International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(4): 1280-1284

Received: 15-05-2017
Accepted: 16-06-2017

Sudharshan Reddy Ravula
College of Agricultural Engineering, Bapatla, ANGRAU, Andhra Pradesh, India

Divyasree Arepally
Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur, West Bengal, India

Ganduri Sandeep
College of Agricultural Engineering, Bapatla, ANGRAU, Andhra Pradesh, India

Surender Reddy Munagala
Food Technology, Osmania University, Hyderabad, Telangana, India

Parabhaker Reddy Ravula
Department of Chemical Engineering, RGUKT, Basar, Telangana, India

Correspondence
Sudharshan Reddy Ravula
College of Agricultural Engineering, Bapatla, ANGRAU, Andhra Pradesh, India

Effect of process variables on osmotic dehydration of carrot slices

Sudharshan Reddy Ravula, Divyasree Arepally, Ganduri Sandeep, Surender Reddy Munagala and Parabhaker Reddy Ravula

Abstract
The objective of the present investigation was to study the effect of temperature (45–55 °C), immersion time (2 and 3 h), and sucrose (45–55% w/v) concentrations on the water loss (WL), solid gain (SG), and Rehydration ratio (RR) of osmotic dehydrated carrot slices. Moreover, the sensory attributes such as colour, taste, appearance, flavour and overall acceptability for both dehydrated and rehydrated carrot slices was also observed. All the dependent variables were significantly affected by the independent variables. In the present investigation, the optimum condition for dehydrated carrot slices was found to be as 55% w/v at 55 °C for 2 h.

Keywords: Carrot, Osmotic, Sugar, Weight loss, Rehydration ratio

Introduction
Osmotic dehydration is one of the pre-treatment processes prior to hot air drying to obtain the high quality of fruits and vegetables. The conventional drying process of fruits, using hot air, is generally expensive due to the water phase change **(**da Silva *et al*., 2013**)** [1] and also requires high energy requirement (Reddy *et al*., 2017) [7]. Osmotic dehydration (OD) is recognized as an economical method of partial dehydration found wide application in the preservation of food-materials since it lowers the water activity of fruits and vegetables. Osmatic dehydration is the partial removal of water from the cellular materials when placed in a concentrated solution of soluble solute and as a consequence requiring less air-drying time (Souza *et al*. 2007) [9]. Three major flows occur during osmotic dehydration: a) flow ofwater from the food into the solution, b) a simultaneous solute transfer from the solution into the food and c) flow of natural solutes such as sugars, organic acids, minerals, salts, etc., draining from the food into the solution. These mass exchanges may have an effect on the organoleptic and nutritional quality of the dehydrated product (Sablani *et al*., 2002; Waliszewski *et al*., 2002) [8, 12]. Osmatic dehydration is effective even at room temperature and retains the color, flavour and texture of food from heat, used as a pre-treatment to improve the nutritional, sensorial and functional properties of food.
Generally, in the process of osmotic dehydration the fruit slices or cubes are treated with the solutes such as sugar syrup whereas vegetables are treated with the salt (sodium chloride) or brine. Osmotic dehydration is a multicomponent diffusion process. It is stated that there are several advantages of the osmotic dehydration process in the food industry: quality improvement in terms of colour, flavour and texture, energy efficiency, packaging and distribution cost reduction, no chemical pretreatment, providing required product stability and retention of nutrients during storage (Sablani *et al*., 2002, El-Aouar *et al*., 2006) [8, 2]. The extensive work has been carried out on osmotic dehydration of many fruits and vegetables viz., apricot (Khoyi and Hesari, 2007) [4], apple (Sablani *et al*., 2002) [8], mango (Nieto *et al*., 2001; Tedjo *et al*., 2002) [6, 10], pineapple (Lombard *et al*., 2008) [5], banana (Waliszewski *et al*., 2002) [12], tomato (Souza *et al*. 2007) [9] and potato (Eren and Kaymak-Ertekin, 2007). The rate of diffusion of water from any material depends upon different factors such as: temperature and concentration of the osmotic solution, the size and geometry of the material, the solution-to-material mass ratio and the level of agitation of the solution **(**El-Aouar *et al*., 2006) [2].
Carrot (*Daucus carota* L.) is a good source of β-carotene, thiamine, iron, vitamin C and sugar with appreciable amount of B_1, B_2, B_6, B_{12} and minerals. It is used raw and cooked as well as for the manufacture of preserves and pickles.

