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Improvement of Quality of Dried Carrots Using Osmotic and Solar Dehydration

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ABSTRACT

The present investigation was carried out to study the effect of incorporation of osmotic dehydration (OD) and drying methods on the quality of carrot slices (gross chemical composition, dehydration parameters, microbiological count and sensory attributes) immediately, after dehydration and during storage at room temperature (25± 3° C) for 6 months. Carrot slices were soaked in different sucrose solutions 15%(C1), 40%(C2), 20-40% (C3) and 20-40%(C4) with adding sodium metabisulphite (0.3%). Osmotic dehydration was followed by two drying methods (solar sun hood and solar cabinet driers). Results indicated that consecutive osmotic solution(C4) succeeded in releasing ≥45%of the moisture content from fresh carrot. Osmosis succeeded in reducing drying ratio of carrot (from 6.52:1 to 2.86:1), also, carrot slices which were osmotically dehydrated prior to drying were preferably rehydrated than non-treated ones. On the other hand, both drying methods as well as sucrose solution at different concentrations didn't affect the contents of different minerals (macro or micro ones). Total carotenoides decreased as a result of dehydration process; however, the lowest decrement was recorded for C4 treatment, with the two dehydration methods (sun hood and cabinet dryers).With regard to total bacterial count, osmo-dried carrot samples are bacteriologically accepted as specified in the Egyptian Standards. Furthermore, obtained results clearly showed that the color, taste, odor , texture and overall acceptability recorded a high rating in a consecutive sucrose solution concentrationC3 (20-40%). It can be concluded from this investigation that osmotic dehydration with sucrose solution positively affect the transfer process of solids, led to water loss and weight reduction during osmotic, besides, a consecutive concentration of 20-40% and solar drying could prolong self-life of the carrot slices, with gaining high rating of the sensory attributes concerning color, taste, odor and texture of carrot after 6 months of storage (25 ± 3° C).

Keywords: Carrot, osmotic dehydration, solar drying, dehydration ratio, sensory attributes.

INTRODUCTION

In recent years, fruits and vegetables have received considerable attention, as these materials have been reported to contain a wide array of phytochemicals, which are claimed to exert many health benefits including antioxidant activity. Also, they have proved to be essential for a balanced diet. Epidemiological and clinical investigations have actually associated diets rich in fruits and vegetables with reduced risks of cardiovascular, coronary heart, metabolic and degenerative diseases, as well as certain form of cancers. This is believed to be mainly due to their content of fibers, vitamins, minerals and phytochemicals, such as polyphenols, flavonoids, sterols, carotenoids, chlorophylls, anthocyanins, etc., responsible in part for their strong antioxidant activity (Siriamornpun *et al.*, 2012**).** In some cases, where bioactive compounds extraction cannot be performed on fresh products, drying appears as a necessary step enabling their later use.

To increase the shelf life of these fruits and vegetables, many methods or combination of methods had been tried. Osmotic dehydration is used for partial removal of water from materials such as fruits and vegetables by immersing in aqueous solutions of high osmotic pressure such as sugar and salts (Pandharipande *et al.,* 2012). Osmotic dehydration is one of the best and suitable methods to increase the shelf life of fruits and vegetables. This process is preferred over others due to their vitamin and minerals, color and flavor retention property (Hobbi and Siddiqui, 2009). Osmotic dehydration is one of the potential preservation techniques which produce high quality products [Sutar and Gupta (2007**),** Gourav *et al*. (2017) and Paradkar and Sahu, (2018)]. Also, the use of osmotic dehydration as a pretreatment before various processes, e.g. drying and freezing can cause an increase the nutritional, sensory and functional value of food products (Ciurzyńska, *et al.* ,2016).

Dehydration of the fruits and vegetables is one of the oldest forms of food preservation techniques known to man. Several types of dryers and drying methods, each better suited for a particular situation are commercially used to remove moisture from wide variety of food products including fruits and vegetables. There are different types of drying processes as follows (Shruti, 2007). Solar drying, atmospheric drying including batch (mechanical/cabinet drying) and continuous (fluidized bed, spray and drum drying), osmotic dehydration and freeze drying. However, utilizing commercial power sources in heating air increases the expenses of drying; such methods is mostly not economic in drying fruits and vegetables in rural areas. For this reason, in many parts of the world, for heating air, solar power dryers have been developed utilizing solar energy in order to dry vegetables and fruits. Solar drying depends on utilizing sun rays to improve drying without having direct sunlight is called solar drying. It refers to methods of using the sun's energy for drying, but excludes open air sun drying. The justification for solar dryer is that it may be more effective than open-air sun drying, but have lower operating costs than mechanized dryer. A number of designs are proven technically and none are used widespread. Thus, there is still optimism about their potential. Solar drying technology is a cheap, simple and practical method, and can be readily adjusted to suit many drying purposes. The market for dehydrated fruits and vegetables has actually known a rapid growth rate (of 3.3%) for most countries worldwide. Dried fruits and vegetables are widely used by the confectionary, bakery, sweet and distilling industries in various sauce, teas, puddings, garnishments and food for infants and children (Zhang *et al*., 2006).

Carrots are one of the best sources of ß-carotene. The carotene content of carrots ranges from 60–120 mg/100 g. It can provide a significant amount of vitamin A; food matrices greatly affect the bioavailability of the plant carotenoids or their efficiency of conversion to vitamin A, or both. Some studies have indicated that ß-carotene may be poorly absorbed from certain vegetables (Fikselova *et al*., 1989).

The aim of this investigation is to determine the combined effect of two techniques of solar drying and osmotic dehydration on gross chemical composition, dehydration parameters, microbiological load and sensory characteristics of carrot slices.

MATERIALS AND METHODS

Materials:

Fifty kg of yellow carrot roots (*Daucus carota),* at the firm ripe stage, were purchased from El-Oboor market, Sharkia Governorate, Egypt. The roots were stored at 4°C until needed.

