Minia J. of Agric. Res. & Develop.
Vol. (٣٢) No. ٦ pp ٩٨٣-١٠٠٤
٢٠١٢

FACULTY OF AGRICULTURE

MASS TRANSFER AND MICROSTRUCTURE DURING OSMOTIC DEHYDROFREEZING OF DATES (*PHEONIX DACTYLIFERA*)

Souzan, S. Latif* ; H. M. Ali; M. N. Kenawi and O. I. A. Soltan
Food Science Dept. Fac. Agric. Minia University

Received ١٨ **Dec.** ٢٠١٢ **Accepted** ٣٠ **Dec.** ٢٠١٢

ABSTRACT

Osmotic dehydrofreezing represent a technological alternative to reduce post-harvest losses of fruits. It refers to the combined process of partial drying in a concentrated solution (osmotic dehydration) followed by freezing. The effect of different parameters on the osmotic dehydration pretreatment of date in terms of water loss and solid gain, such as different osmotic solute (sucrose, glucose and fructose), the concentration of solution (٥٠-٧٠٪w/w), temperature (٣٠-٥٠°C), the ratio of sample to solution (١/٤-١/١٢), duration time (٦-٣٠hrs) and geometry of dates (halves – whole fruits) were investigated. The results revealed that increase of concentration, temperature of osmotic solution caused considerable increasing water loss and solid gain. The decreasing of the ratio of sample to solution avoided significant dillution and increased the water loss and solid gain. In addition, there were a significant differences in water loss and solid gain when the dimenstion of date was decreased and time immersion increased. Light microscope micrographs revealed that osmotic treatment has a significant effect on the structural properties (cell wall and parenchyma cell) of dates. In generaley osmotic treatments of ٧٠٪ sucrose solution at ٥٠°C showed much lower drip losses and tissues damage of osmo-dehydrofrozen dates than that of non treated frozen samples.

*** Corresponding author:** E-mail address: Sozan.Latif@mu.edu.eg

Mass transfer and microstructure of dates

INTRODUCTION

Date is an important commercial crop in the Middle East and Arab countries. Date fruit is a rich source of carbohydrates comprising mainly of sugars and dietary fiber, making it one of the most nourishing natural foods available to the human nutrition. It is also a good source of vitamins and macro elements like phosphorous, iron, potassium and a significant amount of calcium (Gamil- Abdel-Hafez et al. , ١٩٨٠ and Anwar-Shinwari, ١٩٨٧). The production of date fruits in the world was estimated at ٧,٦٢٦,٤٤٨ tones. In Egypt, the annual production was ١,٣٥٢,٩٥٠ tones (FAO, ٢٠١٠). The demand for healthy, natural and tasty processed fruits continuously increases not only for finished products, but also for ingredients to be included in complex foods such as ice- creams, cereals, dairy, confectionery and backery products. (Talens *et al.* , ٢٠٠٠).

Freezing of fruit and vegetables causes changes in quality during subsequent thawing. Freezing leads to significant cellular damage and several chemical–physical and organoleptical deteriorations take place, especially when fruits are thawed, with subsequent loss of product quality. (Blanda, et al, ٢٠٠٨ and Martinez-Navarrete *et al.* , ٢٠٠١). Thus, attempts have been made to reduce the cellular water content in order to reduce changes in tissue resulting from freezing damage (Wu *et al,* ٢٠٠٩). A pre-treatment, such as osmotic dehydration, can be used in order to reduce the initial water content, reducing total processing and air-drying time.

Osmotic dehydration (OD) is the process of water removal by immersion of water containing cellular solid in concentrated aqueous solution of high osmotic pressure (hypertonic media) for a specified time and temperature. Osmotic dehydration for partial dehydration of food aterials, especially of fruits and vegetables, used previous to freezing leads to substantial energy savings. The osmotic dehydration step consists of a simple immersion of the foodstuff in a highly concentrated solution of salt and/or sugar close to room temperature. (Pokharkar, *et al,* ١٩٩٧ and Marani, *et al*, ٢٠٠٧).

The osmotic process has received considerable attention as a pre-treatment to reduce energy consumption and improve food quality

(Torreggiani, ١٩٩٣ and Karathanos, et al, ١٩٩٥). Beside reducing the drying time, the osmotic dehydration as a pre-treatment also inhibits enzymatic growing, retains natural color (without sulphite addition) and retains volatile aromas during the subsequent drying (Pokharkar, et al, ١٩٩٧).In addition, dehydration pre-freeze treatments are a useful tool to improve texture characteristics of thawed fruits and vegetables (Huxon, ١٩٨٢ and Robbers, et al, ١٩٩٧), reduce structural collapse and drip loss during thawing (Forni et al. , ١٩٨٧).Osmotic dehydrofreezing technique was found to be effective in maintating the texture of agricultural product after freez-thawing, with minimal damage to cellular integrity (Ando,et al. ,٢٠١٢).It is useful technique to extend the shelf life and decrease the energy cost (Khan,٢٠١٢). The combined process of OD and freezing is called osmo-dehydrofreezing which is used to get better texture properties of fruits and vegetables as well as minimize the structural collapse and drip loss.

The objective of this study was to evaluate the effects of osmotic pre-treatment (osmotic solutes sucrose, fructose and glucose) on: ١- The mass transfer of osmotic dehydfrozen date ٢- Microstructure changes of osmotic dehydfrozen dates during the process. ٣- Quality loss of frozen date samples untreated and pre-treated with the osmotic solutes.

MATERIALS AND METHODS

Materials:

Fresh date (*Pheonix dactylifera L.*), and commercial sucrose were purchased from a local market. Fructose and glucose were purchased from El Nasr Co., (Abo Zaabel, Egypt).

Sample preparation:

Fresh dates were washed then cut vertical to their axis into half with slicer. The whole date and halves were wrapped in plastic film to avoid superficial dehydration before the start of the experiment.

