OPTIMIZATION OF OSMOTIC DEHYDRATION AS PRE-TREATMENT OF DRYING

[1]Reshma Arable, [2]Amruta Chatte, [3]Aarti Deshmukh

[1]Assistant Professor
Chemical Engineering Department
Aditya Silver Oak Institute of Technology, Ahmedabad, India

***Abstract*: In this study of the carrot and beet root number of experiments of osmotic dehydration at different conditions are performed and by using response surface methodology, it is shown that the independent process variables for osmotic dehydration process were osmotic solution concentrations (10–12.5%) temperature (38-40^{0}C) and process duration (90-120 min) are best optimum conditions for getting maximum water loss. Also the water loss is compared with the water loss under sonication. Results showed that the water diffusivity increases after application of ultrasound by around 20% at about higher temperatures like 50^{0}C and that the overall drying time was reduced which represents an economy of energy since air-drying is energy cost intensive. Use of ultrasonic pre-treatment is interesting when large amounts of water needs to be removed from the fruit, case in which the combined processing time (pre-treatment and air-drying) is shorter.**
***Index Terms* - Osmotic Dehydration (OD), ultrasonication, optimisation, face centered design (CCF), Response Surface Methodology (RSM).**

I. INTRODUCTION

Fruits are important sources of vitamins and minerals. India, with 38.56 mt (8.7%) fruit production occupies second position in world production of fruit and about 59.4 mt (9.45%) production of vegetables[1]. About 20 - 40% fruits and vegetable production in goes waste due to lack of proper retailing and inadequate storage capacity[2]. To increase the shelf life of these fruits and vegetable, many methods and combination of methods had been tried. Conventional preservation techniques are drying, refrigeration, freezing, burial in the ground canning, pickling etc. Conventional pre treatment for drying is osmotic dehydration, alkaline deep, sulfating and blanching. Osmotic dehydration is based on the principal that when cellular materials are immersed in a hypertonic aqueous solution, a driving force for water removal sets up because of higher osmotic pressure. During osmotic processing two major counter current flows takes place simultaneously. First major one is water flow from inside of sample to osmotic solution and second is osmotic agent diffusion into the opposite direction which is flowing from solution into the product. The different types of osmotic agents such as glucose, sorbitol, sucrose and salts are used according to the final product. In this project carrot and beat are selected for carrying out experiments. Osmotic solutions of different concentrations of sugar and salt are used. The purpose of this work is to investigate the effect of process parameters (solute concentrations, process temperature, immersion time and ultrasonic waves) on mass transfer of OD process of different fruits. The optimization of osmotic dehydration process is aimed at finding the levels of independent variables namely, osmotic solution concentration, temperature and process duration which would give maximum possible water loss and rehydration ratio.

II. OBJECTIVE

- To investigate the effect of process parameters (solute concentration, process temperature, immersion time and ultrasonic waves) on mass transfer in osmotic dehydration.
- To find the level of above independent variable for maximum possible water loss.
- To compare water loss at ambient and ultrasonic conditions
- To find optimum combination all parameters for maximum water loss

III. MATERIALS AND METHOD

- **Material:**

Fresh fully ripened fresh carrots were purchased from local merk. Firstly they are washed peeled and then weighed before cutting. The unwanted part is removed to retain the final quality of product. The similar procedure is followed for beet. The peeling loss varied from 17-20%. Carrot cubes of 1.7*1.7*1 cm are prepared by manual dicer. Then the cubes are weighed and arranged according to weight

➢ **Preparation of osmotic solution:**

For OD of carrot osmotic solution of sucrose (Merk grade) and food grade NaCl is used. For that 100 gm of three solutions each containing 30^0Brix sucrose with 5%, 10% and 15% salt solutions were prepared. For beet food grade NaCl is used. For these three salt solutions of different concentrations of 5%, 15% and 20% were prepared.