Sucrose was purchased from Sugar and Integrated Industries Co., Hawamdeia, Giza, Egypt. Citric acid and sodium metabisulphite were obtained from El-Nasr Pharmaceutical, Egypt. However, Plate count agar and Malt agar media were purchased from Biolife Co., Italy. All chemicals used in this investigation were of analytical grade.

Methods:

a. Preparation of carrot

Samples of carrot were washed with tap water, peeled and sliced (1cm) thickness. Then, slices were blanched by exposed to steam for 5 min according to Alzamora *et al.* (1993) .

b. Osmotic dehydration pretreatment

Different concentrations of sucrose solutions were prepared :15% and 40%,beside a collective ascending sugar solution from 20 % to 40%, w/w with or without sodium metabisulfite(0.3%). Citric acid was added to each osmotic solution at 0.3%.(on sugar content basis).

Total soluble solids (TSS) of osmotic solutions in different treatments were followed up at hourly till TSS reached almost a constant level.

c. Dehydration of carrot slices:

After osmosis using previous treatments, drying was applied by using two solar dryers:

1.Solar sun hood dryer

It was locally fabricated and installed in food Science Department, Faculty of Agriculture, Cairo University (Fig.1). The hood was designed by Andrassy, (1978). The sun hood dryer was locally fabricated and installed in food technology department, faculty of agriculture, Cairo University. The sun hood is solar dried

1-Awooden frame, 47.5 x 65 m with a V-shaped notch.
2-Atrans parent glasses, attached to the top of frame.
3-Adrip channel, inserted across the middle of the frame at lowest part of the frame
4-the bottom of the frame is left open. After the frame is assembled with screws, it should be painted inside and outside with mettle, non-leaded, black paint

After accomplish of osmosis dehydration drying times in solar sun hood and in solar cabinet were about 10 hrs. and10-11hr. to reach drying ratio 3.18 :1 and 3.22 :1, respectively, carrot slice samples were packaged in polyethylene bags and stored at 25 ± 3 °C, at a dry place for 6 months. Samples were randomly with drawn for analysis at 0, 3 and 6 months of storage.

2. Solar cabinet tray dryer

A solar cabinet dryer (Fig. 2) consists of a solar energy collector, provided with air blower connected with drying cabinet, inside it 10 racks mounted in a vertical position used to put drying trays on them. The temperature inside cabinet ranged between 47-58°C during the day light and 26-30 °C at night.


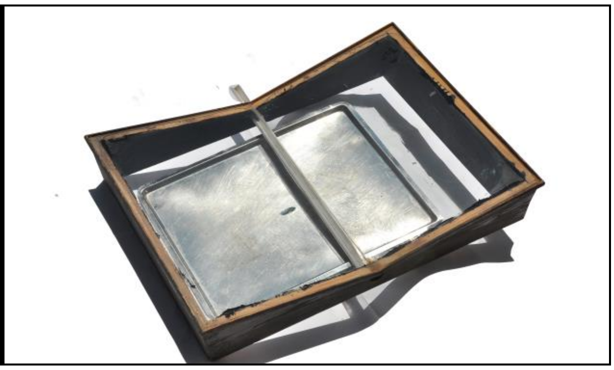

Fig. 1. Solar Sun hood dryer

Fig. 2. Solar cabinet tray dryer

Methods of analysis

Gross chemical composition

Carrot samples were analyzed for their moisture, crude fiber, ascorbic acid, titratable acidity contents according to the methods described in the AOAC (2005). Total sugars were determined appling by the method of Lane-Eynon method as described in A OA C (2005). Minerals content was determined using the official methods described in the A.O.A.C. (2005). The percent of total soluble solids (TSS), were determined, at 20.0±0.5°C, as described by Ranganna, (1977) with a Hand Refractometer (ATAGO, Japan). Total carotenoids were determined according to Askar and Treptow, (1993)

Physical parameters

Drying ratio: Drying ratio was calculated for sample after air drying according to Van –Arsdel and Copley, (1964) as follows:

$$\text{Drying ratio} = \frac{\text{Weight of fresh sample in grams before air drying}}{\text{Weight of dried sample in grams after air drying}}$$

Rehydration properties:

Rehydration properties were calculated according to Ranganna (1977),10gm samples (containing ≤18% moisture) of each treatment were immersed separately in beaker containing 100ml distilled water at room temperature (25°C±2).After fixed time (1,2,3 and 4 hours) the sample was removed from each beaker ,drained ,excess water was discarded from the surface using filter paper before weighing .Ratio of drained weight to fresh weight where calculated to express the results in terms of rehydration ratio, coefficient of rehydration and percentage of water in the rehydrated materials as follows:

$$\text{Rehydration ratio} = \frac{\text{Drained weight of rehydrated sample (WR)}}{\text{Weight of dehydrated sample (WD)}}$$

Rehydration coefficient = WR (100-MF) / (WD- WM) X100

Percentage of water in rehydrated material=WR-(WD-WM) X100/WR

Where : MF: Moisture content of sample before drying, WM: Amount of moisture present in the dried samples taken for rehydration

Microbiological examination

Total bacterial count as well as yeast and mold counts were enumerated using pour plate method on Plate Count Agar and Potato Dextrose Agar, respectively, according to the method of Collins and Lyne, (1976). Each test was performed in triplicate and results were expressed as colony forming units (CFU) per gram.

Sensory evaluation:

The final dried carrot samples obtained from osmotically dehydration followed by drying were subjected to sensory evaluation and were given three digit codes and organoleptically evaluated by ten panelists from Food Science Department, Faculty of Agriculture, Cairo University, by using a hedonic scale of 10 for odor, taste, color and texture according to Hyvonen and Torma, (1983).

