 0.57 mg/100g; respectively on dry weight basis while grape sample dried by natural sun drying showed do not contained β-carotene whereas not detected (disappear) Fratianni *et al*. (2010) and Fratianni, *et al*. (2013). Likewise β-Carotene content of dried apricot samples was observed higher than those obtained in the dried grape samples whereas β-Carotene content of dried apricot samples was found to be 2.50, 3.10, 4.00, and 4.00 mg/100g; on dry weight basis for natural sun drying, solar drying without reflective mirrors, solar drying with reflective mirrors and electric hot air drying methods respectively. In addition, significant differences was observed in β-Carotene content between the grape samples dried by solar drying without reflective mirrors and the samples dried by using electric hot air drying methods whilst, grape samples dried by solar drying with reflective mirrors was noticed compromise between solar drying without reflective mirrors and electric hot air drying methods**.** As well significant variation was exhibited in β-Carotene content of dried apricot samples by natural sun drying and solar drying without reflective mirrors. On the other side, β-Carotene content of dried apricot by solar drying with reflective mirrors and electric hot air drying methods had the same value (4.00 mg/100g). The major cause of carotenoid destruction during food processing and storage is enzymatic or non-enzymatic oxidation. Isomerization of trans-carotenoids to the cis-isomers, particularly during heat treatment, alters their biological activity and discolors the food, but not to the same extent as oxidation. In many foods, enzymatic degradation of carotenoids may be a more serious problem than thermal decomposition Rodriguez-Amaya, and Kimura, (2004). The decreasing in β-Carotene content of dried grape and apricot samples by different drying methods may be due to the degradation processes accrued in carotenoids content as affected by heat, light and oxygen exposure Faulks and Southon (2005). It has been shown that excessive thermal processing may increase the geometric isomerization from the trans to the cis forms of carotenoids Schieber and Carle (2005). Carotenoids and all-trans-β-carotene degradation during thermal treatment of different vegetables Di Scala and Crapiste (2008), Ferreira and Rodriguez-Amaya (2008) and Demiray *et al.* (2013) and the decreasing in carotene depend on the structure and cellular organization of carotenoids in the food matrix Penicaud *et al.* (2011), water activity Lavelli *et al.* (2007), pH, oxygen occurrence and the interactions with other antioxidants Dragovic-Uzelac *et al*. (2007).

As given in the obtained data in the same Table (7). it could be noticed that the total phenolic and flavonoid compounds was the higher content found in fresh grape and apricot fruits (on dry weight basis) when compared with that found in dried grapes and apricots by using all drying methods, whereas the fresh grape and apricot represented about 387.13 and 592.5 mg/100g on dry weight basis; respectively for phenolic compounds and 136.25 and 210.96 mg/100g on dry weight basis; respectively for flavonoid compounds. These results are in accordance with the data obtained by Satisha *et al*. (2008); Madrau, *et al*. (2009); Thakur *et al*. (2010); Ahmed and Masoud (2012) and Jogaiah *et al*. (2014).

With regard to the influence of four different drying methods on the phenolic and flavonoid compounds in dried grape and apricot samples as evident in the obtained data, in the same Table (7), it could be demonstrated that the solar drying with reflective mirrors and electric hot air drying methods caused, in general, a significantly retention of total phenolic and flavonoid compounds as compared to the other drying processes, whereas the grape samples dried by solar drying with reflective mirrors and electric hot air drying methods was found contained 382.80 and 384.0 mg/100g on dry weight basis, respectively of phenolic compounds and the apricot sample was contained 586.90 and 589.65 mg/100g on dry weight basis, respectively. While, flavonoid compounds were found to be as 132.25 and 131.88 mg/100g on dry weight basis, respectively in dried grape; 207.43 and 206.65 mg/100g on dry weight basis, respectively in dried apricots. On the other side, no significant differences was observed between grapes samples dried by solar drying with reflective mirrors and electric hot air drying methods in the total phenolic and flavonoid compounds contents. Also, the same behavior was observed (no significant differences) in total phenolic and flavonoid compounds contents in apricot samples, whereas apricot samples dried by solar drying with reflective mirrors recorded nearly amounts to that obtained with the apricot samples dried by electric hot air drying method (Table 7). The effect of drying processes on the phenolic compounds was also investigated by Satisha *et al*. (2008); Madrau, *et al*. (2009);Ahmed and Masoud (2012); Hussain, *et al*. (2013); Capanoglu (2014) and Jogaiah *et al*. (2014).