IV. EXPERIMENTAL DESIGN

Before starting the actual experimentation, the refractive index (RI) of each osmotic solution is checked by using refractometry. It is used to calculate the difference in concentration of solutions before and after OD. Carrots cubes of known weight are put into osmotic solutions of different concentrations maintained at predefined temperature (30^0C, 40^0C, 50^0C) using hot water bath. Continuous stirring is provided to maintain temperature uniformity, reduce mass transfer resistance and to ensure good mixing. Fruit cubes are removed from solution timely soaked and weighed for determining weight reduction. In this study face-centered central composite design (CCF) is used. The total number of experiments is calculated by

$$Total\ number\ of\ experiments = 2^{number\ of\ experiemtns} + 2 * (nuumber\ of\ variables) + central\ points \text{............. (1)}$$

We have selected three variables (time, temperature and osmotic solution) so the number of experiments were 20[3]. The water loss during osmotic dehydration were calculated by

$$\%\ weight\ loss = [(M_i - M_o)/ W_i] * 100 \text{ ....(2)}$$

Where Mi = moisture content of fresh sample (gm); Mo = moisture content of osmotically dehydrated sample (gm); Wi = Total weight of fresh sample (gm)[3]

Response surface methodology (RSM) was applied to the experimental data using a commercial statistical package. The same software was used for the generation of response surface plots, superimposition of contour plots and optimization of process variables. A graphical multi-response optimization technique was adopted to determine the workable optimum conditions for the osmotic dehydration of fruit cubes[4]. The contour plots for all responses were superimpose and regions that will best satisfy all the constraints will selected as optimum conditions. The main criterions for constraints optimization will maximum possible water loss, rehydration ratio and good quality fruit product. The polynomial model fitted to the data is

$$Y = A + B * X_1 + C * X_2 + D * X_3 + E * X_1 * X_2 + F * X_2 * X_3 + G * X_3 * X_2 + H * X_1 * X_1 + I * X_2 * X_2 + J * X_3 * X_3 \quad (4)$$

Where A, B, C,…….., J are constant of regression coefficients; Y is the response (% weight loss); X1, X2 and X3 are osmotic solution concentration, temperature and time[3].

V. RESULTS

➢ <u>**Effect of concentration on water loss**</u>

Carrot at ambient conditions

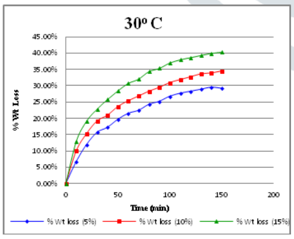


Figure 1

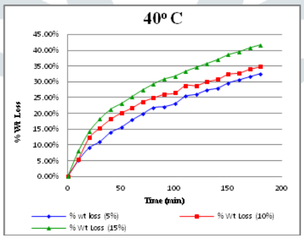


Figure 2

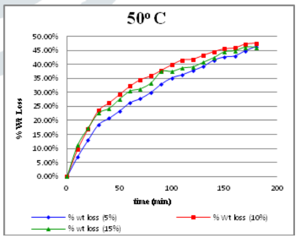
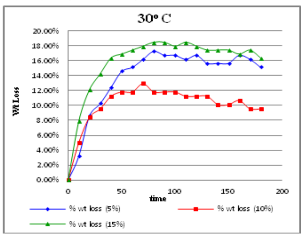
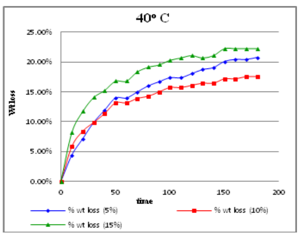


Figure 3

From above Fig. 1, 2 and 3 we can see that at 30 and 40^0C water loss increases as concentration increases but at 50^0C initially the water loss is high at 15% concentration but it decreases as time passes and water loss at 10% concentration is maximum hence we can conclude that 40^0C and 15% concentration can be the optimum combination for maximum weight loss for carrot at ambient conditions.

Beet at ambient conditions





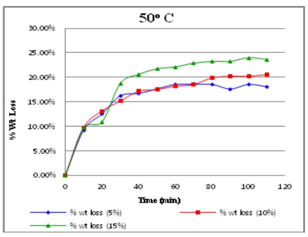
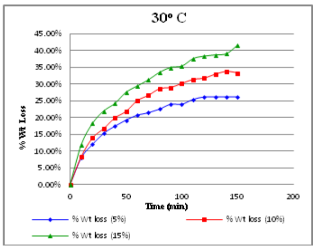
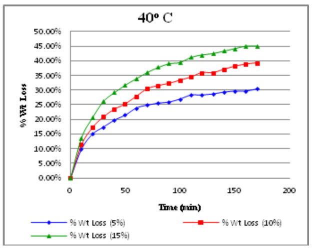