Statistical analysis:

Sensory attributes were subjected to statistical analysis test by analysis of variance (ANOVA)at a significant level of 5 % and standard deviation (SD), also LSD test was calculated as described by Rao and Blane, (1985).

RESULTS AND DISCUSSION

Effect of osmotic agent concentration on TSS

During osmotic dehydration of carrot slices, the sucrose concentration (TSS) 0f osmetic solutions were measured at different immersion times till TSS reached the equilibrium state. Results in Table (1) indicate that increasing sugar solution concentration (osmotic agent) during osmotic dehydration of carrot slices from 15% to 40% accompanied with gradual decrement in TSS value of osmotic solutions. Where the TSS of 15% and40% sucrose solutions decreased by 53.2% , 35.22%(after 8hr)), respectively. Also, results in the same table showed that the TSS of sugar solution decreased gradually during consecutive increase osmosis of carrot slices of 20>40 %solution, with or without sodium metabisulphite. These results are in agreement with those of Assous, (2004)

Table 1. Changes in concentrations of sugar solutions during osmosis of carrot slices at 25°C

Time (hr)	Osmotic solution concentrations			
	C1 (15%)*	C2 (40%)*	C3 (20>40%)**	C4 (20>40%)***
0	15.6	40.6	20.5	20.9
1	12.3	38.2	19.3	19.8
2	11.3	37.1	18.4	18.2
3	10.2	36.1	18.2	18.1
4	10.1	33.1	30.1	30.4
5	8.2	32.3	29.2	29.7
6	7.4	30.2	28.4	29.3
7	7.3	29.2	28.4	29.1
8	7.3	26.3	40.0	40.6
9	7.3	26.3	39.8	40.3
10	7.3	26.3	39.8	40.3

*** Sucrose solution concentrations %**
****collective concentrations% of sucrose solution**
*****collective concentrations% of sucrose solution with adding sodium metabisulphite (0.3%)**

Effect of osmotic solution concentrations on gross chemical composition of carrot slices

Results presented in Table (2) indicate that increasing sugar concentrations of sucrose solution from 15 to 40% at room temperature (25 ± 3°C) caused a marked decrement in moisture content of osmotically dehydrated carrot slices, since moisture content reached (4.10, 3.22, 3.11, and 2.77g moisture/g dry weight) at sucrose concentrations of 15%, 40%, 20-40% and 20-40% with adding sodium metabisulphite, respectively. These results are in agreement with those reported by Nito *et al*., (2001). However, TSS of osmotically dehydrated carrot slices increased to record 19.71, 23.30 , 24.50 and 26.77 %, respectively, as well as total sugars increased when soaking in sucrose solution at concentrations of 15, 40, 20-40, 20-40 % +sodium metabisulphite, compared with 13.50 % for fresh carrot. Also, our findings indicated that increasing sugar content of osmotic solution from 15 to 40% was accompanied by an increment in reducing sugars content of carrot slices from 13.34 %, in fresh carrot to (16.13 - 16.90 % of osmotically dehydrated carrot slices), these increments could be due to hydrolysis of the total sugars especially in the presence of citric acid. From the same results, it could be noticed that increasing sugar content of osmotic solutions (15, 40 , 20-40, 20-40 % +sodium metabisulphite)was accompanied by slight changes in non-reducing sugars however, no noticeable effects were observed on crude fibers, total carotenoids and total pectin contents. These results are in the same line with those found by Phisut, (2012), who found that during extended osmotic treatment, the increase of solute concentrations results in the increase in water loss and solid gain rates. Lenart, (1992) also reported that increase in osmotic solution concentration resulted in corresponding increases in water loss to equilibrium level and drying rate. Therefore, increment of osmotic solution concentrations led to increase weight reductions. This phenomenon was attributed to the water activity of the osmotic solution which decreases with the increase in solute concentration in the osmotic solution as mentioned by Tortoe, (2010).

On the other hand, results revealed that soaking of carrot slices in different concentrations osmotic sucrose solutions (15% , 40% , 20-40% , 20-40%+sodium meta bi sulfite) slightly decreased ascorbic acid content from 53.63 mg/100g in fresh carrot slices to (50.61, 50.91 , 51.12, and 51.25 mg/100gm), respectively. The reduction in ascorbic may be due to the degradation of ascorbic acid by oxidation reaction or partial destruction *via* light (Garc´ıa-Torres, *et al*., 2009).

Table 2. Effect of osmotic solution concentrations on chemical composition of carrot slices (on dry weight basis)

Treatments	Fresh	Osmotic solution concentrations			
Constituents	**Carrot**	**C1(15%)***	**C2(40%)***	**C3(20->40%)****	**C4(20->40%)*****
Moisture %	87	80.41	76.31	75.62	73.50
TSS (%)	13.50	19.71	23.30	24.50	26.77
Acidity (as citric acid %)	10.30	11.43	11.40	11.65	12.34
Total sugars (%)	62.34	67.97	72.29	73.08	73.79
Reducing sugars (%)	13.34	16.90	16.13	16.18	16.52
Non reducing sugars (%)	49	51.07	56.16	56.90	57.27
Total carotenoids (mg/100g)	224.30	221.53	221.8	222.18	223.5
Total ash (%)	3.15	3.19	3.13	3.17	4.16
Ascorbic acid (mg/100g)	53.63	50.61	50.91	51.12	51.25
Total pectin(mg/100g)	4.45	4.55	4.52	4.56	4.72
Crude fibers (%)	12.28	12.17	12.40	12.22	12.26

*** Sucrose solution concentrations % **collective concentrations% of sucrose solution**
*****collective concentrations% of sucrose solution with adding sodium metabisulphite (0.3%)**

Effect of drying method on moisture content and drying parameters

Results in Table (3) showed that increasing sucrose concentrations (SC) from 15 to 40% at room temperature (25±3°C) caused a marked decreased in drying ratio of osmo-dried carrot slices (by two drying methods), compared with control sample, since drying ratio recorded (6.52:1-6.17:1), for dried carrot control samples by solar sun hood and solar cabinet driers, respectively, while, it diminished to a range of (3.19:1 – 2.86:1), for osmo-dried carrot samples with solar sun hood and cabinet driers at different concentration of sucrose solution. No significant differences ,on drying ratio, were recorded among osmo-dried carrot samples concerning drying methods (P≥0.05). Furthermore, no significant differences were noticed with regard to sodium metabisulphite addition. These results in agreement with those of Assous, (2004).