Drying of fruits and vegetables using different techniques has received considerable attention. Carrot have a moisture content of 86-90% (w.b.) at the time of harvest. Carrots are available in plenty only in winter season of the year. During the peak season, selling price of carrots becomes very low, leading to heavy losses to the growers (Uddin *et al*., 2004) [11]. To preserve the carrots over a period of time and also for use during off seasons, it can be preserved by any of these methods like freeze drying, cold storage, dehydration, controlled atmospheric storage. Freeze drying produces a high quality product but expensive. So there is a need for preservation by a simple method which is inexpensive and alternate process. Normally carrots have shelf life of 3-4 days but using osmatic dehydration it is increased to 7-8 months. The present paper represents the effect of different variables *viz.* temperature, solution concentration and immersion time on the water loss, solute gain, rehydration ratio and sensory score in the osmotically dehydrated carrot slices.

2. Materials and Methods

2.1. Raw material

Carrot (*Daucus carota L.*) with an initial moisture content of 86-90% (w.b.) were procured from the local market. Sugar was used as an osmatic agent and was procured from local market to prepare osmatic solution of different concentrations on the basis of (% w/v). Osmatic sugar solution was prepared by dissolving calculated amount of sugar in distilled water so as to obtain the required concentration at particular temperature in a hot water bath.

2.2 Preparation of sample for osmatic dehydration

Carrots were thoroughly washed with the water to remove dust and dirt particles adhering to the surface. After washing, carrots were peeled manually by scraping with a sharp stainless steel peeler and washed thoroughly to remove the scrapped material on carrots. This product was cut into 4-5 mm thickness and 2-3 cm diameter slices by using sharp stainless steel knife as shown in Fig. 1.

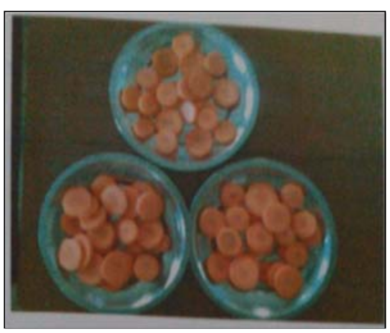

Fig 1: Carrot slices before osmotic

Fig 2: Osmotic dehydration of carrot slices dehydration

2.3 Osmatic dehydration

Carrot slices of 100 g were previously weighed and identified, and immersed in the osmatic solution with the concentration (45-55% w/v), immersion time (2-3 h) and temperature (45-55 °C) in the hot water bath as shown in Fig. 2. A carrot: solution ratio of 1:10 was used. After removing from the solution, the dehydrated slices of each group were drained and blotted with absorbent paper to remove the excess solution. The moisture content of the samples was gravimetrically measured using a hot air oven at 65 °C for 24 h. The weight and moisture content of each sample were utilized in order to calculate the response variables water loss (WL) and solids gain (SG), Rehydration ratio (RR) and sensory evaluation score according to the following equations (Lombard *et al*., 2008) [5]:

$$\text{WR}\ (\%) = \frac{(w_i - w_f)}{w_i} \times 100 \quad (1)$$

$$\text{WL}\ (\%) = \frac{(w_i X_i - w_f X_f)}{w_i} \times 100 \quad (2)$$

$$\text{Rehydration ratio} = \frac{\text{Weight of rehydrated carrots, g}}{\text{Weight of dehydrated carrots, g}} \quad (3)$$

Where w_i and w_f are the initial and final weights of the sample, respectively, (g); X_i and X_f are the initial and final moisture content, respectively, (g water/100 g initial wet carrot). Osmotically treated carrot samples were weighed by electrical balance and spread in the form of thin layer on aluminium trays to obtain the moisture content of less than 10% (w.b.) in a tray dryer. For the measurement of temperature and air velocity, thermostat, fan and temperature controller were arranged. The air velocity inside the tray dryer is maintained to be 0.3 m/s to 2.3 m/s.

