Quality Attributes of Some Fruit and Vegetable Crops Preserved by Three Different Drying Methods

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ABSTRACT

Three different drying methods (sun drying, hot air and solar drying) were investigated to evaluate their performance and effects on quality attributes of six crops. These crops included three fruit crops (grapes, figs and apricots) along with three vegetable crops (tomato, okra and jew's mallow). A solar collector was designed and used in the present study. Values of drying constant (K) and coefficient determination (R^2) were evaluated for each of the aforementioned crops and the Fick's equation diffusion equation was applied. Consequently, the optimum time of drying was interpretated for each crop.

No significant differences could be traced regarding dehydration and rehydration ratios of any of the six crops dried by the three methods under study. Furthermore, losses in some chemical components (sugars, total and fixed acidities, and SO_2) due to drying by different methods were insignificant for each of the crops under investigation. On the other hand, severe destruction of vitamin C could be observed for all dried crops regardless the drying method applied as compared to their fresh correspondings. Microbial analysis exhibited higher bacteria and yeast and mould count (CFU/g) for almost all crops preserved by sun drying than their counterparts preserved by hot air and solar energy. The panelists preferred the colour of grapes, apricots, tomato and jew's mallow dried by solar energy and hot air than their correspondings dried naturally. On the other hand, no significant differences could be observed regarding scores given by the panelists for flavour and texture for all crops under study, with jew's mallow being the only exception and so it was less acceptable.

***Keywords:** sun drying, solar drying, dehydration, fruits, vegetables, dehydration ratio, sugars, vitamin C, acidity, pH, sulfur dioxide.*

INTRODUCTION

Sun drying is done by placing pieces of foods on drying trays and then the food is covered with a layer of cheese cloth. After the food is almost dry, the food is put in an airy, shady place to prevent scorching during the final stage of drying. Vegetables take 3 to 7 days to dry in the sun (Oschwald, 1984). Grapes were sun dried by bunches spread on cloth or in paper boxes or hung under transparent plastic film, exposed to direct sun light. Drying was conducted slowly for 2–3 weeks until a moisture content of about 16% was reduced (Saravacos, 1986). Grapes could be treated by dipping in a solution of 2.5% potassium carbonate +0.5% olive oil for one minute. This pre-treatment "checks" the skin and increases drying rate (Kosteropoulos & Saravacos, 1995). Furthermore, Grapes could be treated by dipping in commercial dipping oil or ethyl oleat or olive oil followed by dipping in potassium carbonate solution and hot sodium hydroxide solution then, grapes were dried in dryer at 60°C and air velocity 0.5 (m/s) (Pangavhane *et al.*, 1999). The dewaxing agent such as sodium hydroxide could be used for dewaxing process of grapes prior to dehydration (Carpi *et al.*, 1999). Figs were dried in drying tunnel by air of a temperature ranged from 85°C to 95°C for 3 hr. Dried figs were moved to dry in a second drying tunnel at 85°C for 14 hrs. (Papoff *et al.*. 1998).

Tomatoes were immersed in boiling solution of 2.5% NaCl, blanched for 60 sec and dipped in cold water. Tomatoes were blanched in brine or water, cut into 1.5 cm thickness slices, and dipped for 2 min (at room temperature) in 2.5% starch solution containing 5% potassium metabisulphite. Slices were dried to about 4% moisture content (Tripathi & Nath, 1989).

Numerous designs for solar dryers have been published. The collector of solar fruit dryer consists of blackened rock for heat storage, and a plastic cover was placed above the rock on a wooden 2 × 4 m frame. The bed was filled with granite to store solar energy (Moyls, 1986). Solar collector leading into a tunnel dryer being arranged parallely to reduce the air resistance. The frame of the collector and tunnel dryer (20 m. long and 6 cm high) is fixed on the ground. The collector was 1 m. wide, the tunnel dryer 2m. Both components are covered by a transparent PE- EVA air - bubble foil. (EL-Shiaty *et al.*, 1991). Ageodesic dome solar fruits dryer was designed and constituted for drying grapes. The base diameter of the dome was 20 feet. Ground below the dome was covered with gravel for thermal energy storage or with a plastic sheet to minimize the effect of ground moisture. Fruit trays were located inside the inner dome, so that the fruits are not exposed to direct sun. The heated air passed through the fruit trays inside the dome before existing at the top of the dome (Goswami *et al.*, 1991). Solar drying system for drying some fruits and vegetables was designed by using eight flat plate solar collectors. Each flat plate solar collector had a gross area of 1.86 m^2., cross section area of air tunnel with 0.048 m^2. The collector has a gross cover which acts as a barrier between the wind and absorber plate (Ahmed & Khan, 1997). The passive solar drying system constructed with tunnel ($1\times2\times0.5$m) with plastic cover sheet in two ventilation openings. The active drying system consisted of flat plate solar collector (2×1 m). The collector was connected to $0.8\times0.7\times$ 0.3 m. metal thin layer containing six circular trays (Yosif, 2002).

