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EFFECT OF OSMOTIC AND CONVENTIONAL DEHYDRATION ON QUALITY OF SOME FRUITS AND VEGETABLES

Zaki , Sahar M.
Food Tech. Res. Inst., Agric. Res. Center , Giza ,Egypt

ABSTRACT

This study deals with the effect of using osmotic pr-etreatment technology applied to plant materials prior to osmotic dehydration ((O.D)) and the conventional drying((C.D)) on some physicochemical and sensory characteristics of apples , papaya fruits and sweet potatoes . The osmosis syrups were sucrose ,high fructose corn syrup (HFCS) and a mixture of sucrose + HFCS (1:1) . Physicochemical properties of apples , papaya fruits and sweet potatoes were evaluated. The quality attributes of osmo –dehydrated ((O.D)) and convectional dried ((C.D)) cubes of apples , papaya fruits and sweet potatoes were evaluated just after processing and during storage for 6 months at ambient temperature . Results indicate that osmo-dried ((O.D)) samples recorded higher values of moisture , sugars , total acidity but lower pectin contents compared to the convention dried ((C.D)) samples . Also, the retention of ascorbic acid and β– carotene was higher in (O.D) samples which means higher nutritive value . The positive effect of osmotic pretreatment on the physical properties of different dried samples was found . The drying ratio , rehydration ratio (R.R) , the texture (firmness) and drying time were lower in (O.D) samples compared with the (C.D) samples . The reduction in Hunter color parameters L , a and b was higher in (C.D) samples than the (O.D) ones . The effect of storage on different quality parameters were more evident in the C.D samples than the (O.D) ones . The evaluation of sensory characteristics indicated that the (O.D) samples gained the highest scores while there were high significant differences found between the (O.D) and (C.D) samples . slight significant differences were found between the different used syrups of osmosis .

Keywords: apples, papaya fruits, sweet potatoes, osmotic dehydration , quality attributes, storage .

INTRODUCTION

Food stuff quality and the cost of their manufacturing are the most important factors to be considered when choosing a food preservation method. Water removal or making water hard to access for microbial development is the main task during food pre-servation (Lenart, 1996). Dried food, especially fruits and vegetables can be stored and transported at a relatively low cost . However , water removal leads to a serious decrease in the nutritive and sensorial values (Lenart, 1996) .

In the course of the last few years a number of activities have been undertaken in order to apply drying for preservation of food (especially of solid food) as widely as possible .

Osmotic dehydration is a useful technique that involves product immersion in a hypertonic aqueous solution leading to a loss of water through the cell membranes of the product and the subsequent flow along the inter-cellular space before diffusing into the solution (Serno *et al.*, 2001). The osmotic dehydration consists of the removal of water from food without the phase change. The process of preliminary treatment before the convection drying is particularly advantageous as far as the quality of the given food product is concerned . Fruits and vegetables dehydrated by osmosis became very attractive for direct use due to their chemical composition and physico-chemical properties (Lenart and Cerkowniake, 1996). As part of the process of fruit and vegetables concentration , after osmotic dehydration, a complementary method such as conventional drying, freezing or pasteurization , must be used (Sankat, *et al.* ,1996). Lenart, (1991), mentioned that the preliminary treatments of fruits and vegetables affect the chemical composition and physical properties of the obtained dried products. Sulphiting does not cause such a change of the physico-chemical properties of dried products, nevertheless , it is estimated negatively due to the toxicity of sulphur components (Lerici *et al.*, 1985). The osmotic process has received considerable attention as a pre-drying treatment so as to reduce energy consumption and improve food quality (Karathanos, *et al.*, 1995, Sereno *et al.*, 2001 and Rastogi and Balasubramanian, 2006). At the same time , the osmo-concection drying narrows the range of the applied inactivation ways of the enzymes such as sulphiting of fruits or blanching of vegetables (Lerici *et al.*, 1983). Osmotic dehydration in solutions of sucrose and polysaccharides increase their share in the chemical composition of dried product, decreasing the content of monosaccharides and acids. The main advantages of osmotic dehydration process, as a pre-treatment, are the stabilization of color parameters , reducing the non – enzymatic browning reactions and often improves fruit product color (Krokida, *et al.* ,2000 and Rodrigues , 2003). Many authers have studied the different aspects of osmotic dehydration : The solutes to be employed, the influence of process variables on drying behaviour, the opportunity to combine osmosis to other stabilizing techniques and the quality of final products (Lenart and Cerkowniak 1996 and Rodrigues *et al.* 2003). Concentrated sucrose solutions (50-70 °Brix) are the most commonly used. Commercial syrups as a ready -to- use osmotic agent were studied. Bolin *et al.* (1983) observed the higher diffusivity of high fructose corn syrup (HFCS) compared to sucrose during apple osmotic dehydration. The quantity and the rate of water removal depend on several variables and processing parameters. In general , it has been shown that the weight loss in osmoses fruit is increased by increasing solute concentration of the osmotic solution, immersion time, temperature, solution / food ratio, specific surface area of the food and by using a low pressure system (Lenart 1991, Dobricevic and Miletic 2000, Genina - Soto *et al.* 2001).

The aim of this work was to investigate the effect of osmo- air drying and conventional air drying methods on some quality indices of partially dried apples ,papaya fruits and sweet potato pieces (cubes) as a trial to obtain an end product suitable for both direct consumption and as an ingredients for novel food products . The effect of using different osmosis solutions , i.e (sucrose, high fructose and combined sucrose + HFCS 1:1) on the physico-chemical and sensory characteristics of different used materials was also studied . Also, the effect of storage for 6 months at ambient temperature~25 °C on some physico- chemical and sensory properties for different used materials will be evaluated .

MATERIALS AND METHODS

Materials

Fresh fruits and vegetables namely, apple fruits (*Malus domestica*) Anna v. , papaya fruits (*Carica papaya* L.), Cylon Red v. , and sweet potatoes (*Ibomea batatas* L.) 17 / 8 with orange color were brought at maturity stage from the Hort. Res. Inst., Ministry of Agric . High fructose corn syrup (HFCS) was obtained from the National Co. for Maize Products, Cairo, Egypt .