Effect of different drying methods on antioxidant activity (AOA) of produced dried grapes and apricot fruit (Means± SE):

The DPPH radical is a stable free radical and accepts an electron or hydrogen radical to become a stable molecule. The free radical scavenging activity of the tested dried vegetables and fruits samples was analyzed using a 2,2,-diphenyl-1-picrylhydrazyl (DPPH) assay. The antioxidant assay was based on the measurement of the loss of DPPH color by the change of absorbance at 517 nm caused by the reaction of DPPH with the tested sample. Also using DPPH method, the result of the analysis of antioxidant activity was determined as percent inhibition of DPPH free radicals (Radical-scavenging activities) (Ishiwata *et al*., 2004).

The antioxidant potential of fresh and dried fruits (grape and apricot) samples extract was determined as percent inhibition of DPPH free radicals (Radical-scavenging activities). Radical-scavenging activities of fresh and dried fruits are presented in Table (8). From the obtained data it could be observed that the inhibition of DPPH free radicals (Radical-scavenging activities) value of fresh tested grape and apricot was 74.60 and 80.0 %; respectively. It should be noted that the percent inhibition of DPPH free radicals by fresh apricot showed more than grapes. These results may be explained by the fact that, the antioxidants compound content of fresh tested grape and apricot which were observed that, the β-Carotene, phenolic and flavonoids compounds showed in fresh apricot more than grape as stated before (Table7). The antioxidant activities of tested fruits have been attributed to the presence of antioxidant compounds, (ascorbic acid, β-Carotene, and phenolic and flavonoids compounds). These results are coincident with those obtained by Gey *et al*., 1991; Willet, 1994; Kalt and Kushad, 2000; Prior and Cao, 2000; Kaur and Kapoor (2002). Moreover numerous studies have conclusively shown that the majority of the anti-oxidant activity may be from compounds such as flavonoids, isoflavone, flavones, anthocyanin, catechin, isocatechin, Vitamin C, E and β -carotene (Wang *et al*., 1996; Kahkonen *et al*., 1999).

With regard to the effect of different drying methods on the total antioxidant capacity of tested dried fruits (grape and apricot) samples extract was determined as percent inhibition of DPPH free radicals as evident in the obtained results in Table (8). From the obtained results as illustrated it Table (8), it could be mentioned that the dried fruits (grape and apricot) by using solar drying with reflective mirrors exhibited that the highest scavenging capacity against DPPH than the other samples dried by the other tested drying methods, which recorded (70.65 and 78.30 %) inhibition of DPPH free radicals for grape and apricot; respectively, followed be the dried grape and apricot by solar drying without reflective mirrors, which represented about 69.50 and 77.17 % inhibition of DPPH; respectively. On the other hand, the dried tested grape and apricot by natural sun drying had the lowest antioxidant activity values, whereas it was recorded 47.65 and 64.30 % inhibition of DPPH free radicals. Furthermore, the dried grape and apricot by electric hot air drying were higher DPPH radical-scavenging activity (62.75 and 70.42%; respectively) than those obtained in the dried samples by natural sun drying. These results may be due to the antioxidant compounds such as phenolic and flavonoid compounds found in the tested samples after drying by the different drying methods as stated before in table (7). Our data suggests that the correlation between the amount of ascorbic acid, β-Carotene, phenolic and flavonoids compounds with the value of the reaction of DPPH with the tested samples. This implies that ascorbic acid, β-Carotene, phenolic and flavonoids compounds in tested fruits might contribute to their radical scavenging activity.

Table 8: Effect of different drying methods on antioxidant activity of produced dried grape and apricot (Means± SE).

Fruits	Drying methods				
	Fresh	Natural Sun drying	Solar drying		Electric hot air drying
			without reflective mirrors	with reflective mirrors	
Grape fruits	74.60^{a}±0.011	47.65^{e}±0.02	69.50^{c}±0.01	70.65^{b}±0.028	62.75^{d}±0.01
Apricot fruits	80.0^{a} ±0.115	64.30^{e}±0.01	77.17^{c}±0.01	78.30^{b}±0.028	70.42^{d}±0.01

From the same data in Table (8). It could be also exhibited that the ability to quench the DPPH radical of tested fruits samples dried by natural sun drying and electric hot air drying was lower than that exhibited in the fresh sample. On the other hand, the tested fruits samples dried by solar drying with and without reflective mirrors were exhibited nearly scavenging capacity against DPPH especially the samples dried by solar drying with reflective mirrors when compared with the fresh tested fruits samples.