The present study was carried out to achieve the following goals :

- Design a solar dryer to dry some fruits and vegetables.
- Evaluation of three drying methods (i.e. solar-drying, hot air and sun drying) for drying the fruits and vegetables under study.
- Investigation of the physical, chemical, microbiological and sensory properties of fruits and vegetables dried by the aforementioned three drying methods.

MATERIALS AND METHODS

Materials

Different kinds of fresh fruits and vegetables were used in the present study. The fruits included: Grapes (*Vitis vinifera*), Sultana variety, Apricot (*Prunus amreniaca*), Canino variety and fig (*Ficus carica*), Sultani variety.

The vegetables included: Tomatoes (*Lecopersicon esculentan*), Castla rock variety, Okra (*Hibiscus esculentus*), Balady variety and Jew's Mallow (*Corchorous olitorius*), local cultivated. The samples were obtained directly after harvest from some farms in Behera Governorate during the seasons of 2002 - 2003.

Methods

An indirect solar dryer (Fig 1) was designed and used in the present experiments. No electrical input was used in the dryer. The solar dryer consists of solar collector, drying chamber and chimney. The solar collector had dimensions of 0.75 m by 3 m. and using a corrugated steel sheet thickness of 0.8 m.m and painted black to absorb the incident solar energy. The glass cover was 6 m.m thickness and placed from the top of the corrugations on the steel sheet and formed the top of the air flow channel. The collector was connected to a drying chamber containing 3 stainless steel trays (1 m, 0.75 m and 0.6 m). The heated air enters the drying chamber underneath the trays and flows upwards through the samples and goes out upwards through the chimney. All the outside parts of the solar dryer were painted black to increase the absorbance of solar energy.

Fruits and vegetables under study were prepared for drying by various techniques. Grapes were washed in water then dipped in a solution of 2.5%

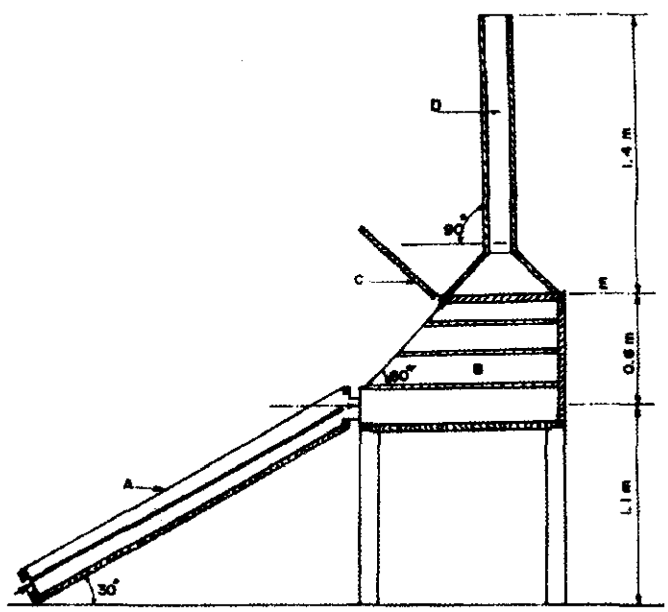

Fig. 1: General view of solar dryer
A : Solar collector, B : Cabinet dryer, C : Reflection dryer, D : Chimney, E : Door

potassium carbonate +0.5% olive oil for 1 min followed by blanching in 0.5% sodium hydroxide solution and cooled by chilled water. Sulphiting was carried out by dipping in 0.04% potassium metabisulphite solution for 15 min. according to Kosteropoulos & Saravacos, (1995). Figs were immersed in 4% NaCl solution at 100°C, then sulphiting was conducted by the exposure to fumigation of sulfur in a wooden box for 4-6 hr. at a rate of 20 g sulfur /kg according to Gouda, (1974) Apricots were cut into halves and pitted. Sulphiting was carried out by placing the cut fruits upside up and were exposured to sulfur fumigation as mentioned previously. according to Von Loesecke, (1955). Tomatoes were immersed in boiled 2.5% NaCl solution, blanched for 60 sec, cut into slices of 1.5 cm. thick followed by keeping on a sieve to drain – off free juice. Sulphiting was undertaken by dipping in 2.5% starch solution containing 5% potassium metabisulphite for 2 min. according to Tripathi, & Nath, (1989). Okra and jew's mallow were dipped in boiling water for 30, 15 sec, respectively, and cooled by chilled water according to Adom *et al.* (1997). The solar dryer was fitted with copper- constant thermocouples fixed at the top of the chimney, cabinet dryer inlet and outlet of air solar– air–collector. All temperature data were measured through thermocouples thermometer digital sensor which were connected to manual selective switch distributer.