The rehydration ratio of control dried carrot and osmo dried carrot by different drying methods also are presented in the Table (3), results illustrated that the rehydration ratio was (5.17:1-5.66:1) of control dried carrot (solar sun hood and cabinet drier, respectively), while it reached to (2.99:1-3.29:1) of osmo dried carrot(15%) by sun hood and cabinet drier, respectively. Also, it reached to (2.86:1-2.68:1)of osmo dried carrot at 40% SC) ,(3.00:1 - 3.05:1) of osmo dried carrot 20->40%) and (3.22:1-3.11:1)of osmo-dried carrot 20-40 % SC+ sodium metabi sulphite) by sun hood and cabinet driers, respectively. From the abovementioned data it could be observed that osmoses process improved drying parameters of dried carrots.

The rehydration coefficient of control dried carrot and osmo dried carrot ,by different drying methods, are also presented in the Table (3), results show that the rehydration coefficient was 0.629, 0.675of control dried carrot (sun hood and cabinet drier, respectively), while it reached 0.724 ,0.779 of osmo dried carrot(15%) by sun hood and cabinet drier, respectively. Also, it reached0.82,0.77 of osmo dried carrot at 40% SC , 0.845&0.859 of osmo dried carrot 20->40% and 0.861 &0.851of osmo-dried carrot 20-40 % SC+ sodium metabisulphite) by un hood and cabinet driers, respectively. From the above mentioned data, it could be observed that osmoses process improved drying parameters of dried carrots.

Table 3. Effect of drying method on the moisture content, drying ratio and rehydration ratio of Osmosis carrot

Drying time (hr)	Moisture content ***									
	Control carrot		Osmosis carrot slices at different sucrose concentrations							
			C1(15%)*		C2(40%)		C3(20-40%)**		C4(20-40)****	
	Sun Hood	Solar cabinet	Sun hood	Solar cabinet	Sun hood	Solar cabinet	Sun hood	Solar cabinet	Sun hood	Solar cabinet
0	6.69	6.69	4.10	4.10	3.22	3.22	3.10	3.10	2.77	2.77
1	5.11	5.31	3.39	3.57	2.54	2.51	2.32	2.44	2.31	2.32
3	4.20	4.22	1.71	1.83	2.33	2.04	1.87	1.78	1.96	1.95
4	2.77	3.48	0.881	0.742	1.63	1.42	0.964	0.976	1.11	1.38
5	1.92	2.98	0.684	0.641	1.28	0.984	0.671	0.753	0.923	0.922
6	1.12	1.23	0.345	0.352	0.946	0.818	0.350	0.543	0.761	0.781
7	0.833	0.940	0.254	0.273	0.754	0.766	0.254	0.368	0.531	0.565
8	0.671	0.765	0.197	0.215	0.561	0.531	0.201	0.266	0.315	0.266
9	0.441	0.565	0.192	0.173	0.256	0.323	0.183	0.198	0.171	0.184
10	0.363	0.342	--	--	0.177	0.258	--	0.182	--	--
11	0.223	0.225	--	--	--	0.178	--	--	--	--
12	0.168	0.161	--	--	--	--	--	--	--	--
Drying ratio	6.52 ^{a}:1 ± 0.92	6.17 ^{a}:1 ± 0.58	3.88 ^{b}:1 ± 0.53	3.69 ^{b}:1 ± 0.54	3.19 ^{b}:1 ± 0.60	3.23 ^{b}:1 ± 0.57	3.78 ^{b}:1 ± 0.58	3.13 ^{b}:1 ± 0.58	3.21 ^{b}:1 ± 1.01	2.86 ^{b}:1 ± 0.52
Rehydration ratio	5.17 ^{a}:1 ± 0.58	5.66 ^{a}:1 ± 0.04	2.99 ^{b}:1 ± 0.58	3.29 ^{b}:1 ± 0.60	2.86 ^{b}:1 ± 0.56	2.68 ^{b}:1 ± 0.53	3.00 ^{b}:1 ± 0.55	3.05 ^{b}:1 ± 0.57	3.22 ^{b}:1 ± 0.58	3.11 ^{b}:1 ± 0.73
Rehydration coefficient	0.629^{g} ±0.62	0.675f ±0.67	0.724e ±0.72	0.779d ±0.77	0.823c ±0.82	0.772d ±0.77	0.845b ±0.84	0.859a ±0.85	.861a ±0.85	.851a ±0.85

*** Sucrose solution concentrations % **collective concentrations% of sucrose solution**
******collective concentrations% of sucrose solution with adding sodium metabisulphite (0.3%)**
*****Moisture content is calculated as (g moisture / g dry matter).**
Mean values within rows followed by the same letter are not significantly different at 0.05 % level.

Effect of drying methods on minerals content of carrot slices

Results in Figs. (3and 4) showed that potassium was the major element in fresh and dried carrot. Although, results in Fig. 3&4 showed that the potassium level in dried carrot (control) with solar sun hood was (344.8 mg/100gm dry weight) and in osmo solar sun hood drier (345 mg/100gm dry weight). These values were higher than that of samples dried with solar cabinet drier (control) (310.68 mg/100gm dry weight)and (334.5and 339.78 mg/100gm dry weight) in osmo solar cabinet drier (C2 40% and C420-40%+sodium metabisulphiate). Results in Figs(3&4) showed that sodium and calcium level were (67.54, 66.49 mg/100gm) in fresh carrot reached (66.3-66.1 mg/100gm) in dried carrot (control) with solar sun hood drier and (65.2-65.1 mg/100gm) in dried carrot (control) with solar cabinet drier .