Citric acid and other chemicals were of analytical grade from El-Gomhuria Company , Cairo , Egypt

Methods :

Osmotic dehydration (OD) : All fruit were washed , peeled , cored (in case of apple) and cut into cubes (0.8 – 1.0) cm . Osmotic dehydration was carried out in sucrose solution (65% Brix) , High fructose corn syrup (HFCS) , (67.5)% and a mixture of sucrose : HFCS (1:1 w/w) ~ 65% Brix , 1% citric acid were added . Osmotic dehydration was performed at 30 ˚C and at the weight ratio of the raw material to solution as 1: 4 w / w . Dehydration time was in the range of 0-20 hours with continuous mixing of the system according to the method described by Lenart(1991) . After osmotic dehydration , samples were washed with water and left on screen to drip for 5 min. The surface of cubes were then dried with filter paper, then the cubes were dried convectionally

Convection drying ((C.D)) : Untreated (raw) and osmo-dehydrated apples , papaya fruits and sweet potato cubes were dried to constant weight . The drying process was carried out in air- circulated oven at 60˚ C at the beginning and at 50˚ C at the end of the drying process . All the above mentioned samples were packed in polyethylene bags and stored at ambient temperature(25 ˚C) for 6 months .

Analytical Methods :

Physicochemical analysis : Moisture , crude fibers , crude protein , ether extract , ash , ascorbic acid, total acidity (as citric acid), pH value and sugars contents were determined according to the methods of AOAC (1995). β-carotene was determined according to Luh *et al.* (1958). Pectin content was determined as described by Lees (1975). Drying ratio was calculated for samples after air drying according to Van- Arsdel and Copley (1996) as follows :

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

Rehydration ratio (RR) was determined according to the method described by Ranganna (1979) . Color was measured according to Hunter – method as described by Karmer and Twigs (1970) using Hunter Lab Model D-25 color and color difference meter , the L, a and b values were recorded .

Firmness : Shear force (lb/in^2) was used to determine firmness by using testing machine model No. AIM339-3 (Largo, Florida 33543, USA) according to the method described by Shannon and Baurene (1971) .

Sensory evaluation :

Sensory evaluation was performed on different dehydrated samples of apples, papaya fruits and sweet potatoes according to the method of Ranganna (1979), immediately after drying and during storage for 6 months at room temperature. Ten panelists were asked to evaluate color, taste ,odor and texture of each sample on a numerical scale from 1 to 10 for each parameter .

Statistical analysis:The collected data of sensory evaluation were statistically analyzed by the least significant differences (L.S.D) at the 5% level of probability procedure according to Sendecor and Cochran (1982) .

RESULTS AND DISCUSSION

Physicochemical properties of raw materials :

The data for some physicochemical analysis of fresh apples, papaya fruits and sweet potatoes are shown in Table (1). The highest percentage of moisture content was recorded for papaya fruits, meanwhile the fresh sweet potato is recorded the lowest percentage. Also, the papaya fruit recorded the highest values for sugars, ash and ether extract , compared with those of apples and sweet potatoes. Meanwhile , the apple fruits recorded the highest values for ascorbic acid, crude fibers and total acidity. These results are in agreement with those of El- Sharony (2001), Rodrigues *et al.* (2003) and Assous (2004).

Concerning the β-carotene content of the different raw materials shown in Table(1) , the results show that papaya fruits recorded the highest values (18.20mg/100g dwb) followed by sweet potatoes (12.40mg/100g dwb) and the lowest values were 0.20mg/100g dwb in apple fruits. So, the calculated Retinol equivalent (R.E) recorded the highest values in papaya fruits (30006.0) followed by sweet potatoes (2070.8). Meanwhile, the lowest value in apple fruits (33.4R.E). In this concern , the papaya fruits and sweet potatoes could supply about (2 ~ 3 times) of the human daily requirements of RE, being recommended to be 1000 RE of "RDA " by the dietary allowances Anon (1980). These results agree with those of Chandrica *et al.* (2003), who mentioned that papaya fruits are one of the main fruits recommended for vitamin A deficiency in Sirlanka. Moreover , Savage and Bolitho, (1993) , reported that the β – carotene content of orange flesh type sweet potatoes compares well to that of carrots , a renowned source of β – carotene . Results in Table (1) represents also the color measurements by using Hunter color Lab measure L , a and b values . Regarding the results in Table (1) a relationship could be detected between the carotenoid content and Hunter color parameters of raw materials . So, it could be noticed that the papaya fruit recorded the highest values of " + a " (17.15) (which means redness) and" + b" (24.70) (which means yellowness), followed by sweet potatoes. Meanwhile , the apple fruits recorded the lowest values for a, b, and the highest values for " + L" which refers to lightness . These results are in agreement with Ibrahim, *et al.* (1994), Rodrigues, *et al.* (2003) and Assous (2004).

Table (1): Physicochemical characteristics of fresh apples , papaya fruits and sweet potatoes on dry weight basis

Characteristics	Apples	Papaya	Sweet potatoes
Moisture content %	84.62	88.10	74.15
T. S %	15.38	11.90	25.85
Total sugars %	70.12	73.10	14.09
Reducing sugars %	42.10	66.15	1.45
Non Reducing sugars %	28.02	6.95	12.54
Ash %	2.15	5.39	4.10
Protein %	2.80	4.52	7.32
Ether extract %	1.95	2.60	1.40
Pectin %	6.50	4.59	2.30
Crude fiber %	7.80	5.20	6.70
β – carotene (mg/100g)	0.20	18.20	12.40
R.E*	33.40	3006.0	2070.0
Ascorbic Acid (mg/100g)	160.00	85.90	30.20
Total Acidity %	2.15	0.87	1.10
pH value	3.20	6.10	5.35
Hunter color L	65.60	61.20	60.30
a	-2.68	17.15	15.12
b	18.93	24.70	20.10

* : R.E : Retinol Equivalent = 0.167 x μgm β-carotene

Chemical properties of dried apples , papaya fruits and sweet potatoes :

Data in Table (2) represent some chemical properties of dried apples , papaya fruits and sweet potatoes which were dried by hot air drying or those pretreated with osmotic solutions (sucrose ,HFCS , or sucrose + HFCS) and then dried by hot air drying method. Concerning these results, it could be found that the moisture content of different air dried samples were lower than those of osmo –dried samples. Moisture content of air- dried apples, papaya fruits and sweet potatoes were 12.50, 15.20 and 11.60 % respectively . Meanwhile the average ratio of moisture content of osmo-dried apple samples ranged between 14.00 _ 14.60 % , for papaya fruits 16.40-17.0 % and for sweet potatoes being 15.42 - 15.90 % . This may be due to the effect of sugars in binding water , therefore having hygroscopic property (Mohamed 2000 and El-Aouar *et al.* 2003) . It could also be noticed that all samples pretreated with HFCS showed a higher moisture content compared with the other tested samples . In this concern , EL-Gharably , *et al.* (2003) mentioned that cherries and raisins pretreated with fructose syrup then dried at 50 °C showed higher moisture content and more water holding capacity compared to other tested processed samples . Also , Lerci *et al.* (1985) mentioned that fructose had a higher diffusion evidently due to the smaller molecular dimension of the smaller saccharide . Concerning the total sugars and subsequently reducing and non- reducing sugars , results in table (2) show that the dried samples had different amounts of sugars which could be attributed to the raw material and the drying method .