After preparation and pre-treatments were carried out, each type of fruits and vegetables were divided into three portions. The first portion was sun dried by spreading in thin layer and exposing to direct solar radiation. The second part was dehydrated as follows:

The grapes were loaded on drying trays in thin layer, drying by hot air was carried out at 55°C until moisture content was reduced to 15–20% (nearly 12 hr) (Von Loesecke, 1955). The figs were dried at 50°C until the moisture content reached 20% (Gouda, 1974). The apricots were dried at 55°C for 15–20 hr until a moisture content of 15–20% was reached (Bhutani & Sharma, 1988). The tomatoes were dried at 78°C for 4 hr and subsequently at 53°C until moisture content of about 5.5% was reached (Tripathi & Nath, 1989). The okra was dried at 55°C until brittle texture was obtained (Shivhare *et al.*, 2000). The leaves of the jew's mallow were dried at 55°C for 4 hr (Kordylas, 1991).

The third part was solar dried by spreading the pre–treated materials on the trays in thin layer and drying was continued until the required moisture content was achieved.

Physical methods:

Dehydration ratio: Dehydration ratio was expressed as the ratio between the weight of fresh sample and the weight of dehydrated sample (Gouda, 1974).

Rehydration ratio: Rehydration ratio was determined by placing ten grams of dried products in 600 ml beaker and a definite volume (100 ml.) of tap water was added. The beaker was covered with watch glass, then heated to boiling within 3 min. and heating continued for 30 min, the contents were transferred to a Buchnner funnel and left for 1 min before weighing. Rehydration ratio was calculated as follows: - The weight of dried sample: The weight of rehydrated sample (Gouda, 1974).

Analytical methods

Moisture content was determined by drying at 70°C according to Tripathi & Nath (1989). Vitamin C was determined by 2, 6 dichlorophenolindo- phenol according to AOAC method (1984). Sugars were determined as total sugars following phenol sulfuric method, and reducing sugars were determined according to the Lane - Eynon method as outlined by Egan *et al.* (1981). Acidity was determined by titration of the extract with 0.05 N solution of sodium hydroxide in the presence of phenolphthalein indicator. Volatile acidity was determined by steam evaporation of the extract and titration with 0.05 N solution of sodium hydroxide in the presence of phenolphthalein indicator. Fixed acidity was calculated by difference as discribed by Egan *et al.* (1981). Sulfur dioxide was determined in the presence of sulfuric acid (1+3) and 0.5 g sodium bicarbonate, by titration with 0.02 N iodine solution using starch solution as an indicator according to AOAC method (1984).

Microbiological evaluation

Samples were prepared under aseptic conditions. The necessary dilutions were made and the pouring plate technique was followed. The count of mesophilic aerobic bacteria on nutrient agar medium (N.A) and yeast and moulds on sabouraud dextrose agar medium (S.D.A.) were determined according to Dificos' s Manual (1984).

Organoleptic evaluation

Samples were presented simultaneously to eleven well trained panelists. They were requested to rank each sample on a hedonic scale as follows: 9-10 (Excellent), 7-8 (Very good), 5-6 (Good), 3-4 (Fair) and 1-2 (Very poor) as outlined by Kramer & Twigg (1962).

Statistical analysis

Data were statistically analyzed using Analysis of Variance (ANOVA) and means were further subjected to Duncan's Multiple Range test as outlined by Steel & Torrie (1980).

RESULTS AND DISCUSSION

Mathematical analysis

Values of moisture ratios with their corresponding drying times are given in Figuers (2) and (3). They were used to obtain the drying constant and predicted equation of drying time. The drying constant is a combination of the transport properties and it may be defined by the following fully exposed equation as outlined by Shokr (1974, 1986).

$$\frac{dM}{dT} = -k(M-Me)$$

Where, M: is the moisture content at any time, Me: is equilibrium moisture content, T: is the time and K: is the drying constant. The fully exposed (thin layer) equation has been used for estimating and predicting the drying rate of several crops and for generalization of drying curves. The drying constant is suitable for the purposes of process design and optimization. The following equation is used to describe the thin layer drying curve of many products for its simplicity and high computational speed. In common practice, data of moisture content are transformed into the dimensionless symbol called moisture ratio denoted by MR and defined as:

$$MR = \frac{M - Me}{Mo - Me} = \exp(-kt)$$

Where, Mo is the initial moisture content. The second form was determined by the linearization of the above model

$$\text{Ln}\,(MR) = KT$$

Where, K is the slope. Since the ambient air temperature and relative humidity are changeable, the equilibrium moisture content will be also changeable throughout the experiments, and thereby, the moisture should be corrected as follows:

$$MR^* = \frac{M}{Mo} = e^{-Kt}$$

Where MR* is the corrected moisture ratio.

This equation fits the data obtained in our experiments. The values of K and R^2 were evaluated for each test as given in Table (1). As the average temperature is almost the same, the drying constant K, which indicates the drying rate, depends on the nature of the material.The moisture ratio was simplified to M / Mo instead of the (M – Me) / (Mo – Me) used by Diamante & Munro (1991). There were three reasons for this simplification. Firstly, in solar drying, the relative humidity (RH) of the drying air continuously fluctuated so at best a mean Me could be calculated. Secondly, accurate Me data are not available at the high drying chamber temperatures reached. Thirdly, approximate calculations indicated that Me was less than 2% at the high temperatures and resultant low air relative humidities in the drying chamber during most of a drying run. So, the error involved in the simplification was very small. The coefficient of determination (R^2) was the primary criterion for selecting the best equation to describe the solar drying curves of fruits and vegetables.