Osmotic media:

Sucrose, fructose and glucose were used as osmotic agents. Sugar solutions were prepared with distilled water at three concentration

levels, ٥٠, ٦٠, and ٧٠ % by weight. The weight ratio of product to osmotic medium were (١/٤, ١/٨, ١/١٠ and ١/١٢).

Experimental Procedure:

The samples were divided into five groups as follows:-

Group ١

To study the effects of different osmotic agent, and concentration using sucrose, fructose and glucose , at ٥٠, ٦٠ and ٧٠٪ (w/w) at (١/١٠) ratio , using time immersion(٢٤ h), and temperatures(٣٠°C) on halves date samples.

Group ٢

To study the different process temperature (٣٠, ٤٠ and ٥٠°C), ٧٠٪ sucrose solution (١/١٠) for ٢٤ h on halves date samples.

Group ٣

To study the effect of the ratio of date to solution. The osmotic process experiments were conductive ٧٠٪ sucrose solution at various ratios of ١/٤, ١/٨, ١/١٠ and ١/١٢ for ٢٤ h, and٣٠°C on halves date samples.

Group ٤

To study the effect of immersion time (٦,١٢,١٨,٢٤,٣٠) hours, ٧٠٪ sucrose solution using of sample to solution ratio (١/١٠), temperatures(٣٠°C), on halves date samples.

Group ٥

To study the effect of sample geometry. Experiments of osmotic dehydration were performed on date with the geometry and sample sizes indicated in Table ١. Sample were immersed in sucrose solution(٧٠٪) ,sample to solution ratio (١/١٠), at ٥٠°C for ٢٤ h.

Table ١: Geometry and sizes of date samples.

Fruit	**Geometry**	**Size**	**weight**
Date	Whole	D=٢.٦ L= ٤.٣ cm	١٧.٠٣g
	Half	L= ٤.٣ cm	٩.٧ g

(D = diameter and L= Length)

ANALYTICAL METHODS

Physical properties:

A random sample of ١٠ date fruits were examined for recording number of fruit/kg, fruit weight, fruit dimensions (length and diameter), navel and seed %, fruit yield percentages, half weight and thickness according to Saker *et al.* (٢٠١٠)

Proximate chemical composition:

Moisture, crude protein, crude fiber, crude ether extract, and ash contents were determined according to official methods of the Association of Official Analytical Chemists (AOAC, ١٩٩٨). Nitrogen free extract was obtained in the usual manner by calculation.

Evaluation of mass transfer:

The evaluation of mass transfer was measured through out the weight loss (WR), total solids (TS) and soluble solids content (°Brix). according to Marani et al. (٢٠٠٧). The parameters usually used to follow the dehydrating process

Water loss:

$$WL\% = \left[\left(1-\frac{TS°}{100}\right)-\left(1-\frac{TS}{100}\right)\left(1-\frac{WR}{100}\right)\right]\times \mathbf{100}$$

Solid gain:

$$SG\% = \left[\left(1-\frac{WR}{100}\right)\frac{TS}{100}-\frac{TS°}{100}\right]\times 100$$

Where:

WL%: Water loss.
TS°%: Total solids in zero time.
WR: Weight loss.
SG%: Solid gain.
TS%: Total solids after treatment.

After the dehydration step, the samples were frozen (PF٨ -٨٠ personal freezer, NESLAB)at - ٤٠ °C. The progress of freezing was

followed by the registration of temperature with a thermocouple placed in the center of the product.

Drip loss evaluation:

Frozen products were laid over an absorbent paper and let to thaw at room temperature. Drip loss was then evaluated by periodically weighing the absorbent paper until a constant value was reached. The results were expressed as drip loss in dry basis according to Marani *et al.* (٢٠٠٧).

$$DL\,\% = \frac{W^t - W^\circ}{WS \times TS} \times 100$$

Where:
DL: Drip loss.
W^o: Weight of the dry absorbent paper.
W^t: Weight of the wet absorbent paper at time t.
WS: Weight of the sample.
TS: Total solids of the sample.

Light microscopy analysis:

Small pieces of date were cut with a very sharp razor blade. Samples were fixed in carnoy's fluid , dehydration in a series of gradually increasing in strength ethanol clarified in xylene embedded in paraffin wax with melting point of ٥٨°c.

Serial cross sections, ١٠µm thick, were cut using a rotary microtome. Sections were stained with light green and, mounted in DPX and microscopically examined (Nasar and Alsahar, ١٩٩٨). Photomicrographs of cell were taken using light microscope with digital capture system (Olympus BX٥١).
Photomicrographs were made in Dept. of Genetics, Cytogenetic Lab, Faculty of Agricultural, Minia University.