In this concern, it is worth to mention that there were strong correlations with the ascorbic acid, β-Carotene, and phenolic and flavonoids composition of tested samples contributed significantly to the antioxidant capacities of dried tested samples as affected by different drying methods. From the above discussion, it could be concluded that the using of solar drying with or without reflective mirrors leading to improve the quality criteria of the final products when compared with the dried samples by using natural sun drying or electric hot air drying, in this concern the samples dried in solar drying with or without reflective mirrors exhibited more the ability to quench the DPPH radical obviously than those found in the samples dried by natural sun drying or electric hot air drying methods**,** In addition to the solar drying with or without reflective mirrors found to be saving the energy and therefore low operating costs especially solar drying with reflective mirrors because the incorporation of reflective mirrors leading to enhances solar radiation collection and then elevation of drying temperature for the utilization of solar energy and reduce the use of electrical power, over and above enhancement of the quality criteria of dried products. The antioxidant activities of tested fruits were also investigated Adiletta *et al*. (2015) and Mongi, *et al*. (2015).

Effect of different drying methods on the organoleptic quality properties of produced dried grapes and apricot fruits:

The organoleptic quality characteristics including; color, taste, odor, texture and overall acceptability of dried grapes and apricot fruits as influenced by different drying methods (Natural sun drying, solar dryer without reflective mirrors, solar dryer with reflective mirrors and electric hot air dryer) were evaluated sensorial. The obtained results are statistically analyzed and recorded in Table (9).

From sensory evaluation results as illustrated in Table (9), it could be observed that there are no significant alteration in color property, which is considered one of the most important of the organoleptic quality properties of dried products, among the seedless grape and apricot fruits samples dried by solar drying with and without reflective mirrors drying methods which was represented about 9.0 and 9.2 respectively, for color property of both dried grape and apricot. On contrary, color property in grape and apricot dried by both solar drying with and without reflective mirrors drying methods showed significantly higher than that found in apricot dried by both natural sun drying and electric hot air drying methods. Also, color property in grape and apricot dried by natural sun drying method found lower significantly than that other tested drying methods. These results may be due to the much longer drying time by using natural sun drying (52 and 36 hr) for grape and apricot respectively, when compared with the other drying methods, especially with solar drying without reflective mirrors, solar drying with reflective mirrors and electric hot air drying which was found need to 36, 24; 24, 18 and, 24, 18 hour as drying to reach adequate moisture content respectively.

On the same trend, aforementioned in color property of both dried grape and apricot typically the same behavior was observed in sensory evaluation results of texture and overall acceptability, which was noticed that there are no significant differences (P>0.05) in texture and overall acceptability among the seedless grape and also apricot samples dried by solar drying with and without reflective mirrors drying methods.

Table 9: Effect of different drying methods on sensory quality properties of produced dried grapes and apricot fruits (Means± SE).

Sensory quality properties	Drying methods			
	Natural sun drying	Solar drying: Without reflective mirrors	Solar drying: with reflective mirrors	Electric hot air drying
Grape fruits				
Color	6.5^{c}±0.057	9^{a}±0.11	9.2^{a}±0.057	8.5^{b}±0.11
Taste	6.5^{c}±0.057	8^{b}±0.057	9^{a}±0.057	8^{b}±0.057
Odor	7^{c}±0.057	8.2^{b}±0.11	9.2^{a}±0.11	8.2^{b}±0.057
Texture	8^{b}±0.057	9^{a}±0.11	9^{a}±0.057	7^{c}±0.057
Overall acceptability	7^{d}±0.057	9^{b}±0.057	9.3^{a}±0.057	8^{c}±0.057
Apricot fruits				
Color	7.8^{c}± 0.057	9^{a}±0.057	9.2^{a}±0.11	8.4^{b}±0.057
Taste	7^{d}±0.11	8.5^{b}±0.057	9^{a}±0.057	8^{c}±0.11
Odor	7^{d}±0.057	9^{b}±0.057	9.3^{a} ±0.057	8.5^{c}±0.057
Texture	8^{c} ±0.057	9^{a}±0.11	9^{a}±0.057	8.5^{b}±0.17
Overall acceptability	7.5^{c}±0.11	9^{a}±0.057	9^{a}±0.057	8.5^{b}±0.11

On the other side, texture and overall acceptability properties in grape and apricot dried by both solar drying with and without reflective mirrors drying methods showed significantly higher than that found in grape and apricot dried by both natural sun drying and electric hot air drying methods. Also, texture and overall acceptability properties in grape and apricot dried by natural sun drying method found lower significantly than that other tested drying methods. The much longer drying time by using natural sun drying for grape and apricot when compared with the other drying methods, especially with solar drying without reflective mirrors, solar drying with reflective mirrors and electric hot air drying methods to reach adequate moisture content (end drying process) may be the cause in decreasing of sensory quality properties of dried products as well exposure period to sunlight, Prolonged drying period and contact with ultraviolet light (UV) could degrade some valuable sensory and nutritional quality such as phytochemicals and vitamins in dried products such as chlorophyll, essential oil, β-carotene and ascorbic acid (Sharma *et al.*, 2009; Hii, *et al.*, 2012).