2.4 Sensory evaluation

Organoleptic quality of dried carrot slices was determined with the help of a 10 member consumer panel using a 9-point hedonic scale. The evaluation of dried product was carried out in its two forms as 1) dried slices and 2) rehydrated slices. For the dried slices, the organoleptic parameters evaluated were color, appearance, odour and acceptability. In the case of rehydrated slices, the aspects taken into consideration were color, appearance, taste, flavour and overall acceptability. The average scores of all the 10 panellists were computed for different characteristics according to sensory evaluation score card as shown in Table 1.

Table 1: Sensory Evaluation score card

S. No	Scale	Characteristics
1	9	Like extremely
2	8	Like very much
3	7	Like moderately
4	6	Like slightly
5	5	Neither like or dislike
6	4	Dislike slightly
7	3	Dislike moderately
8	2	Dislike very much
9	1	Dislike extremely

3. Results and Discussion

The values of water loss (%), solute gain (%), rehydration ratio and sensory evaluation score were observed at different process variables *viz*., osmotic solution concentration, temperature, process duration). The effect of osmotic solution concentration, immersion time on water loss at constant temperature during osmotic dehydration has been studied and presented in Fig 3. At the immersion time of 2 h and 3 h, water loss was increased from 25.5 to 28.9% and 30.54 to 32.44% at a temperature of 45 °C respectively. It shows that water loss was increased with sucrose solution concentration and immersion time at constant temperature because of the decrease in moisture contents and weights of the carrots slices after the osmotic dehydration. Fig. 4 represents that by increasing the concentration from 45-55% at a temperature of 55 °C, the water loss was increased from 32.13 to 34.4% and 34.64 to 38.4% at immersion time of 2 h and 3 h respectively.

Effect of osmotic solution concentration and temperature on water loss at a process duration of 2 h and 3 hisdiscussed in Fig.5. Thewaterlosswasincreasedwithincreaseintemperature and concentration. It increased from 25.5 to 28.9% with an increase in solution concentration from 45 to 55 (% w/v) at 2 h process duration at a temperature of 45 °C. Similar changes were observed at 55 °C. At 3 h duration, the water loss was increased from 30.54 to 32.44% with increase in concentration from 45 to 55 (% w/v) at 45 °C. As a result there was a reduction in weight of the carrot slices after osmotic dehydration

Fig. 6 shows the effect of osmotic solution concentration and immersion time on solute grain at a temperature of 45 °C and 55 °C respectively. The results indicate that an increase in solute gain with increase of process duration and a decrease in solute gain with increase in osmotic solution concentration. This might be due to the high viscosity of more concentrated sucrose solution, which imparted resistance to the solute penetration at solution and carrot cube interface. The solute gain was decreased from 6.615 to 5.16% and 7.995 to 6.01% with increase in concentration from 45 to 55% w/v at 45 °C at the process time of 2 and 3 h respectively. Similar changes were observed at temperature of 55 °C.

Effect of osmotic solution concentration and temperature on solute grain at a process duration of 2 and 3 h is shown in Fig. 7. The figure indicates that an increase in solute gain with an increase of osmotic solution temperature. The solute gain was increased from 6.615 to 7.79% with increase in temperature from 45 to 55 °C at 2 h duration and 45% of solution concentration. Similar changes were found at 50 & 55% solution concentration also. At 3 h process duration the solute gain was decreased from 7.79 to 6.11% with increase in concentration from 45 to 55% at 45 °C temperature.