In this situation , the osmo– dried samples recorded the highest values of total reducing and non reducing sugars compared with those dried with the conventional drying method . In addition , samples pretreated with HFCS were slightly higher in their reducing sugars content compared with other samples . So, all types of sugars increased during the osmotic treatment , due to the partial conversion of sucrose to invert sugars by the added citric acid . The total sugars , reducing and non-reducing sugars in hot air dried apples were 69.20 , 41.30 and 27.90% , meanwhile , the amount of total reducing and non-reducing sugars in osmo- dried apple samples ranged between 85.40 – 85.92 % , 52.50 – 53.60 and 33.42 -33.93 % respectively . Similar trend of change was observed for the amounts of sugars of the papaya fruits and sweet potatoes samples . These results are in agreement with those of Abd-El-Mothy (2004).

Concerning the total acidity (T.A %) as citric acid for different dried samples , results reveal that (T.A) decreased after drying as affected by all treatments. The loss in total acidity could be attributed to the non – enzymatic browning usually occurred during the dehydration process (Mohamed, 2000) . So , the amount of (T.A) in air – dried samples were 1.40 %, 0.65 % and 1.10 % for dried apples , papaya fruits and sweet potatoes respectively. On the other hand, the osmo –dried samples contained higher amounts of (T.A) than the air dried ones. The (T.A) of osmo – dried samples ranged between 1.52-1.70%, 0.79-0.82%, 1.21-1.30% for apples , papaya fruits and sweet potatoes respectively. Also, it could be found that samples pretreated with sucrose solution had slightly higher acidity values than the other pretreatments . Dixon and Jen (1977) mentioned that total organic acid level decreased slightly in the osmo- dried apples , contributing to a three – fold increase in the sugar / acid ratio of the final product , and this apparently could be contributed to the sweet , pleasing taste of the dried apples slices as opposed to the objectionable tartness of some conventionally dried apple . The previous results agree with Arora and Kumar (1999) and EL-Gharably , *et al.* (2003) .

The results of ascorbic acid content in different dried samples are shown in Table (2) . The results show that conventional air drying method affected severely the ascorbic acid content . So, the ascorbic acid content of air- dried apples , papaya fruits and sweet potato samples was 77.12 , 40.20 and 12.14 mg /100g respectively . These figures mean that the percentage of reduction in ascorbic acid were 51.80 , 53.20 and 59.80 % compared to its initial levels at the fresh state (Table 1) for these samples respectively . These decrements in ascorbic acid content in the conventional dried samples could be due to the oxidation of ascorbic acid during the long periods of drying time . On contrary , the osmo – dried samples had retained more amounts of ascorbic acid compared with air –dried samples . So, it could be found that the percentages of reduction of ascorbic acid in osmo-dried samples were lower than those of air – dried ones and ranged between 38.62-39.8 % , 23.00-24.90 % and 37.30-40.00 % in osmo-dried apples , papaya fruits and sweet potatoes respectively. These figures mean that the dried samples pretreated with the osmosis process could retain about 61.00-76.00% of the initial amount of ascorbic acid . Moreover , we could also notice that the samples pretreated with sucrose solution recorded the highest ascorbic acid content followed by samples pretreated with (sucrose + + HFCS 1:1) and finally (HFCS) . These results agree well with EL-Gharably , *et al.* (2003) and Assous (2004) , who mentioned that osmo- air drying method kept about 70.0 % of ascorbic acid level at the fresh state .

Pectin content had been changed during the different drying process . Results in Table (2) indicate that pectin content decreased in different samples after drying . The pectin content in air dried apples, papaya fruits and sweet potatoes were : 6.12 % ,4.45 % and 2.10 % respectively . Meanwhile , the pectin content in the osmo – dried samples ranged between 4.11 - 4.18 % , 3.10 – 3.16 % and 1.90 -1.95 % for apples , papaya fruits and sweet potatoes respectively . In this concern , Assous (2004) observed that the decrement in pectic substance during the osmo air-dried fruit slices were obviously apparent and this decrease could be due to high solid gain in the osmosed fruit slices . Also , Abd - El- Mohty (2004) mentioned that the loss percent in pectic substances during osmotic treatment for two varieties of plum fruits reached 78.18 % and 38.75 % . The higher loss in pectic substances during osmotic treatment led to the increased permeability of the fruit for both moisture and solid exchange during the osmotic treatment (Asker *et al.* 1996 , Taiwo *et al.* 2001) .

β – carotene was subjected to degrative changes during food processing and cooking (Gregory , 1985) . In general , oxidation is a major cause of β - carotene destruction , while thermal processing of foods may lead to β – carotene isomerization . In this respect , results in Table (2) show that the different processed samples of apples , papaya fruits and sweet potatoes recorded different amounts of β – carotene depending upon the process itself , the raw materials used and the type of osmos solutions . Also , this differentiation attributed to the different dry matter for each treatment leads to some leaching of the major components from the tissue especially during osmos treatment . So, results show some decrement in β -carotene as a result of processing (drying) either with or without osmosis . The amount of β – carotene in air dried samples were 0.25 , 12.0 and 9.40 mg/ 100g for dried apples , papaya fruits and sweet potatoes respectively . Meanwhile , the osmo - dried samples recorded slightly higher values of β – carotene which ranged between 0.27 - 0.29 , 13.75 – 13.95 and 10.69 – 10.62 mg /100g dw in the above mentioned samples respectively . This decrement represents a reduction percent of 16.66 %, 33.7 % and 24.19 % in air dried samples of apples , papaya fruits and sweet potatoes compared with those in the osmo -dried samples ranging between 3.3 to 10.00 , 23.00 to 24.00 and 13.79 to 14.35 % in these samples respectively .

The calculated retinol equivalent(RE) showed the same trends as in β– carotene. So , it could be concluded that the osmosis process had resulted in a higher retention of β – carotene comparing with air – dried process Sian and Ishak (1991) .