Table 1: Values of drying constants for fruits and vegetables under study

Material	K	R^2
Grapes	0.0422	0.9761
Figs	0.0625	0.9667
Apricots	0.0603	0.9706
Tomatoes	0.1310	0.9112
Okra	0.2062	0.9285
Jew's mallow	0.1980	0.9380

K: Drying constant
R^2: Coefficient of determination

Physical properties

Physical properties of the dried fruits and vegetables are given in Table (2). Dehydration ratios of samples dried by three different drying methods under study being quite comparable regardless the drying method utilized. This was also true regarding the rehydration ratios since no significant differences could be traced among samples dried by the aforementioned drying methods. Oliveira & Oliveira (1999) reported that the heat applied during drying reduces the hydration of starch and the

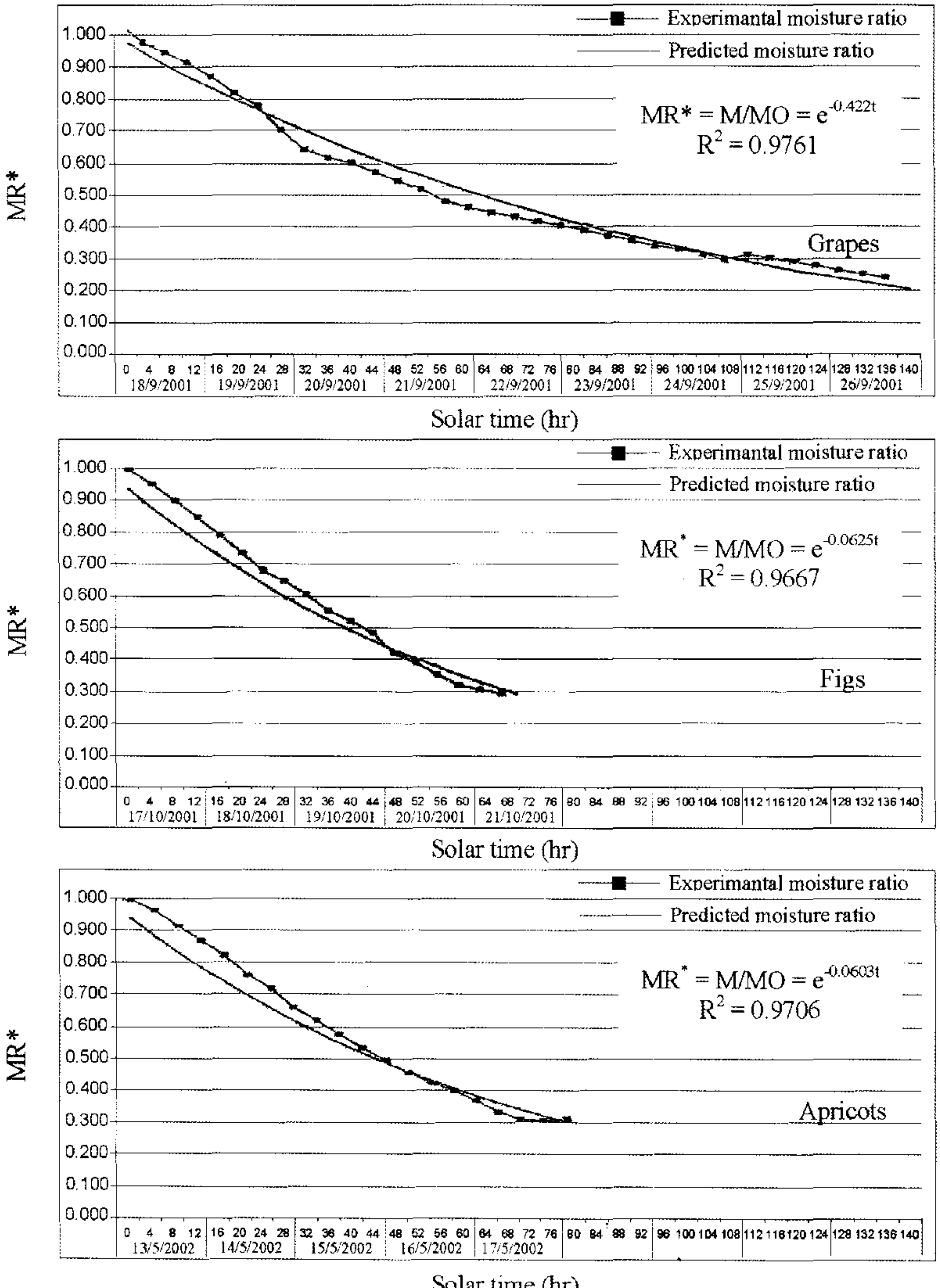

Fig. 2: Corrected moisture ratio MR*, versus accumulated solar drying time (hr) for drying some fruits