Fig. 8 represents the effect of temperature on rehydration ratio at a process duration of 2 h and 3 h. The rehydration ratio was decreased with increase in temperature and there is no significant change with changes in osmotic solution concentration. The rehydration ratio has decreased from 3.39 to 3.20 with increase in temperature from 45 to 55 °C, at solution concentration of 45% w/v, at process duration of 2 h. Similarchanges were observed at 50 & 55% solution concentration. At 3 h process duration also, the rehydration ratio was decreased with increase in temperature and there is no significant change with changes in osmotic solution concentration.

3.1 Effect of process variables on sensory evaluation score

In the present investigation, the sensory score was evaluated based on the panellists for both dried and rehydrated carrots samples as presented in Table 2 and Fig.8, respectively. The overall acceptability was more for treatment 6 as compared to other treatments. The sensory evaluation score had more effects with solution concentration. In order to optimize the process condition for process duration the main criteria was to maximize the water loss, rehydration ration, sensory score and minimum solute gain.

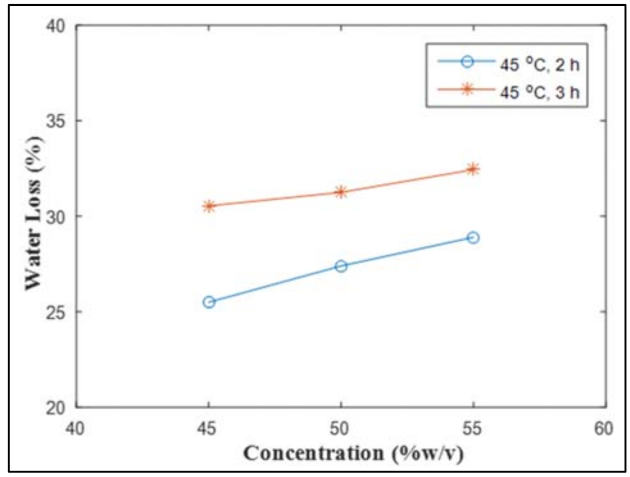

Fig 3: The effect of osmotic solution concentration, immersion time on water loss at constant temperature of 55 °C

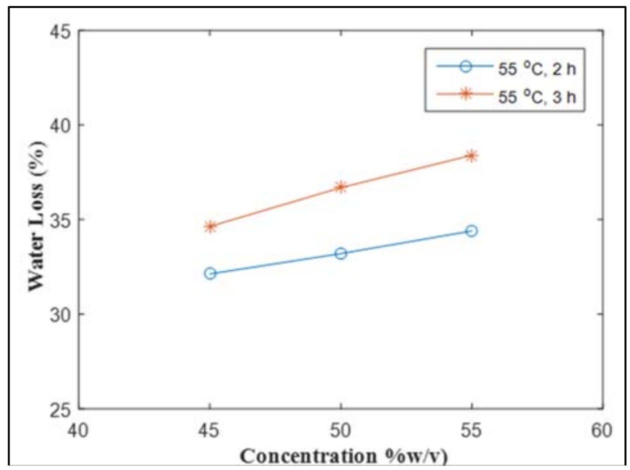

Fig 4: The effect of osmotic solution concentration, immersion time on water loss at constant temperature of 55 °C

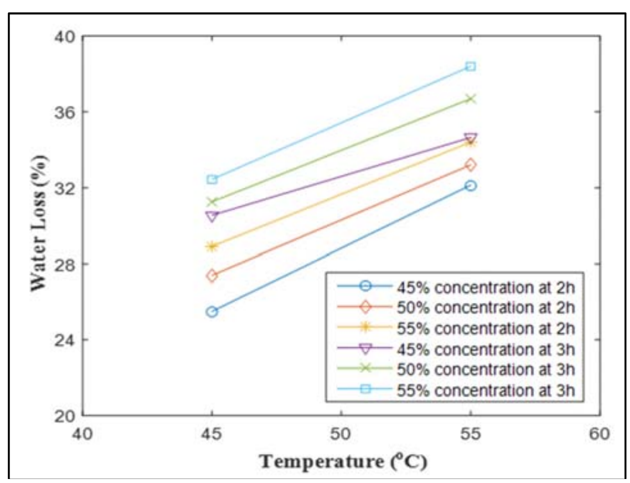

Fig 5: Effect of osmotic solution concentration and temperature on water loss at process duration of 2 h and 3 h