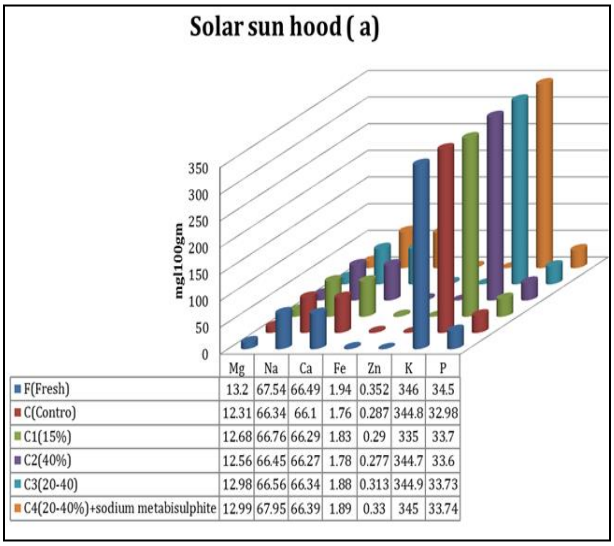

Fig. 3. Effect of osmotic solution concentration and drying method (solar sun hood) on minerals content of carrot slices (mg/ 100g, on dry weight basis)

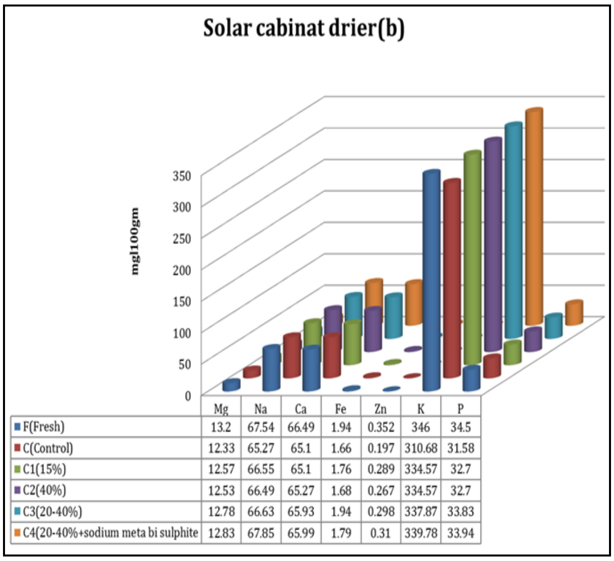

Fig. 4. Effect of osmotic solution concentration and drying method (solar cabinet) on minerals content of carrot slices (mg/ 100g, on dry weight basis)

Results in Figs. (3and4) illustrated that iron ,zinc , magnesium and phosphor contents of fresh carrot were (1.94, 0.352, 13.2 and 34.5 mg / 100gm dry weight) , respectively compared to (1.76, 0.287, 32.98 and 12.31 mg / 100gm dry weight) in dried carrot (control) with solar sun hood and (1.66,0.197,31.58 and12.33) in dried with solar cabinet drier(control) .The same results in Figs. (3&4) showed that iron ,zinc , magnesium and phosphor contents mg /100gm dry weight of osmo dried carrot with solar sun hood ranged between (1.78-1.89 iron),(0.277 – 0.330zinc),(12.56-12.99 magnesium) (33.60-33.74phosphor) compare to (1.68-1.79 iron), (0.267-0.310 zinc), (12.53-12.83 magnesium) and (32.7-33.94 phosphorus) in osmo solar cabinet drier. These results are in agreement with those of Olalude, *et al.* ,(2015).

Effect of osmotic solution concentration and drying methods on total carotenoids of carrot during storage

The results in Table (4) showed that total carotenoids of fresh carrots was affected by drying process since it decreased by23.23% and 25.32% immediately after drying by solar sun hood and solar cabinet, respectively. The lowest decrease in total carotenoids was detected in treatment C4(decrement percents were0.89% and2.40% for carrots dried with sun hood and cabinet dryer, respectively, while the highest decrease of total carotonoides was noticed in treatment C2(decrement percents were4.72% and5.17% for carrots dried in sun hood and solar cabinet, respectively. Total carotenoids decreased as time of storage (25°C) increased in all samples .The loss of total carotenoids was very high in the control sample (unblanched and no osmosis).

Table 4. Effect of osmotic solution concentration and dry methods on total carotenoids (mg /100gm dry sample) of carrot during storage at room temperature.

Storage period Months Treatment	Carotenoids(mg/100gm)					
	3			6		
	Sun hood	solar cabinet	Sun hood	solar cabinet	Sun hood	Solar cabinet
C	172.2	167.5	165.5	154.6	160.3	151.9
C1(15%)*	216.5	213.6	213.3	211.9	210.8	207.1
C2(40%)*	213.7	212.7	211.9	210.8	208.5	206.7
C3(20-40%)**	220.8	216.9	217.4	214.6	214.5	211.5
C4(20-40)***	222.3	218.9	219.3	216.9	216.9	213.5

Total carotenoids for fresh carrots was 224.3mg/100,(on dry weight basis).
Moisture of fresh fruit was 87%] C=Control without additives
*** Sucrose solution concentrations %**
****collective concentrations% of sucrose solution**
*****collective concentrations% of sucrose solution with adding sodium metabisulphite (0.3%)**

