# Osmotic dehydration of pomegranate seeds (*PUNICA GRANATUM* L.)


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## Introduction

The demand for healthy, natural and tasty processed fruits increased continuously, not only for finished products, but also for ingredients that can be included in some food formulation such as ice-cream, cereals, dairy, confectionery and bakery products. In fact, over the last few decades, a lot of research studies about processing of fruits and vegetables were developed using osmotic dehydration (OD). Osmotic dehydration has a lot of benefit, like the use of a low energy and cost compared to other dehydration methods. In addition, it involves effective inhibition of polyphenoxidase, prevention of loss of volatile compounds, even under vacum and reduction of heat damage to color and flavor during dehydration. Nowadays, the industry uses this technique for some previously cutted fruit like apple, banana, mango, apricot, between others. This process has not been used for the conservation of whole pomegranate seeds, neither by scientifics nor by industrials.

The aim of this work was firstly to investigate the kinetics of osmotic dehydration and to determine the influence of osmotic conditions, such as temperature and osmotic solutions on mass transfer during osmotic dehydration of whole pomegranate seeds. And secondly to characterize the internal changes in osmotically dehydrated pomegranate seeds in sucrose, glucose and mixture sucrose & glucose using differential scanning calorimetry (DSC).

## Experimental strategy

*Fresh seeds* ⇒ Freezing treatment ⇒ *Frozen seeds* ⇒ Osmotic dehydration treatment ⇒ Conditions

**Conditions:**

**Time :**
0-20-40-60-80-100-120 min

**Temperature :**
30 – 40 - 50 °C

**Volume Ratio :**
seeds/solution:1/4

**Solution :**
Sucrose, glucose, sucrose/glucose (55 °Brix)

⇒ **Parameters**

**Mass transfer** :
- Water loss (WL)
- Solids gain (SG)
- Weight reduction (WR)

**Physico-chemical :**
- pH, $a_w$
- MS, $D_{df}$, conductivity
- °Brix, color (L*, a*, b*)

**Thermal :**
- Glass transition temperature
- Melting point
- Enthalpy of fusion
- Unfreezable water

## Résultats

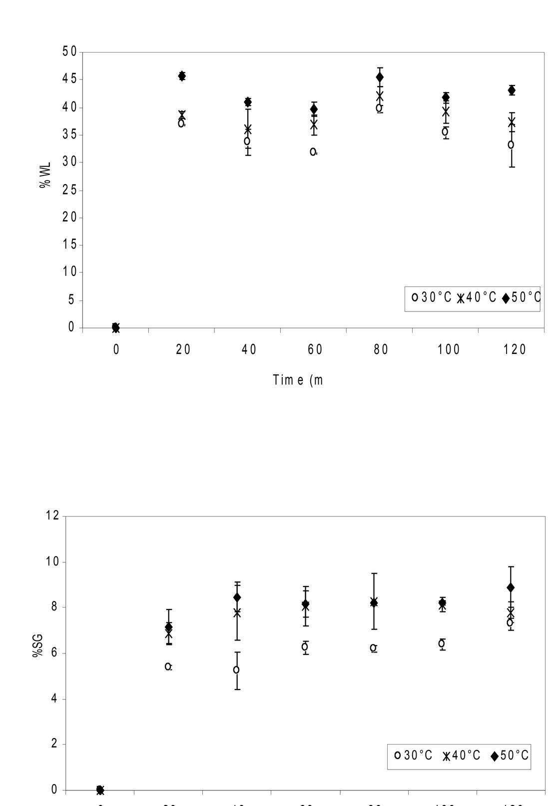

**Figure .** Variation of water loss (WL) and solids gain (SG) with time and temperature (30, 40, 50°C) using sucrose solution during osmotic dehydration.

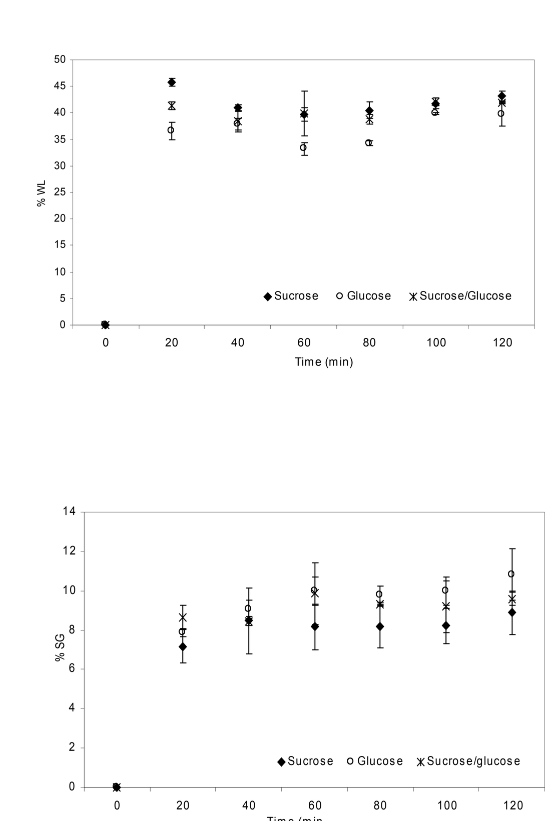

**Figure .** Comparison of WL (a) and SG (b) using different osmotic solutions (sucrose, glucose and mixture sucrose & glucose) at 50°C.