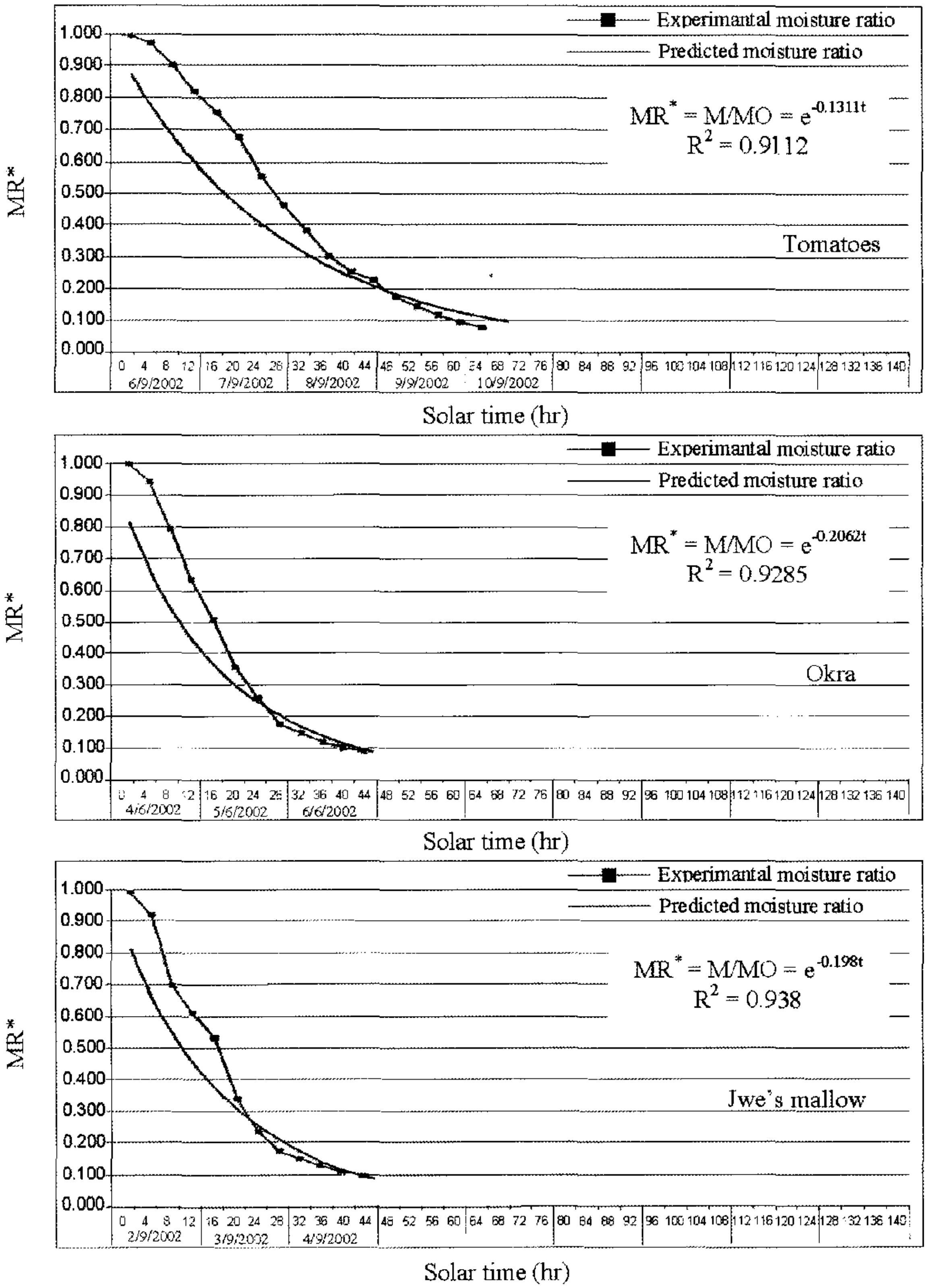

Fig. 3: Corrected moisture ratio MR*, versus accumulated solar drying time (hr) for drying some vegetables

Table 2: Dehydration and rehydration ratios of fruits and vegetables dried by three different methods

Materials	Drying methods					
	Solar drying		Hot air		Sun drying	
Fruits:	**D. R**	**R.R**	**D.R**	**R.R**	**D.R**	**R.R**
Grapes	3.62ª :1	1 : 3.33ª	3.75ª : 1	1 : 3.42ª	3.70ª : 1	1 : 3.20ª
Figs	3.67ª :1	1 : 3.52ª	3.49ª : 1	1 : 3.30ª	3.75ª : 1	1 : 3.38ª
Apricots	4.24ª :1	1 : 3.59ª	4.35ª : 1	1 : 3.63ª	3.89ª : 1	1 : 3.34ª
Vegetables:						
Tomatoes	9.94ª :1	1 : 6.86ª	10.35ª : 1	1 : 6.93ª	10.40ª : 1	1 : 6.78ª
Okra	9.89ª :1	1 : 6.14ª	9.42ª : 1	1 : 6.23ª	9.75ª : 1	1 : 6.07ª
Jew's mallow	8.86ª :1	1 : 6.58ª	8.52ª : 1	1 : 6.65ª	8.92ª : 1	1 : 6.56ª