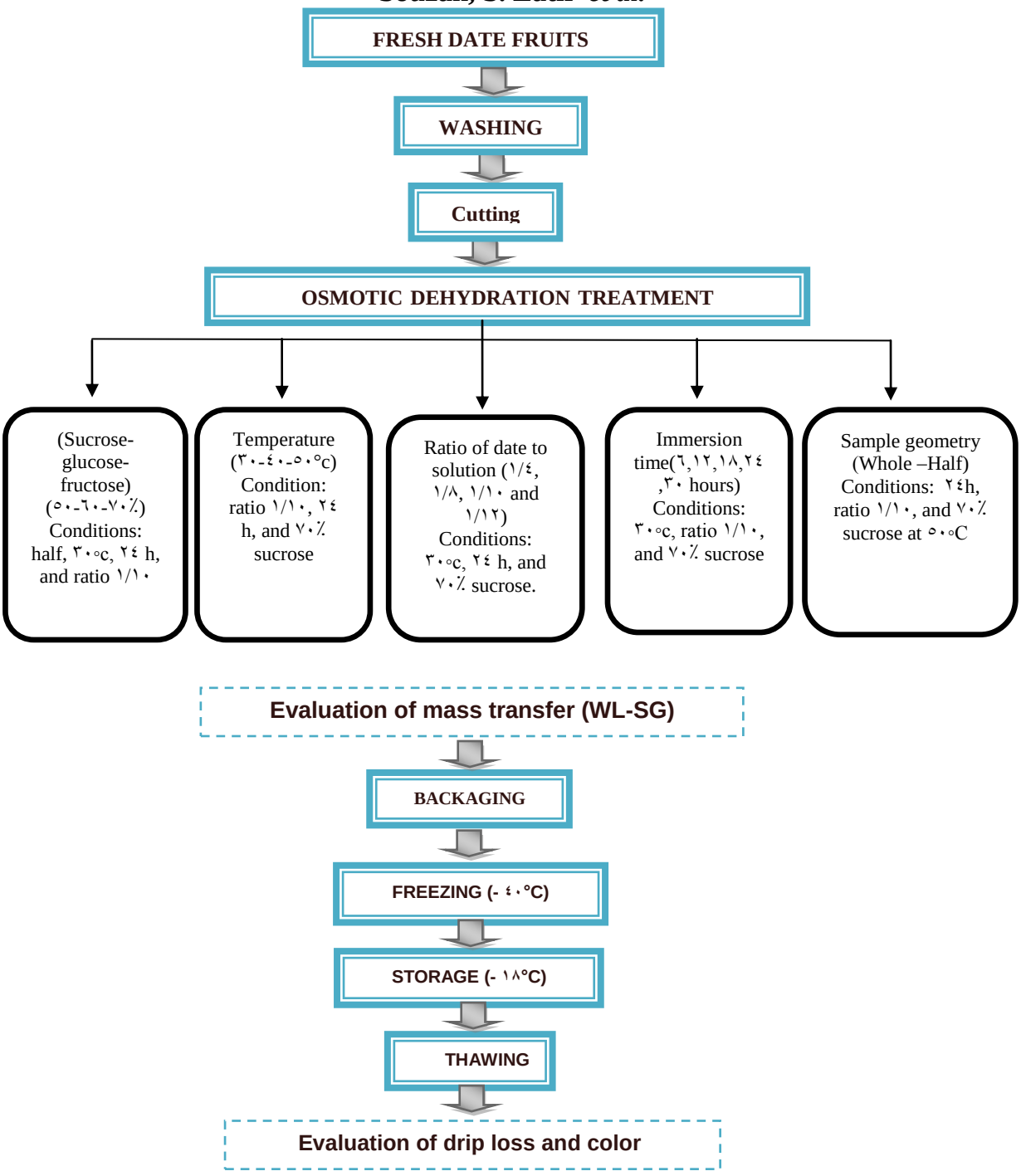

Fig. ١:Osmotic dehydration pre treatment of freezing

Statistical Analysis:

The results were given as means ± SD of triplicate samples. Statistical analysis was performed using one-way ANOVA. P-values less than ٠.٠٥ were considered to be statistically significant (SAS Institute, ٢٠٠٣). Duncan's test was used to examine the significance degrees among means (Duncan, ١٩٥٥).

RESULTS AND DISCUSSION:

Physical characteristics:

Concerning the physical characteristics of fresh date results, as shows in Table (٢), revealed that the number of fruits in each Kg was ٥٢,wheras the mean weight of single fruit was ١٧.٠٣g, the average of length and diameter of date fruit were ٤.٣١ and ٢.٨٢ cm, respectively.

Table ٢: Physical characteristics of fresh dates:-

Physical characteristics	Value*
Number of fruits per kg	٥٢ ± ١.٠٠
Fruit weight (gm)	١٧.٠٣ ± ١.١٣
Fruit length (cm)	٤.٣١ ± ٠.١١
Fruit diameter (cm)	٢.٨٢ ± ٠.٠٨
Seed %	١١.٢١± ٠.١٢
The navel %	٠.٢٧ ± ٠.٠٣
Yield (edible part %)	٨٨.٤٠ ± ٠.٦٤
Half weight (gm)	٩.٧٠ ± ٠.٥٥
Half thickness(cm)	١.٢١ ± ٠.٠٥

* Means ± SD of triplicate.

The seed content of the fruit was ١١٢.١g $Kg^{-١}$.The navel of date was ٢.٧g $Kg^{-١}$. The edible part of date was ٨٨٤g $Kg^{-١}$.The weight of half was ٩.٧ g $Kg^{-١}$. It can be readily mentioned that the physical characteristics of the present results are in agrement with those obtained by (Kulkarni *et al.*, ٢٠٠٨).

Chemical composition:

The chemical composition of the fresh dates is presented in Table (٣). The moisture content of the sample tissues was measured to know the degree of dehydration. The initial mean moisture content in fresh

date fruit was found to be ٦٨.٨٧٪. The protein and fat were ٠.٩٠٪ and ٠.٣١٪, respectively. The ash content was ٠.٠٩٪. The nitrogen free extract (NFE) related to the carbohydrate content was calculated by difference. Its content included crude fiber ١.٣١٪ nitrogen free extract (NFE) was ٢٩.٨٣٪. The results indicated that the date fruits are rich in carbohydrates. The obtained results confirmed the results of Kulkarni et al., (٢٠٠٨) who reported that date fruits are rich in carbohydrates.

Table ٣: Chemical composition of fresh date:-

Constituents	Weight* %
Moisture	٦٨.٨٧±٠.٠١٧
Protein**	٠.٩٠±٠.٠١٥
Fat	٠.٣١±٠.٠١٥
Ash	٠.٠٩±٠.٠١
Crude fiber	١.٣١±٠.٠٣
NFE***	٢٨.٥٢±٠.٠٢١

* Means ± SD of triplicate. ** Protein =Total nitrogen x ٦.٢٥. *** Nitrogen free extract

Type and concentration of osmotic agent:

The type of osmotic agent is very important factor that determines the rate of diffusion. The common solute type used as an osmotic agent are sucrose, glucose, sorbitol glycerol, glucose syrup, corn syrup and fructo-oligosaccaride. Generally, low molecular weight osmotic agent easier penetrates into the cell of fruit compared to high molecular weight osmotic agent (El-Aouar et al., ٢٠٠٦).