As given in the obtained data in the same Table, it could be mentioned that the taste and odor properties in dried grape and apricot by tested different drying methods were found significant higher in judging score when dried by using solar drying with reflective mirrors than dried by other drying methods flowed by solar drying without reflective mirrors drying method and electric hot air drying method, while both grape and also apricot dried by natural sun drying method were noticed significantly lower than all tested different drying methods in judging score of taste and odor properties.

On the other side showed that dried grapes and apricots samples by solar drying with and without reflective mirrors drying method are the best dried samples and the sample dried by electric hot air drying methods was less in sensory quality attributes. This may be due to a sudden rise in temperatures and Millard browning reaction or non-enzymatic browning. The effect of drying methods on the sensory evaluation of dried grapes and apricot was also investigated by Ahmed and Masoud (2012) ,Doymaz (2004) and Evrendilek, (2016).

In the light of these data, obtained from the organoleptic quality characteristics including; color, taste, odor, texture and overall acceptability of dried fruits (grape and apricot) it could be concluded that the solar drying with reflective mirrors and solar drying without reflective mirrors drying processes caused improve in the quality characteristics of the dried fruits (grape and apricot) samples produced when compared with the corresponding samples dried by the electric hot air drying and natural sun drying methods. Whereas, this appear in the sensorial quality properties of dried fruits (grape and apricot) by using the tested drying processes (solar drying with reflective mirrors and solar drying without reflective mirrors drying methods) which were the indicators about the quality criteria of the final dried products by using these drying methods which having the minimize adverse effects on the dried products as compared with that affect by using the electric hot air drying and natural sun drying methods. Furthermore, using solar energy in drying fruits especially solar drying by dryers with concentrator of sun light such as mirrors leading to offers an alternative which can process the fruits in clean, hygienic and sanitary conditions to national and international standards with zero energy costs or it saves energy, time, occupies less area, improves product quality, makes the process more efficient and protects the environment when compared with artificial mechanical drying, which a relatively recent development, is energy intensive and expensive, and ultimately increases the product cost.

Conclusion

Solar drying is an alternative option to natural sun drying and hot air drying (conventional methods) for several reasons, mainly due to the unlimited and renewable source of solar radiations, which can be harvested by using appropriate solar collector system. This eliminates or minimizes the use of fossil fuels and reduces environmental impact due to consumption of non-renewable source of energy. In this work, the effects of four drying methods, natural sun drying and electric hot air drying method compared with solar drying with or without reflective mirrors as utilization from renewable solar energy and environmentally friendly technology, on the operating costs, drying rate, drying time, chemical composition, physiochemical properties, antioxidant compounds, antioxidant activity and sensory evaluation of dried grapes and apricot fruits. In the light of these data, obtained from the former results it is verified that, solar drying with or without reflective mirrors drying processes caused depreciate of costs, reduce drying time , increased drying rate by rising temperature when addition the reflective mirrors to solar dryer. As well improve in the quality characteristics of the dried fruits (grape and apricot) samples produced when compared with the corresponding samples dried by the electric hot air drying and natural sun drying methods. Whereas, this appeared in the determined parameters (Chemical composition, physiochemical properties, antioxidant compounds; antioxidant activity and sensory evaluation) of dried grapes and apricot fruits by using the tested drying processes (solar drying with reflective mirrors and solar drying without reflective mirrors drying methods which were the indicators about the quality criteria of the final dried products by using these drying methods which having the minimize adverse effects on the dried products as compared with that affect by using the electric hot air drying and natural sun drying methods. Furthermore, using solar energy in drying fruits especially solar drying by dryers with concentrator of solar radiation such as mirrors leading to offers an alternative which can process the fruits in clean, hygienic and sanitary conditions to national and international standards with zero energy costs or it saves energy, time, occupies less area, improves product quality, makes the process more efficient and protects the environment when compared with artificial mechanical drying, which a relatively recent development, is energy intensive and expensive, and ultimately increases the product cost.

References

A.O.A.C., 2005. Official Methods of Analysis. Association of Official Analytical Chemists. Puplished by the AOAC. International 18th ed. Washington, D.C.

Aguilera, J.M. and D.W. Stanley, 1999. Microstructural principles of food processing and engineering (seconded.). Gaithersburg, Aspen Publishers.

Aguilera, J.M., 2003. Drying and dried products under the microscope. Food Science and Technology International, 9(3): 137-143.

Ahmed, F.F. and M.R.M. Masoud, 2012. A comparative study on nutritional value and sensory characteristics of raisin produced from different seedless grapevine CVS. Minia J. Agric. Res. Develop., 32(4): 581-592.