**Table .** Water and solids effective diffusivities calculated by Fick's model

| | | Water loss | | Solids gain | |
|---|---|---|---|---|---|
| **Sugar** | **T (°C)** | **$D_{dfw}$ ($m^2s^{-1}$)** | **$R^2$ (%)** | **$D_{dfs}$ ($m^2s^{-1}$)** | **$R^2$(%)** |
| Sucrose | 50°C | $9.44 \times 10^{-12}$ | 99.92 | $4.81 \times 10^{-12}$ | 99.72 |
| | 40°C | $8.09 \times 10^{-12}$ | 99.89 | $4.72 \times 10^{-12}$ | 99.88 |
| | 30°C | $7.43 \times 10^{-12}$ | 99.66 | $4.21 \times 10^{-12}$ | 99.80 |
| Sucrose/glucose | 50°C | $9.10 \times 10^{-12}$ | 99.93 | $5.44 \times 10^{-12}$ | 99.92 |
| | 40°C | $7.88 \times 10^{-12}$ | 99.77 | $4.54 \times 10^{-12}$ | 99.89 |
| | 30°C | $6.98 \times 10^{-12}$ | 99.77 | $4.48 \times 10^{-12}$ | 99.87 |
| Glucose | 50°C | $8.74 \times 10^{-12}$ | 99.83 | $9.54 \times 10^{-12}$ | 99.88 |
| | 40°C | $6.69 \times 10^{-12}$ | 99.68 | $6.52 \times 10^{-12}$ | 99.89 |
| | 30°C | $5.41 \times 10^{-12}$ | 99.65 | $4.94 \times 10^{-12}$ | 99.50 |

**Table .** Evolution of osmotic dehydration parameters in sucrose solution at different temperatures 30, 40, and 50°C

| | 0 min | 20 min | 40 min | 60 min | 80 min | 100 min | 120 min |
|---|---|---|---|---|---|---|---|
| **30°C** | | | | | | | |
| **°Brix of solution** | 55.00±0.00$^{a}$ | 51.10±0.63$^{b}$ | 49.80±0.10$^{b}$ | 49.10±0.70$^{b}$ | 49.40±0.10$^{b}$ | 49.40±0.20$^{b}$ | 49.30±0.20$^{b}$ |
| **°Brix of seeds** | 15.50±0.09$^{a}$ | 39.55±0.63$^{b}$ | 42.85±0.07$^{c}$ | 44.55±0.07$^{d}$ | 45.10±0.28$^{d}$ | 46.25±0.07$^{e}$ | 46.60±0.14$^{e}$ |
| **pH of solution** | 8.27±0.03$^{a}$ | 4.89±0.09$^{b}$ | 4.68±0.08$^{c}$ | 4.54±0.06$^{cd}$ | 4.52±0.04$^{cd}$ | 4.48±0.05$^{d}$ | 4.46±0.08$^{d}$ |
| **Conductivity of solution (µs/cm)** | 0.90±0.01$^{a}$ | 31.75±0.63$^{b}$ | 36.05±1.62$^{c}$ | 39.80±0.84$^{d}$ | 40.80±0.70$^{de}$ | 42.20±1.27$^{de}$ | 43.20±1.27$^{e}$ |
| **Dry matter of seeds (%)** | 16.00±0.05$^{a}$ | 39.30±1.30$^{b}$ | 41.20±1.40$^{b}$ | 45.20±2.60$^{c}$ | 45.20±0.10$^{c}$ | 46.80±0.70$^{c}$ | 48.20±0.10$^{c}$ |
| **40°C** | | | | | | | |
| **°Brix of solution** | 55.00±0.00$^{a}$ | 50.00±0.84$^{b}$ | 50.40±0.84$^{bc}$ | 49.40±0.28$^{cd}$ | 49.20±0.14$^{d}$ | 49.15±0.12$^{d}$ | 49.05±0.14$^{d}$ |
| **°Brix of seeds** | 15.50±0.09$^{a}$ | 40.85±0.07$^{b}$ | 43.35±0.21$^{c}$ | 45.40±1.31$^{e}$ | 45.60±1.13$^{e}$ | 45.85±0.35$^{e}$ | 46.85±0.63$^{e}$ |
| **pH of solution** | 8.27±0.03$^{a}$ | 4.70±0.04$^{b}$ | 4.50±0.02$^{bc}$ | 4.46±0.09$^{c}$ | 4.42±0.17$^{c}$ | 4.43±0.12$^{c}$ | 4.40±0.04$^{c}$ |
| **Conductivity of solution (µs/cm)** | 0.90±0.01$^{a}$ | 33.00±1.83$^{b}$ | 37.35±1.76$^{bc}$ | 40.60±2.97$^{cd}$ | 43.95±3.74$^{d}$ | 42.15±2.89$^{cd}$ | 44.00±1.27$^{d}$ |
| **Dry matter of seeds (%)** | 16.00±0.05$^{a}$ | 40.90±2.97$^{b}$ | 44.20±0.18$^{bc}$ | 45.90±1.02$^{c}$ | 47.30±0.15$^{c}$ | 47.80±0.20$^{c}$ | 49.00±0.06$^{c}$ |
| **50°C** | | | | | | | |
| **°Brix of solution** | 55.00±0.00$^{a}$ | 49.70±0.07$^{b}$ | 49.30±0.01$^{bc}$ | 49.10±0.21$^{c}$ | 48.90±0.28$^{c}$ | 49.00±0.21$^{c}$ | 49.00±0.21$^{c}$ |
| **°Brix of seeds** | 15.50±0.09$^{a}$ | 41.60±0.14$^{b}$ | 45.30±0.14$^{c}$ | 46.40±0.14$^{d}$ | 46.90±0.14$^{d}$ | 48.70±0.28$^{e}$ | 49.10±0.07$^{e}$ |
| **pH of solution** | 8.27±0.03$^{a}$ | 4.60±0.27$^{b}$ | 4.50±0.20$^{b}$ | 4.50±0.01$^{b}$ | 4.40±0.02$^{b}$ | 4.30±0.10$^{b}$ | 4.30±0.07$^{b}$ |
| **Conductivity of solution (µs/cm)** | 0.90±0.01$^{a}$ | 35.50±0.35$^{b}$ | 39.00±1.06$^{c}$ | 40.10±0.07$^{de}$ | 40.50±0.21$^{e}$ | 41.00±0.49$^{e}$ | 41.20±0.28$^{e}$ |
| **Dry matter of seeds (%)** | 16.00±0.05$^{a}$ | 42.70±0.08$^{b}$ | 46.80±0.65$^{c}$ | 47.80±0.83$^{cd}$ | 48.30±0.41$^{cde}$ | 48.60±0.73$^{de}$ | 49.50±0.76$^{e}$ |