Table ٤: Influence of type of solute and concentration on water loss (WL), solid gain (SG) and drip loss (DL) for dates pretreated osmotically before freezing.

Type of solute	Concentration %	WL %	SG %	DL %
Sucrose	٥٠	١٩.٠٢ ^{h} ± ٠.٢٠	٤.٥٨ ^{g} ± ٠.١٥	١.٤٨ ^{c} ± ٠.٠٢
	٦٠	٢٢.١٩ ^{f} ± ٠.٣٠	٥.٣٣ ^{f} ± ٠.١٥	١.٣٤ ^{d} ± ٠.٠٢
	٧٠	٣٠.٠١ ^{c} ± ٠.٠٥	٦.٦٩ ^{e} ± ٠.١٤	٠.٨٧ ^{g} ± ٠.٠٢
Glucose	٥٠	٢٠.٦١ ^{g} ± ٠.١٩	٦.٦٤ ^{e} ± ٠.٢٧	٢.٠٥ ^{a} ± ٠.٠٥
	٦٠	٢٥.١١ ^{e} ± ٠.٢٣	٨.١٣ ^{d} ± ٠.٣٢	١.٠٦ ^{e} ± ٠.٠٣
	٧٠	٣١.١٣ ^{b} ± ٠.٣٢	١١.١٨ ^{a} ± ٠.٠٩	٠.٩٤ ^{f} ± ٠.٠١
Fructose	٥٠	٢٢.٥٠ ^{f} ± ٠.١٢	٨.٦٨ ^{c} ± ٠.٢٥	١.٦٣ ^{b} ± ٠.٠١
	٦٠	٢٧.٤٦ ^{d} ± ٠.٢٧	٩.٣٢ ^{b} ± ٠.٠٤	٠.٩٣ ^{f} ± ٠.٠٣
	٧٠	٣٣.٣١ ^{a} ± ٠.١٣	٩.٦٣ ^{b} ± ٠.١٣	٠.٧٥ ^{h} ± ٠.٠٢

* $^{a\,b\,c\,d\,e\,f\,g\,h}$ Means ± SD of triplicate. Values with the same letter in the same column are not significantly different ($p \leq ٠.٠٥$).

Our experiments on osmotic dehydrofreezing drying of three selected osmotic agents: sucrose, glucose and fructose at three level ٥٠, ٦٠, and ٧٠°Brix were carried out with date fruit. In Table (٤), the results showed that water loss (WL) and solid gain (SG) of date increased with increasing the soluble solids content of the osmotic solution (°Brix). Significant differences ($P \leq ٠.٠٥$) were observed between the osmotic solutions employed in the pretreatment. A greater change was observed for osmotic solution with high sugar content (٧٠°Brix). Water loss and sugar gain were the highest when an osmotic solution of ٧٠°Brix was used. This can be attributed not only to higher osmotic pressure of the process but also to the changes that occurred in date tissue (Fernandes *et al.,* ٢٠٠٨). Solid gain increased considerably because of the breakdowns of cell, which decreased the resistance of the tissue to the flow of large molecules, such as sugar molecules. In our results the highest and the lowest water loss and solid gain were obtained by ٧٠٪ fructose and ٥٠٪ sucrose respectively. On the other hand the highest and lowest drip loss (DL) were obtained by ٥٠٪ glucose and ٧٠٪ fructose, respectively. One interesting variable is evaluation the concentration of osmotic agent

that can influence on mass transfer kinetics. The present results showed that increase of solute concentrations resulted in the decrease of DL throughout the osmotic process. High solid gain (١١.١٨) in the case of using ٧٠°Brix glucose can be explained with its high absorption characteristic. In addition to supplying low solid gain (٤.٥٨٪) of using ٥٠٪ sucrose. Fructose supplies high osmotic pressure in fruit by virtue of water bonding capacities.

Thus, fructose and glucose solution at ٧٠°Brix concentration are the best in osmotic dehydration of date due to high water loss. These results are in accordance with the work of Falade et al., (٢٠٠٧). The drip loss on dry basis during thawing of the osmotically treated frozen samples is reported in Table (٤). It could be noted also that the dehydrated samples exhibited an important decrease in the drip loss for all osmotic solutions. This reduction increase with increasing the solute concentration.

Ratio of sample to solution:

The effect of ratio of sample to solution is shown in Table (٥). There were significant differences (P≤٠.٠٥) in the WL% through out the different ratios. The WL% were considerably increased when the ratio of sample to solution is decreased. The decreasing of the ratio of sample to solution avoids significant dillution of the medium by water removal and subsequent decrease of osmotic driving force during the process. No significant differences were found in SG except for the ratio ١/١٢.

Table ٥: Influence of sample to solution ratio on water loss (WL) *, solid gain (SG) * and drip loss (DL) * for dates pretreated osmotically before freezing.

Sample to solution ratio	WL %	SG %	DL %
١/٤	٢٧.٣٢ ^{d} ± ٠.٤٣	٦.٥١ ^{b} ± ٠.١٢	١.٣٤ ^{a} ± ٠.٠٥
١/٨	٢٨.١١ ^{c} ± ٠.٢٠	٦.٧٠ ^{b} ± ٠.١٣	٠.٩٧ ^{b} ± ٠.٠٢
١/١٠	٣٠.٠١ ^{b} ± ٠.٠٥	٦.٦٩ ^{b} ± ٠.١٤	٠.٨٧ ^{c} ± ٠.٠٢
١/١٢	٣١.٧٣ ^{a} ± ٠.٣٩	٧.١٩ ^{a} ± ٠.٠٨	٠.٧٦ ^{d} ± ٠.٠٢

* $^{a\,b\,c\,d}$. Values with the same letter in the same column are not significantly different (p≤٠.٠٥).