Table (2): Effect of drying method on chemical properties of dried apples – papaya fruits – Sweet potatoes .

Constituents (d.w.b) %	Hot air drying			Osmo- air drying with								
				Apples			Papaya			Sweet potato*		
	Apples	Papaya	B Sweet potato*	Sucrose	HFCS**	S+HFCS	Sucrose	HFCS**	S+HFCS	Sucrose	HFCS **	S+HFCS
Moisture %	12.50	15.20	11.60	14.00	14.60	14.52	16.40	17.00	16.80	15.42	15.90	15.82
Total sugars %	69.20	72.10	40.20	85.92	85.40	85.83	88.69	88.50	88.60	52.82	52.60	52.74
Reducing sugars %	41.30	65.12	14.62	52.50	53.60	52.90	73.10	74.40	72.90	19.45	19.62	19.51
Non Reducing sugars %	27.90	6.98	25.58	31.42	31.80	33.93	15.59	14.10	15.70	33.37	32.98	33.23
β-carotene mg / 100g	0.25	12.00	9.40	0.27	0.29	0.28	13.75	13.95	13.92	10.62	10.69	10.54
% Reduction of β-carotene	16.66	33.70	24.19	10.00	3.33	6.66	24.11	23.00	23.17	14.35	13.79	14.19
*** R.E	41.75	2004	1569	45.09	40.43	46.76	2296.3	2329.8	2324.6	1773.5	1785.2	1776.9
Ascorbic Acid mg / 100g citric acid	77.12	40.20	12.14	98.20	96.23	97.37	66.10	64.45	65.80	18.92	18.10	18.76
% Reduction	51.80	53.20	59.80	38.62	39.85	39.14	23.05	24.90	23.39	37.35	40.06	37.88
Total Acidity %	1.40	0.65	1.10	1.70	1.52	1.60	0.82	0.79	0.81	1.30	1.21	1.25
Pectin %	6.12	4.45	2.10	4.18	4.11	4.15	3.16	3.10	3.12	1.95	1.90	1.92

*** : Sweet potatoes**
**** : HFCS = high fructose corn syrup**
***** : R.E : Retinol Equivelent = 0.167 x µgm β-carotene**

Physical properties of dried apples , papaya fruits and sweet potatoes:

Results in Table (3) represent the drying ratio, rehydration ratio, time of drying and Hunter color parameters of different dried samples . The obtained results show that the drying ratio of air dried apples , papaya fruits and sweet potatoes was 7.5:1 , 7.8:1 and 7.9 : 1 respectively . On the other hand , the drying ratio of the above mentioned osmo- air dried samples ranged from 1.50-1.68 : 1 , 1.65-1.70 : 1 to 1.90-1.93 :1 respectively . The previous obtained results indicate that osmosis process had reduced the drying ratio of the different dried samples as compared to the corresponding values in the air dried ones . In this concern , Assous (2004) mentioned that osmosis succeeded in reducing drying ratio of mango and papaya fruits slices to 41-51% and 21.9-28.8 % of its value in the air dried slices, respectively .

Rehydrayion ratio of dried products could be used as an indicator of food dried quality . Concerning the results of rehydration ratio (R.R) in Table (3) , it could be found that the hot air dried samples recorded higher values of (R.R) being 4.76 ,4.20 and 6.52 for apples , papaya fruits and sweet potatoes , respectively . Meanwhile , the osmo dried samples showed lower values of (R.R) ranging between 3.50-3.52 , 2.10-2.30 and 4.10-4.15 in apples , papaya fruits and sweet potatoes , respectively . The previous results indicate also that the type of raw material and osmosis solutions had affected the (R.R) . So it could be found that the (R.R) of sweet potato samples recorded the highest values compared with the apples and papaya fruits samples . It could be also noticed that the osmo– dried samples pre-treated with HFCS were slightly higher in their (R.R) compared with the other osmo- treated samples . These results agree with Mousa (1998) who mentioned that (R.R) of dried papaya fruit sheets sweetened with HFCS was higher than those of samples sweetened with sucrose. Prothon *et al.* (2001) and Assous (2004) reported that the samples which were osmotically dehydrated prior to drying rehydrated less rapidly than the non- treated ones . This phenomenon could be explained by the fact that the osmosed samples were less porous , since the sugar solution diffused into the intercellular spaces and along the cell walls . So , the cell walls were less permeable to water due to the interaction / adsorption of sucrose molecules on the cell wall material .

Drying Time : Results in Table (3) show that the time of drying had been affected greatly by the pretreatment used before drying, the drying method , the type of raw material and the osmosed solution used . So it could be found that using osmosis pretreatment before drying had reduced total drying time in different dried samples compared to the air –dried samples without osmosis . The time of drying in conventional dried apples , papaya fruits and sweet potatoes were 11.50 , 9.00 and 11.0 (h) respectively . Meanwhile , the time of drying in osmo-dried apples ranged between 7- 8(h) , 7.5-9.5 (h) in papaya fruits and 8 - 9 (h) in sweet potatoes . Moreover , the samples osmosed with HFCS or sucrose + HFCS showed shorter time of drying compared with the other samples treated with sucrose only . Bolin et al. (1983) mentioned that syrup penetration rate into a fruit piece was faster with high fructose corn syrup (HFCS) than sucrose.

Table (3): Effect of drying methods on some physical properties dried of apple , papaya fruits and sweet potato

Constituents %	Hot air drying			Osmo- air drying								
				apple			papaya			Sweet potato		
	Apple	Papaya	Spotato*	Sucrose	HFCS**	Sucrose +HFCS**	Sucrose	HFCS**	Sucrose +HFCS**	Sucrose	HFCS**	Sucrose +HFCS**
Drying ratio	7.5:1	7.8:1	7.9:1	1.5:1	1.68:1	1.60:1	1.7:1	1.86:1	1.65:1	1.90:1	1.92:1	1.93:1
Rehydration ratio	4.76	4.20	6.52	3.50	3.52	3.51	2.10	2.30	2.25	4.10	4.15	4.12
Drying time	11.50	12.0	11.00	8.00	7.50	7.00	9.50	8.50	7.50	9.00	8.00	8.50
Firmness lb/in²	11.00	9.00	10.00	6.00	6.50	6.20	3.00	3.60	3.25	4.90	5.10	5.00
Hunter color parameters L	54.20	53.90	52.70	55.70	55.74	55.73	59.60	55.74	55.73	56.20	59.64	59.63
a	-2.40	15.65	13.62	-2.35	-2.30	-2.32	16.10	17.35	17.32	14.00	16.30	16.22
b	15.50	18.50	13.90	16.70	16.27	16.26	21.20	18.27	18.26	17.50	17.42	17.39

Firmness of fresh apples = 9.00 lb / in²
fresh Papaya = 6.50 lb / in²
fresh sweet potato = 8.00 lb / in²
* = sweet potatoes
HFCS** = high fructose corn syrup

The obtained results also agree with Omar and Rabie (2002) and Assous (2004) . From the above data it could be found that the use of osmosis process before conventional drying had resulted in a noticeable reduction in time of drying , especially with using HFCS , which would help to reduce the cost of energy during the drying process .