Badgujar, V.R., 2012. An experimental investigation of solar dryer with regenerative desiccant material for multicrops. International Journal of Engineering Research and Applications, 2(3): 3144-3149.

Bal, L.M., S. Satya, and S.N. Naik, 2010. Solar dryer with thermal energy storage systems for drying agricultural food products: A review. Renewable and Sustainable Energy Reviews, 14: 2298-2314.

Belessiotis, V., E. Delyannis, 2009. Drying: methods and systems principles of drying procedures. Book n Greek. Athens: Sideris Publishing Co., p: 844.

BeMiller, J.N., 2010. Carbohydrate analysis. In Food analysis, Nielsen, S. (Ed.). (pp. 147-177). Springer US.

Breksa, A.P., G.R. Takeoka, M.B. Hidalgo, A. Vilches, J. Vasse and D.W. Ramming, 2010. Antioxidant activity and phenolic content of 16 raisin grape (*Vitis vinifera* L.) cultivars and selections. Food Chemistry, 121(3): 740-745.

Carranza-Concha, J., M. BenUoch, M.M. Camacho and N. Martinez-Navarrete, 2012. Effects of drying and pretreatment on the nutritional and functional quality of raisins. Food and Bioproducts Processing, 90: 243-248.

Chedid, R., and F. Chaaban, 2003. Renewable-energy developments in Arab countries: a regional perspective. Applied Energy, 74(1): 211-220.

Christensen, L.P., and W.L. Peacock, 2000. The raisin drying process. Raisin Production Manual. UC DANR Pub., 3393: 207-16.

Demiray, E., Y. Tulek and Y. Yilmaz, 2013. Degradation kinetics of lycopene, β-carotene and ascorbic acid in tomatoes during hot air drying. Lebensm Wiss Technol., 50: 172-176.

Demirbas, A., 2000. Recent advances in biomass conversion technologies. Energy Edu. Sci. Technol., 6: 19-40.

Di Scala, K., and G. Crapiste, 2008. Drying kinetics and quality changes during drying of red pepper. LWT-Food Science and Technology, 41(5): 789-795.

Doymaz, I., 2004. Effect of pre-treatments using potassium metabisulphide and alkaline ethyl oleate on the drying kinetics of apricots. Biosystems Engineering, 89(3): 281-287.

Dragovic-Uzelac, V, B. Levaj, V. Mrkic, D. Bursac, M. Boras, 2007. The content of polyphenols and carotenoids in three apricot cultivars depending on stage of maturity and geographical region. Food Chem., 102: 966-975.

El-Awady, M.N., A.M. Mosutafa, A.M. El-Gindy and M.A. Genaidy, 1988. A trial on solar energy drying for agricultural products with simple setup .Masr J. Ag. Eng., 5(3): 377-392.

El-kassas, F.B., A.M. Aliand S.E. Mostafa, 2014. Phenolic compounds as antioxidants of some products manufactured from two cultivated Egyptian varieties of seedless grapes. Annals of Agricultural Science, 59(2): 195-199.

El-Metwally, M., 2005. Sunshine and global solar radiation estimation at different sites in Egypt". Journal of Atmospheric and solar –terrestrial physics, 67(14): 1331-1342.

El-Sebaii, A.A., and S.M. Shalaby, 2012. Solar drying of agricultural products: A review. Renewable and Sustainable Energy Reviews, 16(1): 37-43.

Evrendilek, G.A., 2016. Change regime of aroma active compounds in response to pulsed electric field treatment time, sour cherry juice apricot and peach nectars, and physical and sensory properties. Innovative Food Science and Emerging Technologies, 33: 195-205.

Faulks, R.M., S. Southon, 2005. Challenges to understanding and measuring carotenoid bioavailability. Biochim Biophys Acta., 1740: 95-100.

Fellows, P.J., 2000. Food processing technology, Principles and practice. 2 ed. Cambrige, England: Woodhead Publishing Limited.

Ferreira, J.E.M, and D.B. Rodriguez-Amaya, 2008. Degradation of lycopene and β-carotene in model systems and in lyophilized guava during ambient storage: kinetics, structure, and matrix effects. J Food Sci., 73: C589-C594

Fratianni, A., D. Albanese, R. Mignogna, L. Cinquanta, G. Panfili and M. Di Matteo, 2013. Degradation of carotenoids in apricot (Prunus armeniaca L.) during drying process. Plant foods for human nutrition, 68(3): 241-246.

Fratianni, A., L. Cinquanta and G. Panfili, 2010. Degradation of carotenoids in orange juice during microwave heating. LWT-Food Science and Technology, 43(6): 867-871.