Figure 4 Figure 5 Figure 6

By observing figures 4, 5 and 6 for OD of beet at ambient conditions we can see that there is dehydration in the beginning and after some time rehydration process starts. Here at all three temperatures the water loss increases with concentration, but from graphical analysis it is clear that the water loss is higher at 40^0C and 15% concentration. At 50^0C the weight loss is higher at 15% concentration

Carrot at ultrasonic conditions





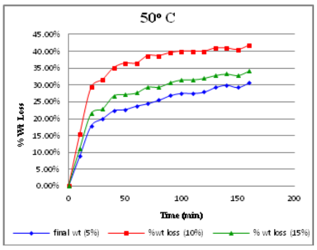
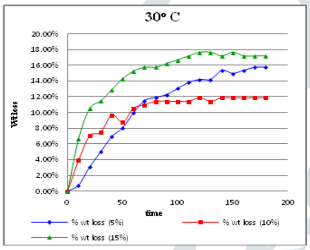
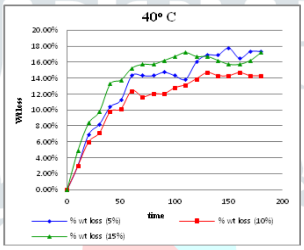


Figure 7 Figure 8 Figure 9

From fig. 7, 8 and 9 same conditions we can observe in OD for carrot at ultrasonic conditions. The only difference is at 50^0C the water loss for 15% concentration is much less from starting.

Beet at ultrasonic conditions





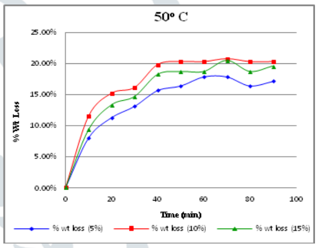


Figure 10 Figure 11 Figure 12

From above figures 10, 11 and 12 we can say that at ultrasonic conditions for beet, at 30^0C water loss increases as concentration increases while at 40^0 C water loss is initially higher for 15% and eventually decreases but at these conditions at 30 and 40^0C the water loss at 5% concentration is higher that at 10%.

- **<u>Effect of temperature on water loss</u>**

Carrot at ambient conditions

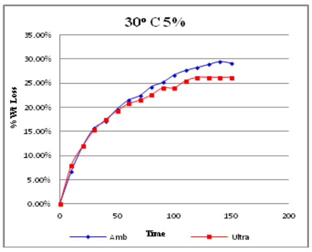
Similarly the effect of temperature on water loss is studied and it is found that for carrot at ambient temperature increases water increases keeping the concentration constant. But comparing water loss at different concentrations it is seen that water loss is maximum at 10% concentration
And for ultrasonic conditions at 10% concentration only the water loss is maximum at 50^0C. Also at 5% and 15% concentration water loss is higher at 40^0C.

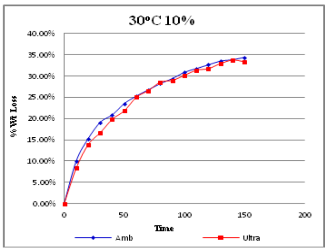
Beet at ambient conditions

For beet at ambient conditions, OD of beet at ambient condition, water loss increases as temperature increases. Therefore the water loss is maximum at 15% concentration at 50^0C while for ultrasonic conditions, at 50^0C water loss is higher for all concentrations and it is maximum for 15% concentration.

- **<u>Comparison between water loss at ambient conditions and ultrasonic conditions</u>**

Carrot at 30^0C





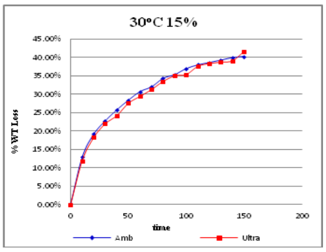


Figure 13 Figure 14 Figure 15

From above figures 13, 14 and 15 we can say that at low temperatures like 30 and 40^{0}C there is no considerable effect of sonication on water loss by osmotic dehydration. But at higher concentrations like 15% the effect can be seen.