The percentage loss of total carotenoids at the end of storage period(6months)at room temperature were(6.91% - 9.31%) in solar sun hood and solar cabinet drier , respectively. However, loss of total carotenoids was greater in the osmo dried carrot by solar cabinet (3.04% of osmo dried carrot15%) ,(2.80% of osmo dried carrot at 40% SC) ,(3.87% of osmo dried carrot 20->40%)and(2.46 %of osmo-dried carrot 20-40 % SC+ sodium metabi sulphite)compared with osmo dried carrot by solar sun hood (2.63% of osmo dried carrot15%) ,(2.43% of osmo dried carrot at 40% SC) ,(2.85 of osmo dried carrot 20->40%) and (2.42 %of osmo-dried carrot 20-40 % SC+ sodiummetabi sulphite)stored for 6months at room temperature. It could be concluded that osmoses process led to minimize loss of total carotonoides during storage process. The loss in the total carotenoids content during storage period might be due to the moisture content which might affect the stability of total carotenoid. These results are in agreement with those of Tawfik ,(2001)and Assous , (2004)

Effect of storage time on microbial count of dried carrot slices

Results illustrated in Table (5) showed that total bacterial count of fresh carrot slices was 1.4 CFU $X10^2 .g^{-1}$. It was observed that total bacterial count increased to 6.00 CFU $X10^2 .g^{-1}$, in control solar sun hood dried, while it reached 3.00- 4.90 CFU $X10^2 .g^{-1}$, in the osmo- solar sun hood dried carrot slices. On other hand, our findings showed that total bacterial count ranged between 3.10- 4.60 CFU $X10^2 .g^{-1}$, in the osmo-solar cabinet dried carrot slices, at different sucrose concentrations. The produced dried samples are bacteriologically accepted according to the specifications of the Egyptian Standards (2005), for dehydrated carrot. Results in the same Table indicated that extending storage time to 6 months caused an increase in total bacterial count of the dried products. This increment was mainly due to gradual increase in the moisture content during storage. On the other hand, results indicated that yeast and mold counts of fresh carrot was 0.65 CFU $X10^2 .g^{-1}$.

However their counts reached, 0.23 and 0.25 CFU $X10^2 .g^{-1}$, of sun hood dried and solar cabinet dried carrot slices, respectively. Extending storage time up to 6 months was accompanied by gradual increase in yeast and mold counts for both the sun hood dried and solar cabinet dried carrot slices 0.60 and 0.5 CFU $X10^2 .g^{-1}$, respectively. No fungal count was recorded for the osmo- sun hood dried and solar cabinet dried carrot even after 6 months of storage. It is interested to report that in all cases the dried samples didn't exceed the microbial cells/g, for TBC and 100 cells/g, for fungal count as presented in onset of spoilage of Egyptian Standards, (2005). This finding could be due to lower water activity, which leads to more stability of the food products, in addition to the presence of good sanitary conditions during different processing steps as well as packing and low moisture content of dehydrated carrot samples. Our finding are in agreement with Akbarian, *et al.* ,(2013), who stated that low water activity (due to low water activity by sugar gain and water loss), reduced chemical reaction and the growth of toxin-producing micro-organisms in food. Product obtained by osmotic process is more stable than untreated fruit and vegetables during storage.

Table 5. Total bacterial count (CFU X $10^2 .g^{-1}$) and fungal count of osmosis- dried carrot slices (sun drying an solar drying) during storage for 6 months at 25° C

Storage time (months) Treatments		Total bacterial count Storage time (mo.) 0	3	6	Yeast and mold counts Storage time (mo.) 0	3	6
	Control without osmosis	6.00	8.07	9.07	0.23	0.34	0.60
Osmo-sunhood drying	15 % Sucrose	4.90	6.59	7.50	-	-	-
	40 % Sucrose	3.90	5.23	6.50	-	-	-
	20-40 % Sucrose	3.50	5.08	6.20	-	-	-
	40 % Sucrose + sodium metabisulphite	3.00	4.04	5.10	-	-	-
	Control without osmosis	6.70	7.75	10.8	0.25	0.59	0.50
Osmo-solar cabinat drying	15 % Sucrose	4.6	6.02	7.80	-	-	-
	40 % Sucrose	4.30	5.29	6.32	-	-	-
	20-40 % Sucrose	3.90	5.47	6.05	-	-	-
	40 % Sucrose + sodium metabisulphite	3.10	4.80	5.09	-	-	-

TBC of control sample 1.4 CFU X $10^2 .g^{-1}$ and Fungal count 0.65 CFU X $10^2 .g^{-1}$

Sensory evaluation of the dehydrated carrot:

A sensory evaluation method adopted for the analysis of acceptability of the osmotic dehydrated carrot slices with the help of a hedonic scale. The data obtained from sensory evaluation are shown in Table (6). Results indicated that taste score of rehydrated carrot slices samples which prepared with osmo solution C3,C4 (20-40%) with or without adding sodium metabisulphite and dried with solar sunhood dryer was significantly higher than those of rehydrated carrot which prepared by other concentrations (C1 15% and C2 40%) at zero time and till the end of storage period (6monthes). Also, no significant differences were recorded between rehydrated carrot slices C3, C4 (20-40% with or without adding sodium metabisulphite at zero time. It is noteworthy that color of any food item is an important visual criterion which has received top attention in food industries and consumers. However, any changes in color could serve as an indicator of microbial and enzymatic qualities as well as bad processing. It could be observed that rehydrated carrot slices prepared with osmo solution C4 (20-40 with adding sodium metabisulphite) and dried

With solar sun hood was significantly higher ($p \geq 0.05$)than those of rehydrated carrot slices which prepared with other concentrations (C1,C2andC3)at zero time and during storage (6 months).