Fudholi, A., K. Sopian, M.H. Ruslan, M.A. Alghoul and M.Y Sulaiman, 2010. Review of solar dryers for agricultural and marine products. Renewable and Sustainable Energy Reviews, 14(1): 1-30.

Gallali, Y.M., Y.S. Abujnah and F.K. Bannani, 2000. Preservation of fruits and vegetables using solar dryer: A comparative study of natural and solar drying, Ш, chemical analysis and sensory evalution data of the dried samples (grapes, figs, tomatoes and onions). Renewable Energy, 19(12): 203-212.

Gardner, P.T., T.A. White, D.B. McPhail and G.G. Duthie, 2000. The relative contributions of vitamin C, carotenoids and phenolics to the antioxidant potential of fruit juices. Food Chemistry, 68(4): 471-474.

Garg, H.P., 2001. Developments in Solar Drying, In Proceedings of the 2nd Asian Oceania Drying Conference, pp: 297-321.

Gey, K.F., P. Puska, P. Jordan and U.K. Moser, 1991. Inverse correlation between plasma vitamin E and mortality from ischemic heart disease in cross-cultural epidemiology. The American journal of clinical nutrition, 53(1): 326S-334S.

Ghanem, T.H., 2003. Improving Thermal Efficiency of a Flat Plate Solar Collector Using Nontraditional Coating under Quasisteady conditions". Misr J. Ag. Eng., 20(2): 498-514.

Gomez, K.A. and A.A. Gomez, 1984. Statistical procedures for agricultural research 2nd Edn. John Wiley, New York, USA.

Hatamipour, M.S., and D. Mowla, 2003. Correlations for shrinkage, density and diffusivity for drying of maize and green peas in a fluidized bed with energy carrier. Journal of Food Engineering, 59: 221-227.

Hii, C.L., C.L. Law, M. Cloke and S. Sharif, 2011. Improving Malaysian cocoa quality through the use of dehumidified air under mild drying conditions. Journal of the Science of Food and Agriculture, 91(2): 239-246.

Hilphy, R.S.A., H.G. Majeed and Y.K. Yaqoop, 2008. Effect of Drying Methods In The Quality Characteristics For Some Of Fruits And Vegetables. Basrah J. Agric. Sci., 21 (Special issue).

Hussain, A., P.I. Akbar, and K. Lamo, 2012. Apricot drying: preservation technique currently practiced in Ladakh, India. Stewart Postharvest Review, 8(3): 1-6.

Hussain, P.R., R.S. Meena, M.A. Dar and A.M. Wani, 2011. Gamma irradiation of sun-dried apricots (Prunus armeniaca L.) for quality maintenance and quarantine purposes. Radiation Physics and Chemistry, 80(7): 817-827.

Hussain, P.R., S. Chatterjee, P.S. Variyar, A. Sharma, M.A. Dar and A.M. Wani, 2013. Bioactive compounds and antioxidant activity of gamma irradiated sun dried apricots (Prunus armeniaca L.). Journal of food composition and analysis, 30(2): 59-66.

Ishiwata, K., T. Yamaguchi, H. Takamura, and T. Matoba, 2004. DPPH radical-scavenging activity and polyphenol content in dried fruits. Food Sci. Technol. Res., 10: 152-156.

Jaramillo-Flores, M.E., L. González-Cruz, M. Cornejo-Mazon, L. Dorantes-Alvarez, G.F. Gutierrez-Lopez, and H. Hernandez-Sanchez, 2003. Effect of thermal treatment on the antioxidant activity and content of carotenoids and phenolic compounds of cactus pear cladodes (Opuntia ficus-indica). Food science and technology international, 9(4): 271-278.

Jiménez, A.M, M. Martínez-Tomé, I. Egea, F. Romojaro and M.A. Murcia, 2008. Effect of industrial processing and storage on antioxidant activity of apricot. European Food Research Technology, 227: 125-134.

Jogaiah, S., A.K. Sharma and P.G Adsule, 2014. Rootstock Influence on the Biochemical Composition and Polyphenol Oxidase Activity of 'Thompson Seedless' Grapes and Raisins. International J. Fruit Science, 14: 133-146.

Jongen, W., 2007. Fruit and vegetable processing: Improving quality. Woodhead Publishing Limited, Abington Hall, Abington, Cambridge, CB21 6AH, England., pp: 350.

Kähkönen, M.P., A.I. Hopia, H.J. Vuorela, J.P. Rauha, K. Pihlaja, T.S. Kujala and M. Heinonen, 1999. Antioxidant activity of plant extracts containing phenolic compounds. Journal of agricultural and food chemistry, 47(10): 3954-3962.