All values given are means of three determinations. Means in line with different letters are significantly different ($P<0.05$)

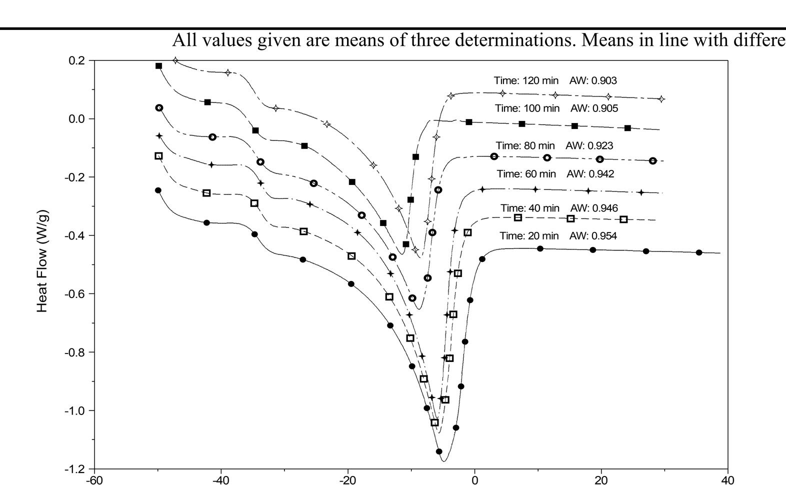


**Figure :** DSC thermogram obtained for pomegranate seeds soaked in sucrose solution at 50°C.

## Conclusion

❖ The rate of different parameters was directly related to temperature, time, and solute. In fact process showed that operating 20 min at 50°C offered the best result. As a consequence, it could be better to stop the process after 20 min as it implies no addition of thermal energy to the system.

❖ The nature of sugar used for the dehydration solution involves modifications in the evolution of mass transfers and effective diffusivity during the process. Therefore we suggest using sucrose solution to have the best dehydration.

❖ DSC data provide complementary information on the mobility changes of water and solute in osmotically dehydrated pomegranate seeds. Product presented a higher % of UFW than % of frozen water, this is an advantage for a better conservation of seeds. product presented a higher % of UFW than % of frozen water, this is an advantage for a better conservation of seeds.

❖ The finished product has an attractive colour and presents a good texture in mouth, a pleasant sugar taste and a good aroma. Osmotic dehydration process found to be good alternative to valorize pomegranate seeds, suggesting the use of these products as ingredients in foods formulations.