Means ± SD of triplicate

DL values decrease with increasing the solute ratio. The data revealed that there were significant differences (P≤٠.٠٥) in DL values. Increasing volume of osmotic media increases the mass transfer rate and, more solution volume more water loss and solid's gain. Therefore, the weight ratio of solution to sample should be optimized as conducted in experiment at ٣٠°C, ٢٤hrs and ٧٠٪sucrose. In this work, it can be seen that the dehydration rate for ١/١٢ ratio is the best ratio. It increases the WL and SG from (٢٧.٣٢-٦.٥١)at١/٤ ratio to (٣١.٧٣-٧.١٩), respectively. This result is in harmony with other researcher's results (Singh, ٢٠٠١ and Khoyi and Hesari, ٢٠٠٧).

Temperature of osmotic media:

It is well recognized that high temperatures of osmotic media cause accelerated mass transfer. Higher process temperature seems to promote faster water loss through swelling and plasticizing of cell membranes, faster water diffusion within the product and better mass (water) transfer characteristics on the surface due to lower viscosity of the osmotic medium (Devic *et al.,* ٢٠١٠). As shown in Table (٦) there were significant differences (P≤٠.٠٥) in WL, SG and DL. It seems that at ٥٠°C the WL and SG were increased greatly. Data of Table (٦) showed that at ٧٠٪ sucrose, increasing temperature from ٣٠°C to ٥٠°C, had much higher effect on the WL and SG, they were increased from (٣٠.٠١, ٦.٦٩٪) to (٥٠.٣٨, ١١.٣٥٪), respectively. DL decreased from ٠.٨٧ to ٠.٤٣٪. So the best temperature is found to be ٥٠°C.

Table ٦: Influence of solute temperature on water loss (WL), solid gain (SG) and drip loss (DL) for dates pretreated osmotically before freezing.

Solution temperature	WL %	SG %	DL %
٣٠ °C	٣٠.٠١ ^{c} ±٠.٠٥	٦.٦٩ ^{b} ±٠.١٤	٠.٨٧ ^{a} ±٠.٢٠
٤٠ °C	٤٣.٢٣ ^{b} ±٠.٢٥	١٠.٧٤ ^{a} ±٠.٣٦	٠.٦٣ ^{b} ±٠.٠٢
٥٠ °C	٥٠.٣٨ ^{a} ±٠.٥٧	١١.٣٥ ^{a} ±٠.٦٣	٠.٤٣ ^{c} ±٠.٠١٥

* $^{a\ b\ c}$ Values with the same letter in the same column are not significantly different (p≤٠.٠٥).

Means ± SD of triplicate

It must be kept in mind that increasing temperature was associated with increase of WL an SG because of two reasons: the first related to increasing diffusion coefficients and the second associated with decreasing viscosity of sucrose solution. This is in agreement with similar observations by Ispir and Togrul (٢٠٠٩) and Mundada *et al.* (٢٠١١).

Immersion time during osmotic dehydrofreezing:

It can be seen in Table (٧) that there were significant differences (P≤٠.٠٥) in WL and SG. AT ٦hrs, the WL and SG was ١١.٣١٪ and ٣.١٩ %, respectively. At ٣٠hrs, the WL and SG have reached its highest value ٣٧.٩٥٪ and ٨.٦٩٪, respectively. These results indicated to the longer periods of pre-treatment lead to higher WL and SG. This is constant with the fact that the penetrations of sucrose keep always growing. The DL during thawing of osmotically treated frozen samples is reported in Table (٧). There were, no significant differences in DL at ٦hrs and ١٢hrs, the same trend at ٢٤hrs and ٣٠hrs. DL values decreased with increasing the periods. At the beginning of the process DL was ١.٢٥ % and with the elongation dehydrating time to ٣٠ hrs it is became ٠.٨٢٪. As regards osmotic dehydrofreezing has demonstrated to be useful for limiting the drip loss. The results are in agreement with those of Marani et al., (٢٠٠٧). However osmotic dehydrofrozen treatment for longer period of time with sugar solution gave much loss of moisture and high solid gain.

Table ٧: Nfluence of immersion time on water loss (WL), solid gain (SG) and drip loss (DL) for dates pretreated osmotically before freezing.

Immersion time	WL %	SG %	DL %
٦hrs	١١.٣١ ^{e} ±٠.٤٨	٣.١٩ ^{e} ±٠.٢٥	١.٢٥ ^{a} ±٠.٠٣
١٢ hrs	١٦.٠٠ ^{d} ±٠.٧٠	٣.٣٨ ^{d} ±٠.٤٨	١.٢٤ ^{a} ±٠.٠٧
١٨ hrs	٢٥.٩٢ ^{c} ±٠.١٩	٦.٠٥ ^{c} ±٠.٠٧	٠.٩٧ ^{b} ±٠.٠١٥
٢٤ hrs	٣٠.٠١ ^{b} ±٠.٠٥	٦.٦٩ ^{b} ±٠.١٤	٠.٨٧ ^{c} ±٠.٠٢
٣٠ hrs	٣٧.٩٥ ^{a} ±٠.٣٧	٨.٦٩ ^{a} ±٠.٣٢	٠.٨٢ ^{c} ±٠.٠١٥

* $^{a\ b\ c\ d\ e\ f}$ Values with the same letter in the same column are not significantly different (p≤٠.٠٥).
Means ± SD of triplicate

Fruit style of sample:

The Fruit style of sample pieces affects the behavior of the osmotic concentration due to the variation of the surface area per unit volume (or mass) and diffusion length of water solutes involved in mass transport (Lerici et al., ١٩٨٥). It can be seen in Table (٨) that there were a significant differences (P≤٠.٠٥) in WL and SG. A surprise results that the WL% increased from ٦.٥٥٪ in the whole fruit to ٥٠.٣٨ in the half of fruits. Also, the SG increased from ٢.١٨٪ to ١١.٣٥٪.

Table ٨: Influence of geometry of sample on water loss (WL), solid gain (SG) and drip loss (DL) for dates pretreated osmotically before freezing.