Texture : (firmness) Results in Table (3) show the firmness measurements of different dehydrated samples. Results show that firmness of the rehydrated hot air dried apples, papaya fruits and sweet potatoes were 11.0 ,9.00 and 10.0 lb/m² respectively . Meanwhile , the osmo-air dried samples recorded lower values of firmness which ranged between 6.00-6.50 lb/m² in apples, 3.00- 3.60 lb/m² in papaya fruits and 4.90-5.10 lb/m² in sweet potatoes. These figures indicate that hot – air dried samples were more firm than the osmo- air dried samples. This could be due to the higher moisture and lower pectin content in the osmosed samples . Also , it could be observed that osmosis before dehydration of samples caused a noticeable decrease in firmness by about 45 , 65 , and 51 % in apples , papaya fruits and sweet potatoes respectively , which is largely depending on the raw materials used. It could be also noticed that samples pretreated with HFCS was more firm compared with those pretreated with sucrose ,the obtained results agree with those obtained by Mousa(1998) ,Porthon *et al.* (2001), Omar and Rabie (2001) who indicated significant softening of the osmotically pretreated samples after rehydration compared with samples dried without osmosis. Lazarides *et al.* (1999) mentioned that food preserved by osmo- convective drying have better texture and lower shrinkage compared to traditionally dried products .

Hunter color : The Hunter color measurements L , a and b values of different dried samples are shown in Table (3). The obtained results indicate noticeable changes in L , a and b values for different dried samples , represented by decreasing in their color value measurements compared with their values in fresh state . The reduction in color parameters L , a and b was higher in hot- air dried samples compared with the osmo- air dried ones. These results are in accordance with those obtained by Robbers et. al.(1997), Forni *et al.* (1997). Rodrigues *et al.* (2003) mentioned that sugar impregnation seemed to maintain luminosity , resulting in a final product very close to the fresh state .

Effect of storage time on physical and chemical properties of dried apples , papaya fruits and Sweet potatoes :

Tables (4) , (5) , (6) represent the changes in some physical and chemical properties of dried apples , papaya fruits and sweet potatoes after storage for 6 months at ambient temperature .

Regarding the moisture content of different dried samples during storage , a little increase in moisture content was recorded during storage for 6 months at ambient temperature for all tested samples and reached to its maximum value at the end of storage period . Results in the previous tables show that the osmo-dried papaya fruits samples had slightly higher increase in their moisture content than the other osmo- dried samples of apples and sweet potatoes during storage .

Table (4): Physical and chemical properties of dried apples during storage at room temperature for 6- months

Properties (d.w.b)	Hot air dried apples			Osmo- dried apples with								
				sucrose			HFCS*			Sucrose + HFCS*		
	Storage period (month)			Storage period (month)			Storage period (month)			Storage period (month)		
	0	3	6	0	3	6	0	3	6	0	3	6
Moisture %	12.50	13.10	13.42	14.00	14.52	14.80	14.60	15.00	15.35	14.52	15.00	15.40
Total sugars %	69.20	68.97	68.58	85.92	85.71	85.30	85.40	85.17	84.77	85.83	85.61	85.40
Reducing sugars %	41.30	41.52	41.67	52.50	52.72	52.86	53.60	53.82	53.96	52.90	53.12	53.27
Non Reducing sugars %	27.90	27.45	26.91	33.42	32.99	32.44	31.80	30.80	30.81	33.93	32.49	31.83
Total Acidity % As citric acid	1.40	1.32	1.26	1.70	1.62	1.56	1.52	1.44	1.38	1.60	1.52	1.46
Ascorbic Acid mg / 100g	77.12	65.50	58.10	98.20	87.00	80.00	96.23	84.23	78.12	97.37	85.37	79.30
β – carotene mg / 100g	0.25	0.22	0.20	0.27	0.26	0.25	0.29	0.28	0.27	0.28	0.27	0.26
Hunter color : L	54.20	52.70	51.00	55.70	55.10	54.90	55.74	55.20	54.80	55.73	55.10	54.60
a	-2.40	-2.00	-1.90	-2.35	-2.10	-2.00	-2.30	-2.15	-1.90	-2.32	-2.20	-1.95
b	15.50	15.70	15.10	16.70	16.10	15.10	16.27	15.77	15.20	16.26	15.76	15.10

HFCS * = high fructose corn syrup

Table (5): Physical and chemical properties of dried papaya fruits during storage at room temperature for 6 months

Properties (d.w.b)	Hot air dried papaya			Osmo- dried papaya with								
				sucrose			HFCS*			Sucrose + HFCS*		
	Storage period (month)			Storage period (month)			Storage period (month)			Storage period (month)		
	0	3	6	0	3	6	0	3	6	0	3	6
Moisture %	15.20	15.75	16.12	16.40	16.90	17.25	17.00	17.50	17.85	16.80	17.30	17.65
Total sugars %	72.10	71.87	71.45	88.69	88.46	88.40	88.50	88.27	87.88	88.60	88.47	88.40
Reducing sugars %	65.12	65.35	65.49	73.10	73.32	73.46	74.40	74.65	74.79	72.90	73.25	73.40
Non Reducing sugars %	6.98	6.52	5.96	15.59	15.14	14.94	14.10	13.62	13.09	15.70	15.22	15.00
Total Acidity % As citric acid	0.65	0.57	0.51	0.82	0.74	0.68	0.79	0.71	0.65	0.81	0.73	0.67
Ascorbic Acid mg / 100g	40.20	29.15	24.10	66.10	57.20	55.35	64.45	55.30	52.20	65.80	56.20	54.15
β - carotene mg / 100g	12.00	11.10	10.42	13.75	13.06	12.53	13.95	13.20	12.71	13.92	13.10	12.65
Hunter color : L	53.90	52.40	50.22	59.60	58.10	57.40	55.74	54.84	53.10	55.73	54.00	53.20
a	15.65	15.15	12.90	16.10	15.60	15.00	17.35	16.80	16.00	17.32	16.72	15.90
b	18.50	17.70	17.10	21.20	19.70	18.90	18.27	17.67	17.00	18.26	17.75	16.90

HFCS * = high fructose corn syrup

Table (6): physical and chemical properties of dried Sweet potatoes during storage at room temperature for 6 months .