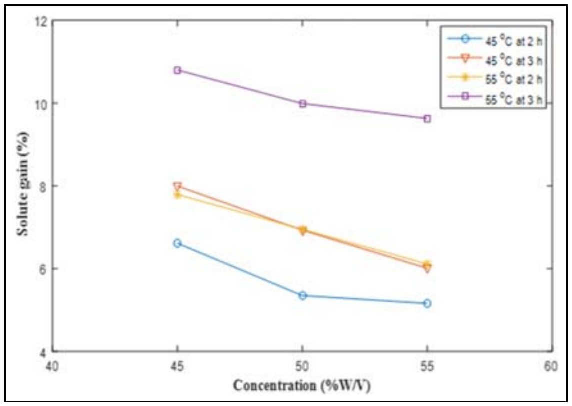

Fig 6: Effect of osmotic solution concentration and immersion time on solute grain at a temperature of 45 °C and 55 °C

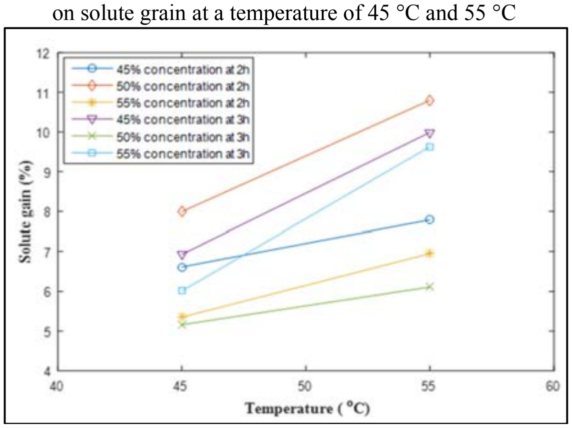

Fig 7: Effect of osmotic solution concentration and temperature on solute grain at process duration of 2 and 3 h

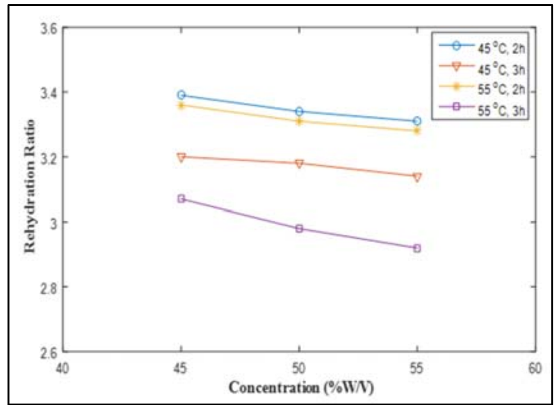

Fig 8: Effect of temperature on rehydration ratio at process duration of 2 h and 3 h