Fruit style	WL %	SG %	DL %
Whole fruits	٦.٥٥ **b** ±٠.٣٨	٢.١٨ **b** ±٠.١٣	١.٣٤ **a** ±٠.١٩
Halves	٥٠.٣٨ **a** ±٠.٥٧	١١.٣٥ **a** ±٠.٦٣	٠.٤٨ **b** ±٠.١٥

* **a b**. Values with the same letter in the same column are not significantly different (p≤٠.٠٥).
Means ± SD of triplicate

Results indicated that the water loss and solid gain were increased when the dimention of date decreased because of increasing contact surface area and deforming of the cell. Khoyi and Hesari (٢٠٠٧) reported similar results of the results of this study. The DL decreased from ١.٣٤ for the whole fruit to ٠.٤٨ of the half fruit.

Tissue structure:

Microstructural features (i.e. cell form) such as shape and size change in cell and intercellular spaces, cell wall deformations relaxation changes are captured by microscopic techniques (Aguilera and Lillford,١٩٩٦).The microscopic image analysis of the fresh, frozen and pretreatment date by ٧٠٪sucrose for ٢٤hrs, ratio ١/١٠, half at ٥٠°C showed that parenchyma cell (Fig. ٢). The parenchyma cells (white cells) of the fresh fruit were mostly round-shaped. Tissue of fresh date showed round clearly visible cell with contact cell walls. The inter cellular spaces are recognized as small space. Large white

spots correspond to vascular bundles. Fig. (٣) showed date tissue which was frozen at -٤٠ °C induced large changes of the cellular structure : cell walls seemed to be collapsed. More and larger intercellular spaces were observed. A lot of dark area appeared in the cross sections. Fruit texture was to be damaged by freezing. Freezing produced an abnormality of cell shape, damage in cell wall and increase the light density of cytoplasm in date cell. These changes in tissue structure were first reported by Fernandes et al. (٢٠٠٩). The reason was that fruit consist of much quantity of water, so ice crystals damaged the cellular structure of fruits (Li and Sun, ٢٠٠٢). A decrease in moisture content was directly related to the water which available to freezing and if less quantity of water was frozen then it would less damage to fruits (Lazar, ١٩٧٨). Therefore, a pretreatment was done with date fruit in this work decreased the water content and help in improving quality of frozen fruit.

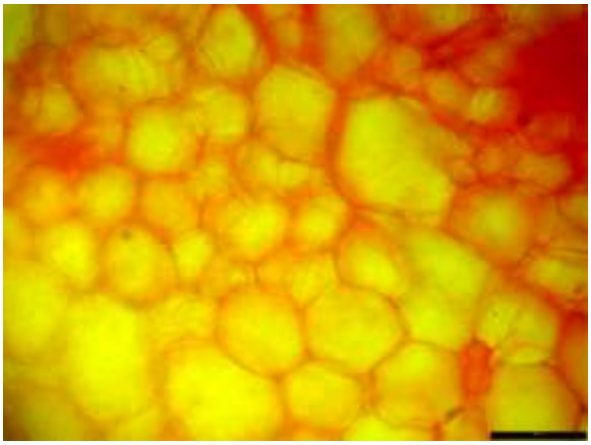

Fig. ٢. Photomicrograph of fresh date (before processing)

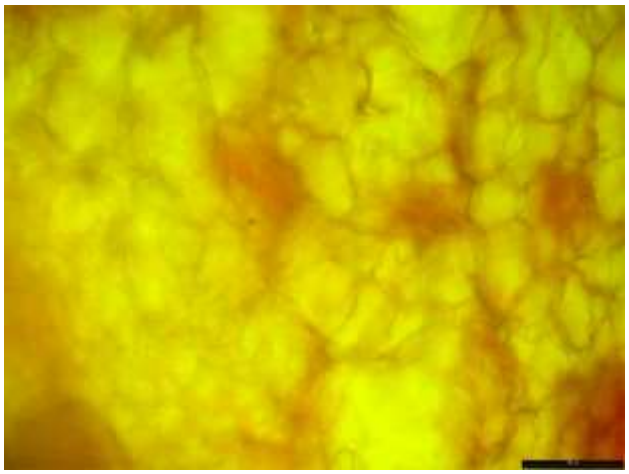

Fig. ٣. Photomicrograph of untreated frozen date at - ٤٠◦C

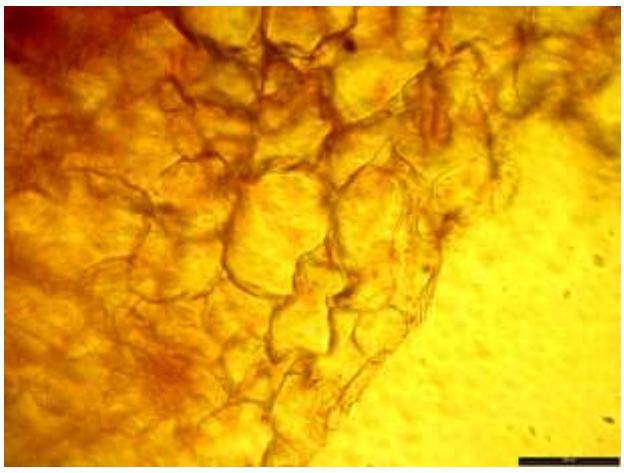

Fig. ٤. Photomicrograph of frozen dates pretreated by the osmo dehydro-freezing using ٧٠◦Brix (١/١٠sample to solution rat at٥٠°c for ٢٤ hrs.

Osmotic treatments for date in ٧٠٪ sucrose solution showed that the cells became more distorted (Fig. ٤) and the microscopic channels was accompanied by break-down (rupture) of cell walls. The cell walls became distorted and smaller in all regions of the samples where loss of adhesion of the cells was observed in some regions causing an increase of intercellular spaces that may be caused by the solubilistion

of chelator-soluble pectin of the middle lamella. Osmotic treatment showed drip losses (٠.٤٨٪ in Table ٨) and tissues damage (Fig. ٤) of osmo-dehydrofrozen date were much lower than that of non-treated samples. Solid gain increased considerably after ٢٤hrs because of the appearance of micro-channels and breakdown of cell, which decreased the resistance of the tissue to the flow of large molecules, such as sucrose molecules. The large micro-channels formed in the fruit tissue explain the low resistance of the tissue toward the flow of molecules in the fruit and the consequent higher sugar and water loss observed when this osmo-dehydrofreezing condition was applied (Table ٧ and Fig. ٤). The same results reported by Fernandes et al. (٢٠٠٨) and Ando et al. (٢٠١٢).