D.R : Dehydration ratios R.R : Rehydration ratios

elasticity of the cell walls and coagulate protein to reduce their water holding capacity. Foods that dried under optimum conditions suffer less damage and rehydrate more rapidly and to a greater extent than poorly dried foods. Rapid drying at high temperature cause greater changes as compared to moderate rates of drying and lower temperature. The three methods of drying applied here were conducted at up to 60°C and thereby, the physical properties of the products did not change significantly.

Chemical composition

Chemical composition of dried fruits and vegetables are given in Tables (3) and (4). Total sugars and reducing sugars of fruits and vegetables did not exhibit any significant differences as a result of drying by any of the three drying methods. During the 1st step of drying, the natural α and β amylases actviate and react with the freshly gelatinized starch, decreasing iodine blue value, and producing dextrins, maltose and glucose. Then these effects decrease possibly as water decreases and denaturation of enzymes occurs (Richardson & Finaley, 2003). Total acidity and fixed acidity of dried fruits and vegetables investigated here being insignificantly different. In contrast, significant differences could be traced regarding volatile acidity of vegetable crops dried by the different methods utilized in the present study. Moreover, the differences between pH values were insignificant. No significant differences could be figured out in the content of vitamin C due to the method of drying of grapes. Vitamin C in figs, apricots and tomatoes samples was destroyed. The results showed that vitamin C was destroyed as a result of drying process and this agrees with Eheart & Oldland (1972) who reported that vitamin C of dried fruits was destroyed by heat. Notwithstanding, it was obvious that vitamin C contents of okra and Jew's mallow samples dried by hot air and solar drying were significantly higher than their counterparts dried by sun- drying. Ascorbic acid is subject to degradation during heating foods in the presence of water (e.g. 1st step of drying). The least concentration of sulfur dioxide was found in samples dried by sun- drying but the differences were insignificant.

Microbiological properties

The count of mesophilic aerobic bacteria on nutrient agar (N. A) medium of the dried fruits and vegetables are shown in Table (5). Data revealed that the fruits and vegetables dried by sun- drying had the highest count of bacteria than the samples dried by solar drying and hot air methods. The lower count of bacteria for the samples dried by solar drying and hot air could be attributed to the highest temperature applied by the two methods as explained by Whitfield (2000) who reported that temperature ranging between 37.2°C to 71.2°C was found to effectively kill bacteria.

Data of yeast and mould counts on sabouraud dextrose agar (S.D.A) medium, presented in Table (5) indicated that fruits and vegetables dried by hot air and solar drying had a lower counts of yeast and mould. This may be attributed to the low moisture contents, as found by Scalin (1997) who reported that reducing the moisture content of food to the range between 10 % and 20% resulted in preventing food from yeast and mould contaminations. But, the highest count of yeasts and moulds of the samples dried by sun-drying could be attributed to the low temperatures along with the long period of drying which make microorganisms grow before the food is adequatly dried (kendall & Allen, 1998).

Organoleptic properties

Table (6) shows the obtained data of the organoleptic properties of fruits and vegetables dried by

Table 3: Chemical composition of fruits dried by three different methods (on dry weight basis)

Chemical composition	Grapes			Figs			Apricots		
	Sun drying	Hot air	Solar drying	Sun drying	Hot air	Solar drying	Sun drying	Hot air	Solar drying
Total sugars (%)	72.00a (8.62)	73.01a (7.43)	72.06a (8.55)	55.92a (10.69)	55.29a (11.07)	54.97a (12.21)	41.28a (17.14)	41.67a (16.17)	42.08a (15.53)
Reducing sugars (%)	66.37a (5.46)	67.19a (4.30)	67.10a(4.24)	51.94a (6.11)	51.51a (6.88)	51.05a (7.71)	38.34a (11.96)	38.45a (11.71)	38.75a (11.20)
Total acidity (%)	0.54a (14.28)	0.57a (9.52)	0.58a (7.93)	0.45a (13.46)	0.41a (21.15)	0.43a (17.30)	0.76a (12.64)	0.77a (11.49)	0.75a (13.79)
Fixed acidity (%)	0.47a (9.61)	0.50a (3.84)	0.50a (3.84)	0.38a (7.31)	0.33a (19.51)	0.35a (14.63)	0.73a (2.66)	0.74a (1.30)	0.73a (2.66)
Volatile acidity (%)	0.07a (36.36)	0.07a (36.36)	0.08a (27.27)	0.07a (36.36)	0.08a (27.27)	0.07a (36.36)	0.03a (72.72)	0.03a (72.72)	0.02a (81.81)
pH	3.93a	3.84a	3.83a	3.94a	4.05a	3.95a	3.62a	3.59a	3.64a
Vitamin C (mg/ 100g)	2.46a (83.3)	2.77a (83.09)	2.24a (86.25)	1.73a (85.22)	1.50a (87.19)	1.75a (85.05)	1.61a (96.91)	1.88a (96.39)	1.77a (96.60)
Sulphur dioxide (ppm)	194.03a (75.74)	243.33a (75.74)	204.20a (74.74)	152a (81.00)	183.83a (77.02)	158.70a (80.16)	200.80a (74.90)	242.36a (69.70)	203.36a (74.58)