Properties (d.w.b)	Hot air dried sweet potato			Osmo- dried sweet potato with								
				sucrose			HFCS*			Sucrose + HFCS*		
	Storage period (month)			Storage period (month)			Storage period (month)			Storage period (month)		
	0	3	6	0	3	6	0	3	6	0	3	6
Moisture %	11.60	12.00	12.25	15.42	15.90	16.10	15.90	16.30	16.50	15.82	15.20	15.40
Total sugars %	40.20	40.00	39.60	52.82	52.59	52.19	52.60	52.47	52.00	52.74	52.51	52.10
Reducing sugars %	14.62	14.81	14.95	19.45	19.65	19.80	19.62	19.80	19.92	19.51	19.72	19.84
Non Reducing sugars %	25.58	25.19	24.65	33.37	32.94	32.39	32.90	32.67	32.08	32.98	32.79	32.24
Total Acidity % As citric acid	1.10	1.05	1.00	1.30	1.22	1.16	1.21	1.13	1.07	1.25	1.17	1.10
Ascorbic Acid mg / 100g	12.14	9.20	8.00	18.92	12.66	11.50	18.10	12.50	11.60	18.76	12.00	11.40
β - carotene mg / 100g	9.40	8.10	7.50	10.62	9.80	9.00	10.69	9.50	9.10	10.54	9.80	9.00
Hunter color : L	52.70	51.20	49.00	56.20	55.70	55.00	59.64	59.00	58.60	59.63	59.13	58.92
a	13.62	13.12	10.87	14.00	13.52	13.10	16.30	15.82	15.22	16.22	15.70	15.10
b	13.90	13.10	12.90	17.50	17.00	16.70	17.42	17.10	16.62	17.39	16.80	16.10

HFCS * = high fructose corn syrup

This could be due to the higher levels of reducing sugars in the osmo- dried papaya fruits samples compared to that of dried apples and Sweet potatoes.These results agree with those of Assous (2004) and Sagar et. al(1998) . Results in Tables (4,5,6) indicate that the air dried or osmo- air dried different samples stored for 6 months at 25 °C was accompanied by a gradual and slight decrease in total sugars content compared with its level at zero time before storage . Also , the obtained results reveal that non – reducing sugars content decreased meanwhile , the reducing sugars content increased . These results were similar to those of Mohamed (2000) and EL-Gharably *et al.* (2003)who mentioned that there were a little increase in reducing sugars and greater decrease in non- reducing sugars was occured , but total sugars were relatively constant up to 6 month of storage for osmo- dried and sun-dried samples .

Concerning the total acidity of different dried samples , it could be found that gradual decrease was found during storage . This decrement in total acidity in the dried products could be attributed mainly to the breakdown of ascorbic acid during storage (Assous,2004) . Concerning the ascorbic acid content , it could be noticed that there was a sharp decrease in its content in air – dried and osmo- air dried samples especially in the first 3 months of storage at room temperature . Decrements of ascorbic acid content continued with extending the storage time to 6 months . The decrement percentages for ascorbic acid ranged between 15.0 to 24.66 % , 27.48 to 40.0% , and 24.21 to 46.45% in hot air dried apples , papaya fruits and Sweet potatoes respectively . Meanwhile , the decrement percentages in osmo- dried apples , papaya fruits and Sweet potatoes samples ranged between 18.5 to 18.8 , 13.46 to 16.26 and 35.91 to 39.21 respectively . The considerable decrease in ascorbic acid could be attributed to oxidation or conversion to dehydro- ascorbic acid during drying as reported by Kirk *et al.* (1977) . Also , it could be observed that the reduction of ascorbic acid for different dried samples would be dependent on the initial content of ascorbic acid , the drying method used , time , temperature of drying and type of osmosis solution used .

Concerning the β – carotene contents of different dried samples , results in Tables (4 , 5 , 6) show some degradation in β – carotene content during storage at 25 °C . This degradation could be attributed to the oxidation of carotenoids by oxygen , storage temperature and light (Chen and Chiang 1985 b) , but it was not a destructive degradation . The obtained results show that the percentage of reduction in β – carotene in air dried apples , papaya fruits and sweet potato samples ranged between 12.0 -20.0 % , 7.5 – 13.6% and 13.8 – 20.21 % respectively . Meanwhile , the reduction in osmo- dried apple samples ranged between 3.7 – 7.4 % ,for the osmo dried papaya fruit samples ranged between 3.44 – 6.89 % and sweet potato samples ranged between 3.57 – 7.14 %. These results agree with those of Abd EL – Magid *et al.* (1992) , Zaki, (2000) and Assous (2004) .

Effect of storage on Hunter color parameters :

Results in Tables 4 ,5 and 6 , show the effect of storage on the Hunter color parameters L , a and b values of different dried samples . So , it could be found that 'L' , 'a' and 'b' values of air dried apples , papaya fruits and sweet potatoes samples decreased during storage for 6 months at 25 °C On the other hand , the same parameters in the osmo-dried samples also decreased during storage . For instance, we found that the L, a and b values of air dried papaya fruits samples during storage decreased from 53.90 to 50.22, 15.65 to 12.90, 18.50 to 17.10 respectively. Meanwhile, the corresponding values in osmo-dried papaya fruit samples decreased from 59.60 to 57.40 (for osmo-dried with sucrose) , 55.74 to 53.10 (for osmo-dried with HFCS) and from 55.73 to 53.20 (for osmo-dried with mixture of sucrose + HFCS) . The ' b' values of osmo-dried papaya fruits samples decreased during 6 months storage at 25 °C from 16.10 to 15.0 , from 17.35 to 16.0, from 17.35 to 15.90 for the osmo-dried samples treated with sucrose, HFCS and sucrose + HFCS respectively . The decrement in ' b' values was found to be decreased from 21.20 to 18.90 , from 18.27 to 17.00 and from 18.62 to 16.90 for osmo- dried papaya fruits samples . These figures indicate that a drastic change in color during storage could be noticed for the hot- air dried samples . Meanwhile , the osmo-dried samples were better in their color during storage than those of the air-dried samples . This means that the osmosis – pretreatment could retain higher values of ' L', ' a' and ' b' which indicate the intensity of yellow – orange color of osmo-dried samples during storage . These results are in accordance with Assous (2004) and Almeida – Murdian *et al.* (1992) who attributed the reduction in a, b values during storage to the decrement in β – carotene .