CONCLUSION

The osmotic dehydration prior to freezing on date has demonstrated to be useful for limiting the drip loss and reducing structural collapse of fruit tissues during thawing. Finally, it can be concluded that factors such as using osmotic agent (sucrose), high concentration (٧٠°Brix) of osmotic agent, high processing temperature (٥٠°C), immersion time (٢٤hrs), the ratio of sample to solution (١/١٠) and half of date fruit were more pronounced for water loss, solid gain and drip loss. Therefore, this knowledge can be used to optimize osmotic dehydrofreezing and quality product.

REFERENCES

Aguilera, J.M. and Lillford, P.J. (١٩٩٦). Microstructural and imaging analyses are related to food engineering. In: Food Engineering ٢٠٠٠. Fito P, Ortega-Rodriguez E, Barbosa-Canovas GV (Eds.). Chapman and Hall, New York, USA. pp. ٢٣-٣٨.

AOAC (١٩٩٨). Official Methods of Analysis, Association of Official Analytical Chemists, Washington, DC.

Ando ,H.; Kajiwara, K. ; Oshita, S. and Suzuki,T. (٢٠١٢). The effect of osmotic dehydrofreezing on the role of the cell

membrane in carrot texture softening after freeze-thawing. J. of Food Eng., ١٠٨: ٤٧٣–٤٧٩.

Anwar-Shinwari, M. (١٩٨٧). Iron content of date fruits. J. of the College of Science-King-Saud-University, ١٨: ٥–١٣.

Blanda, G.; Cerretani, L.; Bendini, A.; Cardinali, A.; Scarpellini, A. and Lercker, G. (٢٠٠٨). Effect of vacuum impregnation on the phenolic content of Granny Smith and Stark delicious frozen apple cvv. European Food Research and Technol., ٢٢٦: ١٢٢٩–١٢٣٧.

Devic, E.; Guyoi, S. ; Daudin, J. and Bonazzi, C. (٢٠١٠). Effect of temperature and cultivar on polyphenol etention and mass transfer during osmotic ehydration of apples. J. of Agri. and Food Chem., ٥٨: ٦٠٦-٦١٤.

Duncan, D. B., (١٩٥٥). Multiple ranges and multiple F-test. Biometric, ١١: ١٠٤٢.

El-Aouar, A.A.; Azoubel, M.P.; Barbosa, L.J. and Murr, X.E.F. (٢٠٠٦). Influence of osmotic agent on the osmotic dehydration of papaya (*Carica papaya L.*). J. of Food Eng., ٧٥: ٢٦٧-٢٧٤.

Falade, K.O. and Adelakun, A.T. (٢٠٠٧). Effect of prefreezing and solutes on mass transfer during osmotic dehydration and color of oven-dried African star apple during storage. Int. J. of Food Sci. and Technol., ٤٢: ٣٩٤-٤٠٢.

F.A.O. (٢٠١٠). Food and Agriculture Organization of the United Nations, World and Egypt production. Static`s of crops(fruit and vegetables).

Fernandes, F.A.N.; Gallao, M. I. and Rodrigues, S. (٢٠٠٨). Effect of osmotic dehydration and ultrasound pre-treatment on cell structure: Melon dehydration. LWT, ٤١: ٦٠٤–٦١٠.

Fernandes, F.A.N.; Gallao, M. I. and Rodrigues, S. (٢٠٠٩). Effect of osmosis and ultrasound on pineapple cell tissue structure during Dehydration. J. of Food Eng., ٩٠ :١٨٦–١٩٠.

Forni, E.; Torreggiani, D.; Crivelli, G.;Mastrelli, A.; Bertolo, G., and Santelli, F. (١٩٨٧). Influence of osmosis time on the quality of dehydrofrosen kiwifruit. Acta Horticulturae, ٢٨٢:٤٢٥–٤٣٣.

Gamil-Abdel-Hafez, M.; Fouad-Shalaby, A. and Akhal, I. (١٩٨٠). Chemical composition of ١٥ varieties of dates grown in Saudi Arabia. Fourth Symposium on biological aspects of Saudi Arabia, ٨٩–٩١.

Huxon, C.C., (١٩٨٢). Reducing the refrigeration load by partial concentration of food prior to freezong. Food Technol., ١٧: p. ٣٨٧-٤٠٣.

Ispir, A. and Togrul, I.T. (٢٠٠٩). Osmotic dehydration of apricot: Kinetics and the effect of process parameters. Chemical eng. research and design, ٨٧ : ١٦٦–١٨٠.

Karathanos ,V.T.; Kostarropoulos, A.E. and Saravacos, G. D. (١٩٩٥). Air drying kinetics of osmotically dehydrated fruits. Drying Technol., ١٣:١٥٠٣-١٥١٢.

Khan,M.R.(٢٠١٢). Osmotic dehydration technique for fruits preservation-A review. Pakistan J. of Food Sciences, ٢٢: ٨٥-٧١.

Khoyi, M.R. and Hesari, J. (٢٠٠٧). Osmotic dehydration kinetics of apricot using sucrose solution. J. of Food Eng., ٧٨(٤): ١٣٥٥–١٣٦٠.

Kulkarni, S.G. ; Vijayanand, P. ; Aksha, M. ; Reena, P. and Ramana, K.V.R.(٢٠٠٨). Effect of dehydration on the quality and storage stability of immature dates (Pheonix dactylifera). LWT - Food Sci. and Technol., ٤١:٢٧٨-٢٨٣.