Values give in brackets represent loss % on the basis of initial values due to drying.
Means in a row for certain crop followed by the same superscript are not significantly different at $P<0.05$.

Table 4: Chemical composition of vegetables dried by three different methods

Chemical composition	Tomatoes			Okra			Jew's mallow		
	Sun drying	Hot air	Solar drying	Sun drying	Hot air	Solar drying	Sun drying	Hot air	Solar drying
Total sugars	40.97a (5.62)	40.43a (6.86)	40.43a (6.86)	15.35a (22.16)	15.73a (20.23)	15.96a (19.06)	14.66a (16.84)	15.29a (13.27)	14.79a (16.16)
Reducing sugars	37.51a (3.39)	36.26a (6.61)	37.19a (4.22)	13.92a (15.27)	14.13a (13.98)	14.37a (12.53)	13.09a (13.54)	13.48a (10.96)	13.21a (12.74)
Total acidity	0.39a (17.02)	0.41a (12.76)	0.45a (4.25)	0.016 (14.78)	1.185a (19.56)	0.187a (18.69)	0.142a (29.00)	0.141a (29.50)	0.138a (31.00)
Fixed acidity	0.34a (10.52)	0.33a (13.15)	0.37a (2.63)	0.18a (5.26)	0.171a (10.00)	0.17a (10.52)	0.13a (24.41)	0.134a (22.09)	0.132a (23.25)
Volatile acidity	0.05b (44.44)	0.08a (11.12)	0.08a (11.12)	0.016a (60.00)	0.014b (65.00)	0.017a (57.50)	0.012a (78.57)	0.007b (75.00)	0.006b (78.57)
p H	4.40a	4.34a	4.24a	6.01a	6.09a	6.07a	6.89a	6.94a	7.06a
Vitamin C	1.30a (99.56)	1.45a (99.51)	1.46a (99.51)	2.32b (98.98)	2.80a (98.78)	2.79a (98.79)	1.46a (99.64)	2.79a (99.32)	1.88b (99.54)
Sulphur dioxide	227.46a (71.56)	243.56a (69.55)	221.10a (72.36)						

Values give in brackets represent loss % on the basis of initial values due to drying.
Means in a row for certain crop followed by the same superscript are not significantly different at $P<0.05$.

Table 5: Microbiological evaluation of fruits and vegetables dried by three different methods

Material	Drying methods	Bacteria (C.F.U) g	Yeasts & Moulds (C.F.U) g
	Solar-	$23 \times 10^{2\,b}$	$33 \times 10^{2\,b}$
Grapes	Hot air	$12 \times 10^{2\,b}$	87×10^{c}
	Sun-	$15 \times 10^{3\,a}$	$86 \times 10^{2\,a}$
	Solar-	$16 \times 10^{2\,b}$	$21 \times 10^{2\,b}$
Figs	Hot air	$10 \times 10^{2\,b}$	95×10^{b}
	Sun-	$15 \times 10^{3\,a}$	$10 \times 10^{3\,a}$
	Solar-	79×10^{b}	$11 \times 10^{2\,b}$
Apricots	Hot air	55×10^{b}	$16 \times 10^{2\,c}$
	Sun-	$17 \times 10^{3\,a}$	$93 \times 10^{3\,a}$
	Solar-	$18 \times 10^{2\,b}$	$17 \times 10^{2\,b}$
Tomatoes	Hot air	$14 \times 10^{2\,b}$	$13 \times 10^{2\,b}$
	Sun-	$13 \times 10^{3\,a}$	$51 \times 10^{2\,a}$
	Solar-	$29 \times 10^{2\,b}$	$10 \times 10^{2\,b}$
Okra	Hot air	$39 \times 10^{2\,b}$	$17 \times 10^{2\,b}$
	Sun-	$16 \times 10^{3\,a}$	$71 \times 10^{2\,a}$
	Solar-	$12 \times 10^{2\,b}$	$23 \times 10^{2\,b}$
Jew's mallow	Hot air	82×10^{b}	$12 \times 10^{2\,b}$
	Sun-	13×103^{a}	$17 \times 10^{3\,a}$

Means followed by the same superscript (in a column, for the same crop) are not significantly different at $P < 0.05$.