With regard to texture, results in Table (6) indicated that texture of rehydrated carrot slices which prepared with osmo solution C3 (20-40%) recorded the higher significant score versus those of rehydrated carrot which prepared with osmo solution (C1,C2and C4) and dried with solar sun hood at zero time and during storage. Our findings are in agreement with those found by Rastogi, *et al.* (2005), who showed that the sugar to acid ratio can enhance the stability of pigments and texture during drying and storage. However, Phisut (2012) reported that sugar uptake of low molar mass saccharides (glucose, fructose and sucrose) is high due to the maximum diffusion rate of molecules, which produce greater sensory resemblance between the dehydrated and natural products.

Also, results in Table (6) indicated that odor score of rehydrated carrot slices which prepared with, osmo solution C3 (20-40%) was significantly higher than those of rehydrated carrot which prepared with osmo solution (C1, C2 and C4) and dried with sun hood at zero time and during storage.

Our findings are in harmony with those of Tortoe, (2010), who ascertained that heat damage to color and flavor are minimized, as products are not subject to a high temperature over an extended period of time, where discoloration of the fruit by enzymatic oxidative browning is prevented by the high concentration of sugar surrounding the fruit pieces. They also added that the process achieves sweeter products compared with conventionally dried products. In general, fruits and vegetables osmotically dehydrated become very attractive for direct use due to their chemical composition as well as physico-chemical properties.

Also, results in Table (6) Regarding the overall acceptability perception score of rehydrated carrot slices which prepared with, osmo solution C3 (20-40%)andC4(20-40+sodium metbisulphite) recorded the higher significant scores than other rehydrated carrot which prepared with osmo solution (C1-15%,and C2(40).

Results in Table (7) showed that taste scores of rehydrated carrot slices which prepared with, osmo solution C3 (20-40%) and C4(20-40+ sodium metabisulphite) and dried with solar cabinet drier were significantly higher than those of osmo solutionC1 and C2(15% and40%) at zero time and during storage period (6months).The same table showed that, rehydrated carrot slices prepared with osmo solution C4(20-40 with adding sodium metabisulphite) and dried with solar cabinet drier was significantly higher (p ≥0.05)than those of rehydrated carrot slices which prepared with other concentrationsC1,C2,andC3 (15%,40%,20-40%) at zero time and till the end of storage period. Sodium metabisulphite was added to fruit and vegetable to prevent either discoloration or quality deterioration in dried fruit and vegetable and to improve the storage stability. On other hand, results in Table (7) indicated that texture of rehydrated carrot slices which prepared with osmo solution C3 (20-40%) and C4(20-40%+ sodium metabisulphite) recorded higher significant score than those of rehydrated carrot which prepared with osmo solution C1&C2(15%and40%) and dried with cabinet drier at zero time and during storage.Also, results in Table (7) indicated that odor score of rehydrated carrot slices which prepared with, osmo solution C3 (20-40%) was significantly higher than those of rehydrated carrot which prepared with osmo solution C1,C2 and C4(15%, 40%, 20-40%+ sodium metabisulphite) and dried with solar cabinet at zero time and during storage period.

Also data in Table (7) observed that, overall acceptability perception scores of rehydrated carrot slices which prepared with, osmo solution C4 (20-40% with adding sodium metabisulphite) recorded the higher significant score than those rehydrated carrot which prepared with osmo solutionC1,C2 and C3 (15%,40%,20-40%)

Finally, it can be concluded that the color, taste, odor ,texture and overall acceptability recorded a high rating in a consecutive sucrose solution concentration (20-40%).

Table 6. Sensory evaluation of rehydrated carrot slices dried with sunhood drier during storage at room temperature 25 ± 3 ° C

Treatments	Storage periods (months)														
	Taste			Color			Texture			Odor			Overall acceptability		
	0	3	6	0	3	6	0	3	6	0	3	6	0	3	6
Control	7.4 c	6.2 c	5.4 c	5.8 d	5.4 d	5.2 c	6.0 d	5.6 c	5.2 c	6.6 b	6.2 c	5.4 b	7.6c	6.9c	6.8c
	±0.55	±0.45	±0.54	±0.45	±0.55	±0.45	±0.00	±0.55	±0.45	±0.55	±0.45	±0.55	±0.69	±0.73	±0.63
C1*	7.6 c	7.2 b	6.6 b	6.6 c	6.6 c	6.2 b	7.4 c	7.4 b	7.2 b	7.6 a	7.2 b	6.8 a	8.5b	8.2b	7.7b
(15%)	±0.55	±0.45	±0.54	±0.54	±0.55	±0.45	±0.55	±0.45	±0.45	±0.55	±0.45	±0.45	±0. 527	±0.63	±0.483
C2*	8.4 b	7.6 b	6.8 b	7.6 b	7.2 bc	6.6 b	7.6 bc	7.4 b	7.4 b	7.6 a	7.4ab	6.8 a	8.8b	7.9b	7.8b
(40%)	±0.55	±0.55	±0.45	±0.55	±0.45	±0.55	±0.55	±0.55	±0.55	±0.55	±0.55	±0.45	±0.42	±0.56	±0.72
C3	9.2 a	9.2 a	8.2 a	8.0 c	7.6 b	6.8 b	8.2 ab	8.0 ab	7.4 b	8.2 a	8.0 a	6.8 a	9.5a	9a	8.8a
(20-40%)**	±0.45	±0.45	±0.45	±0.00	±0.55	±0.45	±0.45	±0.00	±0.55	±0.45	±0.71	±0.45	±0.52	±0.47	±0.42
C4	9.2 a	8.8 a	8.4 a	9.4 a	9.4 a	8.8 a	8.4 a	8.4 a	8.2 a	8.2 a	7.8 ab	6.5	9.6a	9.1a	8.7a
(20-40%)***	±0.45	±0.45	±0.55	±0.55	±0.55	±0.45	±0.55	±0.55	±0.45	±0.45	±0.55	a±0.55	±0.51	±0.56	±0.48