Sensory evaluation : Method of drying has a clear effect on the quality of dried fruit and vegetables . Results of sensory parameters including color , taste, odor, texture and overall acceptability of different dried samples were judged by ten panelists. All these parameters were evaluated through the stages of storage from zero to 6 months at room temperature (25° C). Statistical analysis were done for each parameter to show the significant among the different dried samples during storage . Results in Tables (7, 8, 9) show significant differences between convection hot air dried apples, papaya fruits and sweet potatoes compared with the osmo-dried samples in all parameters of the test panelists after zero time and at the end of storage for 6 months . The panelists rated the different air dried samples to be the lowest score values compared to the (OD) samples at zero time . The decline of sensory scores of these samples were more pronounced after 6 months of storage compared to those treated with the osmo-dried process. On contrast, the osmo-dried samples of apples , papaya fruits and sweet potatoes gained high scores for different parameters of the test panel. Slight significant differences were found in color, taste, odor, texture and the overall acceptability between different dehydrated samples pretreated with the three tested osmosis syrups (sucrose, HFCS and sucrose + HFCS). Regarding the sensory scores of different osmo - dried samples, results in tables (7, 8, 9) reflect that all samples pretreated with HFCS rated the highest values for all color and texture compared with the other (OD) samples. Slight differences were observed in taste and odor for samples (OD) with sucrose and HFCS and also with the mixture of sucrose+ HFCS . So, the type of raw material used, the drying process and the type of osmosis solution had affected the sensory scores of different dried samples of apples , papaya fruits and sweet potatoes.

These results agree with those obtained by EL-Gharably *et al.* (2003) and Assous(2004) The obtained results in Tables (7,8,9) accertained the great benefits of using the osmosis pretreatment before final drying to produce a suitable product for consumption in the dry form as snacks foods , compared to the conventional air dried product which can't be consumed directly in the dry state and should be rehydrated (being in accordance with Lenart and cerkowniak 1996) . It could be conclude that solute uptake and leaching of natural acids , color and flavor compounds out of osmo-dehydrated plant tissue affect its organoleptic properties , since they modify its natural composition . Also in agreement with Lazarides *et al.* (1999) mentioned that osmotic pretreatment contributes to retention of flavor in convectively dried fruits to make it more acceptable as ready –to-eat as snacks compared to the air –dried products .

Table (7): Effect of storage on sensory properties of different types of dried apples.

Characterististics	Time of storage (month)	Hot air dried apples	Osmo- air dried apples			LSD at 0.05 level
			Sucrose	HFCS*	Sucrose + HFCS*	
Color	0	5.58^{Ac}	9.07^{Ab}	9.25^{Aa}	9.05^{Ab}	**0.121**
	3	5.03^{Bc}	8.47^{Bb}	8.87^{Ba}	8.60^{Bb}	**0.188**
	6	4.38^{Cc}	7.53^{Cb}	8.13^{Ca}	7.93^{Ca}	**0.250**
LSD at 0.05 level		**0.163**	**0.237**	**0.196**	**0.218**	
Taste	0	5.63^{Ac}	9.53^{Aa}	9.23^{Ab}	9.43^{Aa}	**0.184**
	3	5.17^{Bc}	9.03^{Ba}	8.70^{Bb}	8.91^{Ba}	**0.176**
	6	4.57^{Cc}	8.23^{Ca}	7.90^{Cb}	8.03^{Cb}	**0.169**
LSD at 0.05 level		**0.182**	**0.207**	**0.185**	**0.173**	
Odor	0	5.93^{Ac}	9.43^{Aa}	9.10^{Ab}	9.30^{Aa}	**0.180**
	3	5.53^{Bc}	9.12^{Ba}	8.87^{Bb}	9.03^{Ba}	**0.127**
	6	5.13^{Cc}	8.33^{Ca}	8.00^{Cb}	8.13^{Cb}	**0.163**
LSD at 0.05 level		**0.163**	**0.191**	**0.156**	**0.159**	
Texture	0	6.10^{Ad}	9.07^{Ac}	9.47^{Aa}	9.23^{Ab}	**0.133**
	3	5.53^{Bc}	8.73^{Bb}	9.07^{Ba}	8.93^{Ba}	**0.151**
	6	5.03^{Cc}	8.00^{Cb}	8.30^{Ca}	8.03^{Cb}	**0.160**
LSD at 0.05 level		**0.188**	**0.148**	**0.124**	**0.163**	
Overall acceptability	0	5.81^{Ab}	9.27^{Aa}	9.27^{Aa}	9.25^{Aa}	**0.163**
	3	5.32^{Bb}	8.84^{Ba}	8.87^{Ba}	8.87^{Ba}	**0.180**
	6	4.75^{Cb}	8.02^{Ca}	8.08^{Ca}	8.03^{Ca}	**0.213**
LSD at 0.05 level		**0.288**	**0.238**	**0.133**	**0.128**	

Where: Mean values in the same column (as a capital letter) or row (as a small letter) with the same letter are not significant different at 0.05 level.
HFCS* = High fructose corn syrup

Table (8): Effect of storage on sensory properties of different types of dried papaya fruits.