Table 6: Sensory evaluation of fruits and vegetables dried by three different methods

Material	Drying methods	Colour	Flavour	Texture
	Solar-	7.82^{a}	8.36^{a}	7.72^{a}
Grapes	Hot air	8.18^{a}	8.18^{a}	7.63^{a}
	Sun-	5.90^{b}	8.18^{a}	7.45^{a}
	Solar-	7.31^{a}	6.94^{a}	6.87^{a}
Figs	Hot air	7.12^{a}	7.01^{a}	6.73^{a}
	Sun-	7.01^{a}	6.86^{a}	6.81^{a}
	Solar-	7.90^{a}	7.09^{a}	6.72^{a}
Apricots	Hot air	7.27^{ab}	7.27^{a}	6.72^{a}
	Sun-	6.45^{b}	7.27^{a}	6.90^{a}
	Solar-	7.80^{a}	7.54^{a}	7.45^{a}
Tomatoes	Hot air	7.27^{ab}	8.00^{a}	8.09^{a}
	Sun-	6.54^{b}	7.63^{a}	7.72^{a}
	Solar-	8.45^{a}	8.54^{a}	8.81^{a}
Okra	Hot air	8.27^{a}	8.54^{a}	7.81^{b}
	Sun-	7.90^{a}	8.00^{a}	7.72^{b}
	Solar-	8.72^{a}	8.45^{a}	8.36^{a}
jew's mallow	Hot air	8.18^{ab}	8.36^{ab}	8.00^{ab}
	Sun-	7.54^{b}	7.54^{b}	7.27^{b}

Means followed by the same superscript (in a column, for the same crop) are not significantly different at $P < 0.05$.

the three different drying methods under investigation. It was obvious that the organoleptic properties (colour, flavour and texture) were significantly influenced by the drying methods that were applied with the exception of dried grapes by sun – drying which had the lowest acceptance as judged by panelists, since it gained significantly lower score as compared to grapes dried by solar–drying or hot air methods. It was reported that the best overall quality of dried foods is obtained at a constant temperaturs of about 60°C during drying. The pigments degrade above 60°C and stability to thermal degradation increases as pH decreases (Oliveira & Oliveira, 1999).

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محددات جودة بعض محاصيل الفاكهة والخضر المحفوظة بثلاث طرق تجفيف مختلفة

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أجري هذا البحث بغرض المقارنة بين ثلاث طرق مختلفة للتجفيف (الطبيعي، الصناعي بالهواء الساخن، الطاقة الشمسية) وذلك من حيث كفاءتها في تجفيف ثلاثة محاصيل من محاصيل الفاكهة (العنب، التين، المشمش) وكذا ثلاثة محاصيل خضر (الطماطم، البامية، الملوخية).

ولتحقيق هذا الهدف فقد تم تصميم مجفف يعمل بالطاقة الشمسية وتم تقدير قيمة K (ثابت التجفيف)، R^2 (معامل التقدير) لكل من المحاصيل الستة موضع الدراسة. وتم تطبيق معادلة Fick للانتشار في حالة التجفيف بالطاقة الشمسية. ومن خلال رسم العلاقات البيانية بين نسب الرطوبة، وقت التجفيف لكل محصول أمكن حساب الزمن الأمثل لتجفيفه بالطاقة الشمسية.

أوضح التحليل الإحصائي عدم وجود فروق جوهرية في قيم معاملي التجفيف والتشرب للمحاصيل الستة التي تم تجفيفها بالطرق الثلاث موضع الدراسة. وقد تبين عدم وجود فروق معنوية في نسب الفقد في المكونات الكيماوية (السكريات، الحموضة الكلية والثابتة. ثاني أكسيد الكبريت) وذلك بالنسبة للمحاصيل الستة موضع الدراسة، وذلك على الرغم من حدوث تحطم لمعظم محتوى هذه المحاصيل من فيتامين C بفعل حرارة التجفيف وبغض النظر عن الطريقة المتبعة في التجفيف.

أوضح التحليل الميكروبيولوجي ارتفاع الأعداد الميكروبية جوهرياً في جميع عينات المحاصيل التي تم تجفيفها طبيعياً (تجفيف شمسي) وذلك مقارنة بالعينات المناظرة التي جففت بطريقتي التجفيف الصناعي بالهواء الساخن والطاقة الشمسية وقد تبين من نتائج الاختبارات العضوية الحسية تفوق عينات المحاصيل التي تم تجفيفها بطريقتي التجفيف الصناعي بالهواء الساخن والطاقة الشمسية من حيث اللون مقارنة بالعينات المناظرة التي جففت طبيعيا. وذلك بالنسبة للعنب، المشمش، الطماطم، الملوخية، في حين لم تكن هناك ثمة فروق جوهرية في نكهة وقوام هذه العينات التي جففت بالطرق الثلاث، وذلك باستثناء الملوخية المجففة بطريقة التجفيف الطبيعي حيث كانت الأقل تقبلا من هذا المنظور.