Kalt, W. and M.M. Kushad, 2000. The role of oxidative stress and antioxidants in plant and human health: introduction to the colloquium. HortScience, 35(4): 572-572.

Kamiloglu, S., G. Toydemir, D. Boyacioglu, J. Beekwilder, R.D. Hall and E. Capanoglu, 2015. A review on the effect of drying on antioxidant potential of fruits and vegetables. Critical reviews in food science and nutrition,

Karatas, F., and F. Kamışlı, 2007. Variations of vitamins (A, C and E) and MDA in apricots dried in IR and microwave. Journal of food engineering, 78(2): 662-668.

Karathanos, V.T., N.K. Kanellopoulos. and V.G. Belessiotis, 1996. Development of porous structure during air drying of agriculture plant products. Journal of Food Engineering, 29: 167-183.

Kaur, C., and H.C. Kapoor, 2002. Anti-oxidant activity and total phenolic content of some Asian vegetables. International Journal of Food Science and Technology, 37(2): 153-161.

Kerkhoks, N, C. Lister, G. Savage, 2005. Change in colour and antioxidant content of tomato cultivars following forced-air drying. Plant Foods Hum Nutr., 60: 117121.

Kim, D.O., S.W. Jeong, and C.Y. Lee, 2003. Antioxidant capacity of phenolic phytochemicals from various cultivars of plums. Journal of Agricultural and Food Chemistry, 51: 7292-7295.

Kim, H.R., I.D. Kim, S.K. Dhungana, M.O. Kim, and D.H. Shin, 2014. Comparative assessment of physicochemical properties of unripe peach (Prunus persica) and Japanese apricot (Prunus mume). Asian Pacific journal of tropical biomedicine, 4(2): 97-103.

Kraisid, T., W.C. MacLean and P. Warwick, 2003. Food energy: methods of analysis and conversion factors: report of a technical workshop, Rome, 3–6 December 2002. Rome: FAO.

Krokida, M., and Z. Maroulis, 2000. Quality changes during drying of food materials. Drying technology in agriculture and food sciences, pp: 61-106.

Lavelli, V., B. Zanoni and A. Zaniboni, 2007. Effect of water activity on carotenoid degradation in dehydrated carrots. Food Chem., 104: 1705-1711.

Lee, S.C., J.H. Kim, S.M. Jeong, D.R. Kim, J.U. Ha, K.C. Nam and D.U. Ahn, 2003. Effect of far-infrared radiation on the antioxidant activity of ricehulls. J Agric Food Chem., 51: 4400-4403.

Lewicki, P.P., 1998. Some remarks on rehydration of dried foods. Journal of Food Engineering, 36: 81-87.

Madrau, M.A., A. Piscopo, A.M. Sanguinetti, A. Del Caro, M. Poiana, F.F. Romeo and A. Piga, 2009. Effect of drying temperature on polyphenolic content and antioxidant activity of apricots. European Food Research and Technology, 228(3): 441-448.

Mayor, L. and A.M. Sereno, 2004. Modeling shrinkage during convective drying of food materials. Journal of Food Engineering, 61: 373386.

Merrill, A.L. and B.K. Watt, 1973. Energy value of foods: basis and derivation. Agriculture Hand book No. 74. Washington, DC, ARS United States Department of Agriculture.

Milosevic, T., N. Milosevic, I. Glišić, and J. Mladenović, 2012. Fruit quality, phenolics content and antioxidant capacity of new apricot cultivars from Serbia. Acta Sci. Pol., Hortorum Cultus, 11: 3-15.

Mongi, R.J., B.K. Ndabikunze, T. Wicklund, L.M. Chove and B.E. Chove, 2015. Effect of solar drying methods on total phenolic contents and antioxidant activity of commonly consumed fruits and vegetable (mango, banana, pineapple and tomato) in Tanzania. African Journal of Food Science, 9(5): 291-300.