Mean values within columns followed by the same letter are not significantly different at 0.05 % level.
C = Control without additives ** Sucrose solution concentrations % **collective concentrations% of sucrose solution
*****collective concentrations% of sucrose solution with adding sodium metabisulphite (0.3%)**

Table 7. Sensory evaluation of rehydrated carrot slices dried with solar cabinet drier during storage at room temperature 25 ± 3 ° C

Treatments	Storage periods (months)														
	Taste			Color			Texture			Odor			Over all		
	0	3	6	0	3	6	0	3	6	0	3	6	0	3	6
Control	6d	5.6d	5.1d	6.0d	5.3e	5.1e	5.9d	5.4d	5.1d	6.0c	5.3e	5.0d	7.5d	7.1c	6.7b
	±0	±0.51	±0.31 d	±0	±0.48	±0.31	±31	±0.51	±0.31	±0	±0.48	±0.0	±0.52	±0.56	±0.82
C1*	7.1c	6.8c	6.3c	8.6c	6.6d	5.9d	6.6c	6.3c	5.7c	6.4c	6.0d	5.5c	8.7c	8.4b	8.2a
(15%)	±0.56	±0.78	±0.48	±0.42	±0.51	±0.31	±0.51	±0.48	±0.48	±0.51	±0	±0.52	±0. 48	±0.51	±0.42
C2*	8.7b	7.9b	7.3b	8.1b	7.5c	7.1c	8.4b	7.9b	7.2b	8.4b	7.6c	7.0b	9.0bc	8.6 b	8.4a
(40%)	±0.48	±0.56 b	±0.48	±0.31	±0.52	±0.31	±0.51	±0.31	±0.42	±0.51	±0.51	±0.00	±0.00	±0.51	±0.84
C3	9.2a	8.7	8.2a	8.3b	8.3b	7.7b	8.9a	8.6a	8.1a	9.0a	8.5a	7.9a	9.4ab	9.1a	8.8a
(20-40%)**	±0.63	±0.48	±0.42	±0.67	±0.67	±0.67	±0.56	±0.51	±0.56	±0.74	±0.52	±0.31	±0.51	±0.56	±0.63
C4	8.8ab	8.5a	8±a	9.6a	9.4a	8.9a	8.8ab	8.2ab	7.7a	8.6ab	8.1b	7.7a	9.7a	9.1a	8.7a
(20-40%)***	±0.63	±0.52	0.47	±0.51	±0.51	±0.31	±0.42	±0.42	±0.48	±0.51	±0.31	±0.48	±0.48	±0.31	±0.67

Mean values within columns followed by the same letter are not significantly different at 0.05 % level.
C = Control without additives ** Sucrose solution concentrations % **collective concentrations% of sucrose solution
*****collective concentrations% of sucrose solution with adding sodium metabisulphite (0.3%)**

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تحسين جودة الجزر المجفف باستخدام التجفيف الاسموزي والطاقه الشمسيه

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في هذا البحث تم دراسة تاثير التجفيف الاسموزي و التجفيف بالطاقه الشمسيه علي جوده شرائح الجزر من حيث التركيب الكيميائي –قياسات التجفيف –العد الكلي الميكروبي – والخصائص الحسيه و ذلك بعد التجفيف مباشرة وخلال فترات التخزين علي درجه حراره الغرفه (25±3 °م) لمدة 6 اشهر حيث تم نقع شرائح الجزر في محاليل سكروز بتركيزات مختلفه المعاملة الاولي C1(15% سكروز) ، المعاملة الثانيةC2 (40%) ، المعاملة الثالثة C3 (20-40%)، و المعاملة الرابعة C4(20-40% سكروز مع اضافة صوديوم ميتا ثنائي الكبريتيت بنسبة 0.3%) وعقب معاملة التجفيف الاسموزي السابقة تم التجفيف بنوعين من المجففات الشمسيه (solar cabinet & sunhood) واوضحت النتائج ان المعامله C4 نجحت في ازاله اكثر من 45%من المحتوي الرطوبي في الجزر الطازج كما نجح التجفيف السموزي في خفض نسبه التجفيف في الجزر من 1:6.52 الي 1:86.2كذلك كان ادت معاملة التجفيف الاسموزي الي زيادة تشرب الماء عن عينات شرائح الجزر غير المعامل اسموزيا ومن ناحيه اخري لم تؤثر المعاملة بالمحاليل الاسموزيه اوطرق التجفيف علي محتوي المعادن في الجزر (الكبري او الصغري). كذلك اوضحت النتائج ان نسبه الفقد في الكاروتينويدات زادت نتيجة عملية التجفيف في حين ان اقل انخفاض في محتوي الكاروتينيدات سجل للمعاملة الرابعة بكلا طريقتي التجفيف المستخدمتين. كما اوضحت النتائج ان الجزر المعامل بالتجفيف الاسموزي كان بالعد الكلي للبكتريا مقبولا طبقا للمواصفه القياسيه المصريه ,علاوة علي ذلك اظهرت النتائج ان المعامله) C3 حققت اعلي نتائج من حيث الصفات الحسيه (من حيث اللون- الطعم – الرائحه –القوام – القبول العام). و بالتالي يمكن ان نستنتج ان التجفيف االسموزي باستخدام محاليل السكروز يؤثر تاثيرا ايجابيا علي نقل المواد الصلبه ممايؤدي الي زيادة فقد الماء واختزال الوزن الي جانب ان التركيز المتدرج 20-40%مع التجفيف الشمسي ادي الي اطاله فترة صلاحية شرائح الجزر مع جودة الصفات الحسيه من حيث اللون و الطعم و الرائحة و القوام, و ذلك بعد 6 اشهر من التخزين علي درجه حراره الغرفه 25±3 °م.

الكلمات الافتتاحية: الجزر ، التجفيف الاسموزي ، التجفيف الشمسي ، نسبة التجفيف ، الصفات الحسية .