Lazar, M. E. (١٩٧٨). Dehydrofreezing of fruits and vegetables. In D. K. Tressler, and C. F. Evers (Eds.), The freezing preservation of foods (pp. ٣٤٧–٣٧٦).Wextport, Conn., USA: Avi Publishing Co.

Lerici, C.R.; Pinnavia, G. ; Rosa, M. D. and Bartolucci, L. (١٩٨٥). Osmotic dehydration of fruit: influence of osmotic agents on drying behaviour and product quality process. J. Food Technol.,٧: ١٤٧-١٥٥.

Li, B. and Sun, D. (٢٠٠٢). Novel methods for rapid freezing and thawing of foods – a review. J. of Food Eng., ٥٤ : ١٧٥–١٨٢.

Marani, C.M. ; Agnelli , M.E. and Mascheroni, R.H.(٢٠٠٧). Osmo-frozen fruits: mass transfer and quality evaluation. J. of Food Eng., ٧٩ : ١١٢٢–١١٣٠.

Mundada, M.; Hathan, S.B. and Maske, S. (٢٠١١). Mass transfer kinetics during osmotic dehydration of pomegranate arils. J. of Food Sci., ٧٦: ٣١-٣٩.

Martinez-Navarrete, N.; Moraga, G.; Martinez-Monzo , J.; Botella, F.; Tirado, N. and Chiralt, A. (٢٠٠١). Mechanical and color changes associated to dehydrofreezing of strawberry. In J. Welti-Chanes, G. V. Barbosa-Canvas, and J. M. Aguilera (Eds.), Proceedings of the Eighth International Congress on Engineering and Food: ICEF-٨ (pp. ٧٩٣–٧٩٧). Lancaster, PA, USA: Technomic Publishing Company, Inc.

Nasar, M.A and Alsahar, K.F(١٩٩٨). Plant preparations and microscopic examination (Micro technic) Academic library.

Pokharkar, S.M.;Prasad, S. and Das, H. (١٩٩٧). A model for osmotic concentration of bananas slices. Journal Food Science and Technology, ٣٤, ٢٣٠–٢٣٢.

Robbers, M.; Singh, R. P. and Chuna, L. M. (١٩٩٧). Osmotic-convective dehydrofreezing process for drying kiwifruit. J. of Food Sci., ٦٢: ١٠٣٩–١٠٤٧.

Sakr, M.M.; Abu Zeid, I.M.; Hassan, A.E.; Baz, A-G.I.O. and Hassan, W.M. (٢٠١٠). Identification of some Date palm (Phoenix dactylifera) cultivars by fruit characters) cultivars by fruit characters. Indian J.Sci.Technol., ٣:٣٣٨-٣٤٣.

SAS Institute. (٢٠٠٣). SAS User's Guide: Statistics. SAS Institute, Cary, NC.

Singh, H. (٢٠٠١). Osmotic dehydration of carrot shreds for Gazraila preparation. J. Food Sci. Technol., ٣٨:١٥٢–١٥٤.

Talens, P.; Hartong, S.; Martınez-Navarrete, N.; Chiralt, A. and Fito, P. (٢٠٠٠). Kinetics and equilibrium status in osmotic dehydration of strawberry. In P. J. A. M. Kerkhof, & W. J. Coumans (Eds.), Proceedings International Drying Symposium IDS ٢٠٠٠ (Paper N_١٠١). Amsterdam: Elsevier Sci.

Torreggiani, D. (١٩٩٣). Osmotic dehydration in fruit and vegetable processing. Food Research Int., ٢٦(١):٥٩-٦٨.

Wu, L.; Orikasa, T.; Tokuyasu, K.; Shiina, T. and Tagawa, A. (٢٠٠٩). Applicability of vacuum-dehydrofreezing technique for the long-term preservation of fresh-cut eggplant: effects of process conditions on the quality attributes of the samples. J. of Food Eng., ٩١:٥٦٠–٥٦٥.

Mass transfer and microstructure of dates

انتقال الكتلة والتركيب الدقيق أثناء التجفيد الاسموزي للبلح

سوزان سعد لطيف ، هاني مصطفي علي ، محمد نجيب قناوي ، اسأمه إسماعيل احمد سلطان
قسم علوم الأغذية – كليه الزراعة – جامعه المنيا

يمثل التجفيد الاسموزي معامله تكنولوجيه لتقليل فاقد الفواكه بعد الحصاد، و يشير إلى عمليه متكاملة للتجفيف الجزئي في محاليل مركزه (التجفيف الاسموزي) يتبعها التجميد. تم دراسة تأثير المعاملات المختلفة علي المعاملة المبدئية للتجفيف الأسموزي البلح فيما يعرف بفقد الماء وزيادة المواد الصلبة باستخدام محلول اسموزي (سكروز، جلوكوز ، وفركتوز)، بتركيز ٥٠-٧٠% وزن /وزن، ودرجه حراره ٣٠-٥٠°م ونسبه العينات إلي المحلول(١/٤: ١/١٢)، وزمن المعاملة (٦-٣٠ ساعة)، وشكل العينة (أنصاف- ثمار كاملة). وأوضحت النتائج أن زيادة التركيز ودرجه حرارة المحاليل الأسموزيه تسبب زيادة ملحوظة في فقد الماء وزيادة المواد الصلبة. يؤدي نقص نسبه العينات للمحلول إلى عدم تخفيف المحلول وزيادة فقد الماء وزيادة المواد الصلبة. بإلاضافه إلي وجود اختلافات معنوية في فقد الماء وزيادة المواد الصلبة عند انخفاض حجم البلح وزيادة مده الغمر. وتعكس صور الميكروسكوب الضوئي تأثيرا معنويا للمعاملات الأسموزيه علي الخصائص التركيبية (جدار الخلية والخلايا البرانشيميه). وعامه تبين أن ألمعامله الأسموزيه للبلح في محلول سكري تركيزه ٧٠% ودرجه حرارة ٥٠°م ساعد على انخفاض كبير في السائل المنفصل (الناضح) وتحطيم الخلايا للبلح المعامل مقارنة بالبلح الغير معامل.