Morris, J.R., and P.L. Brady, 2003. Milestones in Fruit and Vegetable Production, Processing and Quality. HortScience., 38(5): 968-976.
Mujumdar, A.S., 2007. Handbook of Industrial drying, Taylor and Francis group, U.K.
Murthy, M.R., 2009. A review of new technologies, models and experimental investigations of solar driers. Renewable and Sustainable Energy Reviews, 13(4): 835-844.
Panceri, C.P., T.M. Gomes, J.S. De Gois, D.L. Borges and M.T. Bordignon-Luiz, 2013. Effect of dehydration process on mineral content, phenolic compounds and antioxidant activity of Cabernet Sauvignon and Merlot grapes. Food research, international, 54(2): 1343-1350.
Panwar, N.L., 2007. Renewable energy sources for sustainable development. New India Publishing.
Penicaud, C., N. Achir, C. Dhuique-Mayer, M. Dornier, P. Bohuon, 2011. Degradation of β-carotene during fruit and vegetable processing or storage: reaction mechanisms and kinetic aspects: a review. Fruits, 66: 417-440.
Prior, R.L., and G. Cao, 2000. Antioxidant phytochemicals in fruits and vegetables: diet and health implications. HortScience, 35(4): 588-592.
Rodriguez-Amaya, D.B., and M. Kimura, 2004. HarvestPlus handbook for carotenoid analysis (Vol. 2). Washington: International Food Policy Research, Institute (IFPRI).
Satisha, J., P. Doshi and P.G. Adsule, 2008. Influence of Rootstocks on Changing the Pattern of Phenolic Compounds in Thompson Seedless Grapes and Its Relationship to the Incidence of Powdery Mildew. Turk. J. Agric. For., 32: 1-9.
Schieber, A, and R. Carle, 2005.Occurrence of carotenoid cis-isomers in food: technological, analytical, and nutritional implications. Trends Food Sci Tech., 16: 416-422.
Sen, F., M. Ozgen, B.M. Asma, and U. Aksoy, 2015. Quality and nutritional property changes in stored dried apricots fumigated by sulfur dioxide. Horticulture, Environment, and Biotechnology, 56(2): 200-206.
Shanmugam, V., and E. Natarajan, 2006. Experimental investigation of forced convection and desiccant integrated solar dryer. Renewable Energy, 31(8): 1239-1251.
Shanmugam, V., and E. Natarajan, 2007. Experimental study of regenerative desiccant integrated solar dryer with and without reflective mirrors. Applied Thermal Engineering, 27(8): 1543-1551.
Sharma, A., C.R. Chen and N.V. Lan, 2009. Solar-energy drying systems: A review. Renewable and Sustainable Energy Reviews, 13(6-7): 1185-1210.
Sjoholm, I., and V. Gekas, 1995. Apple shrinkage upon drying. Journal of Food Engineering, 25, 123-130.
Teissedre, P.L., E.N. Frankel, A.L. Waterhouse, H. Peleg, and J.B. German, 1996. Inhibition of in vitro human LDL oxidation by phenolic antioxidants from grapes and wines. Journal of the Science of Food and Agriculture, 70(1): 55-61.
Thakur, A.K., V.K. Saharan and R.K. Gupta, 2010. Drying of 'Perlette' grape under different physical treatment for raisin making. J. Food Sci. Technol., 47(6): 626-631.
Toğrul, İ.T., and D. Pehlivan, 2003. Modelling of drying kinetics of single apricot.Journal of Food Engineering, 58(1): 23-32.
Toor, R.K. and G.P. Savage, 2006. Effect of semi-drying on the antioxidant components of tomatoes. Food Chemistry, 94: 90-97.
Türkyılmaz, M., S. Tağı, M. Özkan, K. Öztürk and B. Öztürk, 2013. CHEMICAL and MICROBIAL DIFFERENCES in DRIED APRICOTS CONTAINING SULFUR DIOXIDE at DIFFERENT LEVELS GIDA/The Journal of FOOD, 38(5): 275-282.
Vadivambal, R., and D.S. Jayas, 2007. Changes in quality of microwave-treated agricultural products-A review. Biosystems Engineering, 98: 1-16.
Velić, D., M. Planinić, S. Tomas, and M. Bilić, 2004. Influence of air flow velocity on kinetics of convection apple drying. Journal of Food Engineering, 64: 97-102.
Wang, C.Y., M.W. Mayo and A.S. Baldwin, 1996. TNF-and cancer therapy-induced apoptosis: potentiation by inhibition of NF-κB. Science, 274(5288): 784-787.
Wang, J. and Y.S. Xi, 2005. Drying characteristics and drying quality of carrot using a two-stage microwave process Journal of Food Engineering, 68: 505-511.
Willett, W.C., 1994. Diet and health: what should we eat? Science, 264(5158), 532-537.
Zakhidov, R.A., 2008. Central Asian countries energy system and role of renewable energy sources. Applied Solar Energy, 44(3): 218-223.
Zhang, M. and Y. Y. Xu, 2003. Research developments of combination drying technology for fruits and vegetables at home and abroad. J. Wuxi University of Light Industry, 22(6): 103-106.
Zhang, M., C.L. Li, and X.L. Ding, 2005. Effects of heating conditions on the thermal denaturation of white mushroom suitable for dehydration. Drying Technol., 23(5): 1119-1125.
Zhishen, J., T. Mengcheng and W. Jianming, 1999. The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. Food Chemistry, 64: 555-559.