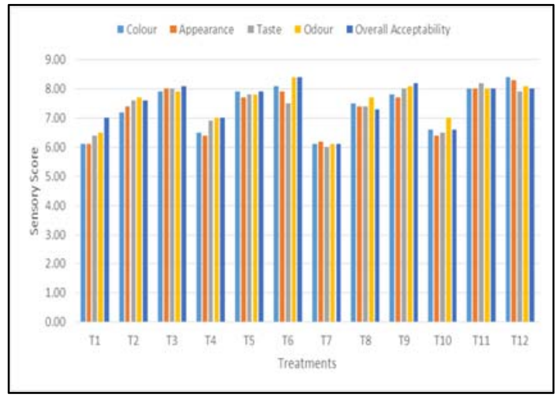

Fig 9: Sensory score for rehydrated carrot samples

Table 2: Sensory score for dried carrot samples

Treatments	Concentration (%w/v)	Time (h)	Temperature (°C)	Colour	Appearance	Odour	Acceptability to purchase
T1	45	2	45	6.3	6.00	6.50	7.00
T2	50	2	45	7.1	7.40	7.60	7.50
T3	55	2	45	7.8	8.20	8.00	7.90
T4	45	3	45	6.6	6.50	6.90	7.00
T5	50	3	45	7.8	7.60	7.70	7.80
T6	55	3	45	8.2	7.70	8.40	8.30
T7	45	2	55	6	6.20	6.00	6.10
T8	50	2	55	7.3	7.30	7.50	7.80
T9	55	2	55	7.8	7.80	8.00	8.20
T10	45	3	55	6.5	6.30	7.00	6.50
T11	50	3	55	8	8.00	8.20	7.90
T12	55	3	55	8.5	8.20	8.00	8.00

4. Conclusion

The optimum operating conditions for concentration, temperature and process duration were observed to be 55% w/v at 55 °C for 2 h. Here the water loss was found to be 34.4%, solute gain was 6.11%, rehydration ratio was 3.28 and sensory evaluation score was 8.0, which means that the panellist liked the product. The water loss was increased with increase in osmotic solution concentration, temperature and process duration due to the decrease in the weight of carrot slices after the osmotic dehydration. The solute gain was decreased with increase in osmotic solution concentration. Solute gain increase with increase in process duration and temperature. Further salt and combination of sugar and salt can be used as osmotic agent in experiments. Blanching treatment can be done before osmotic dehydration process.

5. References

1. da Silva WP, do Amaral DS, Duarte MEM, Mata ME, e Silva CM, Pinheiro RM*et al.* Description of the osmotic dehydration and convective drying of coconut (*Cocos nucifera* L.) pieces: a three-dimensional approach. Journal of Food Engineering. 2013; 115(1):121-131.
2. El-Aouar AA, Azoubel PM, Barbosa JL, Murr FEX. Influence of the osmotic agent on the osmotic dehydration of papaya (*Carica papaya* L.). Journal of Food Engineering. 2006; 75(2):267-274.
3. Eren İ, Kaymak-Ertekin F. Optimization of osmotic dehydration of potato using response surface methodology. Journal of Food Engineering. 2007; 79(1):344-352.

4. Khoyi MR, Hesari J. Osmotic dehydration kinetics of apricot using sucrose solution. Journal of Food Engineering, 2007; 78(4):1355-1360.
5. Lombard GE, Oliveira JC, Fito P, Andrés A. Osmotic dehydration of pineapple as a pre-treatment for further drying. Journal of food engineering. 2008; 85(2):277-284.
6. Nieto A, Castro MA, Alzamora SM. Kinetics of moisture transfer during air drying of blanched and/or osmotically dehydrated mango. Journal of Food Engineering. 2001; 50(3):175-185.
7. Reddy RS, Ravula PR, Arepally D, Munagala SR, Golla S. Drying kinetics and modelling of mass transfer in thin layer convective drying of pineapple. Chemical Science International Journal. 2017; X(X):xxx-xxx, in press.
8. Sablani SS, Rahman MS, Al-Sadeiri DS. Equilibrium distribution data for osmotic drying of apple cubes in sugar-water solution. Journal of Food Engineering. 2002; 52(2):193-199.
9. Souza JS, Medeiros MF, Magalhães MM, Rodrigues S, &Fernandes FA. Optimization of osmotic dehydration of tomatoes in a ternary system followed by air-drying. Journal of Food Engineering. 2007; 83(4):501-509.
10. Tedjo W, Taiwo KA, Eshtiaghi MN, Knorr D. Comparison of pretreatment methods on water and solid diffusion kinetics of osmotically dehydrated mangos. Journal of Food Engineering. 2002; 53(2):133-142.
11. Uddin MB, Ainsworth P, İbanoğlu Ş. Evaluation of mass exchange during osmotic dehydration of carrots using response surface methodology. Journal of Food Engineering, 2004; 65(4):473-477.
12. Waliszewski KN, Pardio VT, Ramírez M. Effect of Chitin on color during osmotic dehydration of Banana Slices. Drying Technology. 2002; 20(3):719-726.