Characterististics	Time of storage (month)	Hot air dried papaya	Osmo- air dried papaya fruits			LSD at 0.05 level
			Sucrose	HFCS*	Sucrose + HFCS*	
Color	0	5.87^{Ac}	9.33^{Ab}	9.50^{Aa}	9.40^{Aab}	0.12
	3	5.20^{Bc}	8.83^{Bb}	9.00B^{ab}	9.10^{Ba}	019
	6	4.73^{Cb}	7.93^{Ca}	8.13^{Ca}	8.07^{Ca}	0.22
LSD at 0.05 level		0.196	0.16	0.218	0.19	
Taste	0	5.23^{Ac}	8.93^{Aa}	8.73^{Ab}	8.87^{Aab}	0.165
	3	5.00^{Bc}	8.40^{Ba}	8.07^{Bb}	8.13^{Bb}	0.128
	6	4.30^{Cb}	7.50^{Ca}	7.30^{Ca}	7.33^{Ca}	0.20
LSD at 0.05 level		0.176	0.156	0.169	0.215	
Odor	0	4.90^{Ac}	8.80^{Aa}	8.50^{Ab}	8.63A^{ab}	0.227
	3	4.63^{Bc}	8.40^{Ba}	7.93^{Bb}	8.08^{Bb}	0.169
	6	4.07^{Cc}	7.59^{Ca}	7.10^{Cb}	7.27^{Cb}	0.186
LSD at 0.05 level		0.196	0.215	0.176	0.237	
Texture	0	5.90^{Ac}	9.27^{Ab}	9.57^{Aa}	9.40^{Ab}	0.16
	3	5.27^{Bc}	8.63^{Bb}	8.93^{Ba}	8.90^{Ba}	0.176
	6	4.77^{Cc}	7.77^{Cb}	8.13^{Ca}	7.92^{Cb}	0.20
LSD at 0.05 level		0.196	0.244	0.128	0.176	
Overall acceptability	0	5.47^{Ab}	9.08^{Aa}	9.07^{Aa}	9.07^{Aa}	0.33
	3	5.02^{Bb}	8.57^{Ba}	8.48^{Ba}	8.55^{Ba}	0.32
	6	4.47^{Cb}	7.70^{Ca}	7.67^{Ca}	7.64^{Ca}	0.30
LSD at 0.05 level		0.295	0.18	0.416	0.34	

Where: Mean values in the same column (as a capital letter) or row (as a small letter) with the same letter are not significant different at 0.05 level.
HFCS* = High fructose corn syrup

Table (9): Effect of storage on sensory properties of different types of dried sweet potatoes.

Characterististics	Time of storage (month)	Hot air dried sweet potato	Osmo- air dried sweet potato fruits			LSD at 0.05 level
			Sucrose	HFCS*	Sucrose + HFCS*	
Color	0	5.77Ac	9.30Ab	9.57Aa	9.43Aab	0156
	3	5.17Bc	8.63Bb	8.97Ba	8.77Bab	020
	6	4.70Cc	7.60Cb	7.93Ca	7.77Cab	0.19
LSD at 0.05 level		0.24	0.20	0.128	0.19	
Taste	0	5.40Ac	9.30Aa	9.10Ab	9.13Aab	0.178
	3	5.10Bc	8.63Ba	8.27Bb	8.20Bb	0.197
	6	4.50Cc	7.73Ca	7.47Cb	7.35Cb	0.186
LSD at 0.05 level		0.199	0.22	0.235	0.12	
Odor	0	5.70Ac	9.20Aa	9.0Ab	8.97Ab	0.178
	3	4.87Bb	8.63Ba	8.60Ba	8.40Ba	0.48
	6	4.77Cb	7.80Ca	7.63Ca	7.63Ca	0.215
LSD at 0.05 level		0.60	0.156	0.218	0.205	
Texture	0	5.77Ac	9.07Ab	9.33Aa	9.10Ab	0.21
	3	5.33Bc	8.50Bb	8.83Ba	8.67Bab	0.169
	6	4.83Cc	7.70Cb	8.07Ca	7.90Cab	0.247
LSD at 0.05 level		0.207	0.246	0.23	0.21	
Overall acceptability	0	5.66Ab	9.22Aa	9.25Aa	9.16Aa	0.157
	3	5.12Bb	8.60Ba	8.67Ba	8.51Ba	0.20
	6	4.70Cb	7.71Ca	7.77Ca	7.66Ca	0.167
LSD at 0.05 level		0.18	0.099	0.22	0.185	

Where: Mean values in the same column (as a capital letter) or row (as a small letter) with the same letter are not significant different at 0.05 level.
HFCS* = High fructose corn syrup

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تأثير التجفيف الإسموزى والتجفيف بالطريقة التقليديه على جودة بعض أنواع الخضر والفاكهه

سحر محمد ذكى
معهد بحوث تكنولوجيا الأغذيه ، مركز البحوث الزراعيه- الجيزه- مصر

هذه الدراسه معنية بتأثير إستخدام المعامله بالأسموزيه كمعامله مبدئيه قبل التجفيف الأسموزى وكذلك طريقة التجفيف التقليديه (بالهواء فقط) على بعض الخصائص الطبيعيه والكيميائيه لكل من ثمار التفاح والبابا ظ وكذلك البطاطا . المحاليل المستخدمه هى : السكروز ، شراب عالى الفركتوز ، وخليط من : السكروز و شراب عالى الفركتوز بنسبة ١ : ١ . وقد تم تقدير الخواص الطبيعيه والكيميائيه للثمار الطازجة لكل من من ثمار التفاح والبابا ظ وكذلك البطاطا-. كما تم تقدير خواص الجوده لمكعبات ثمار التفاح والبابا ظ وكذلك البطاطا المجففه اسموزيا وكذلك تلك المجففه بالطريقة العاديه وذلك بعد التصنيع مباشرة ثم أثناء التخزين على درجة حرارة الغرفة (٢٥°م) لمدة ٦ أشهر . وقد أوضحت النتائج المتحصل عليها أن العينات المجففه بالطريقه الأسموزيه سجلت قيم أعلى من الرطوبه والسكريات والحموضه الكليه وقيم أقل فى المحتوى من البكتين مقارنة بالعينات المجففة بالطريقة التقليديه ، وكذلك كانت نسبة الأحتفاظ بحامض الإسكوربيك والبيتا كاروتين أعلى فى العينات المجففه اسموزيا مما يعنى إرتفاع قيمتها الغدائيه. وكذلك لوحظ التأثير الإيجابى للتجفيف الأسموزى على الخواص الطبيعيه للعينات المجففه المختلفه. وقد وجد أن نسبة التجفيف ونسبة الأسترجاع والقوام وكذلك الوقت اللازم للتجفيف كانت أقل فى العينات المجففه اسموزيا مقارنة بتلك المجففة بالطريقة التقليديه (بالهواء فقط) و بالنسبه لقيم اللون

بجهاز هنتر فقد وجد أن معدل النقص كان أعلى فى العينات المجففة بالطريقة التقليديه وكذلك وجد أن تأثير التخزين على مختلف عوامل الجوده كان أكثر وضوحا فى هذه العينات مقارنة بتلك المجففه بالطريقه الأسموزيه . كما أوضحت نتائج التقييم الحسي أن العينات المجففه اسموزيا قد حصلت على أعلى الدرجات فى التقييم الحسى كما وجدت فروق معنويه بينها وبين تلك المجففة بالطريقة التقليديه .