Carrot at 40^{0}C

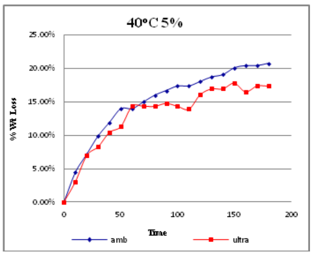


Figure 16

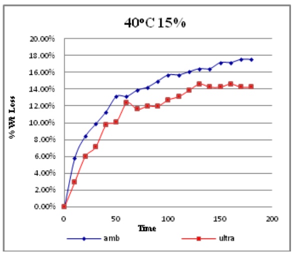


Figure 17

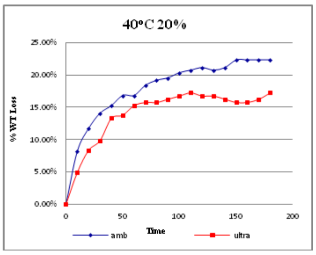


Figure 18

By observing above figures 16, 17 and 18, we can say that for carrot at 40^{0}C there is no effect of ultrasound on water loss by OD but as temperature increases by sonication the time for water loss decreases under this condition.

Carrot at 50^{0}C

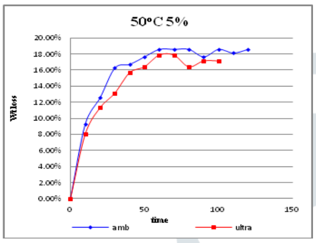


Figure 19

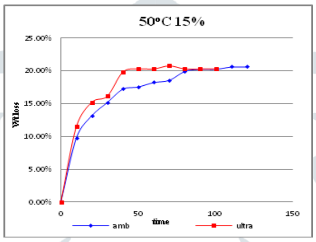


Figure 20

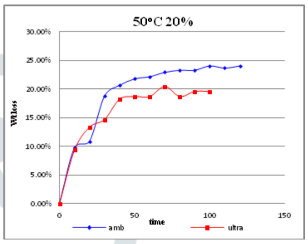


Figure 21

Figure 19, 20 and 21 says that at 50^{0}C there is considerable effect of ultrasound on water loss. At 20% concentration we can clearly see that water loss increased by 20% under sonication.

Beet at 30^{0}C

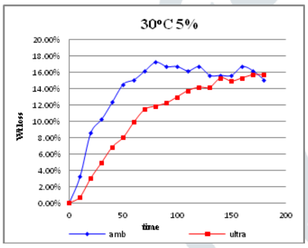


Figure 22

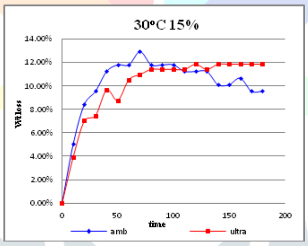


Figure 23

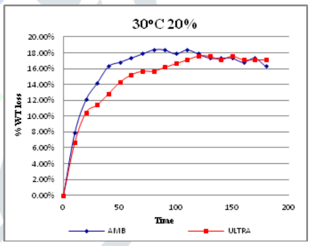


Figure 24

From above figure 22, 23 and 24 it can be concluded that for beet initially the water loss is higher at ambient conditions but as time passes water loss under sonication exceeded.

Beet at 40^{0}C

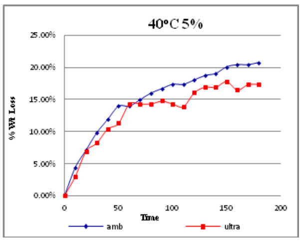


Figure 25

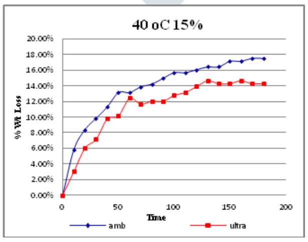


Figure 26

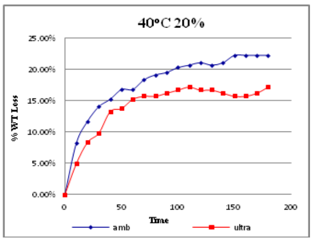


Figure 27

Figure 25, 26 and 27 says that there is no effect of ultrasound on water loss by OD. So the process is not useful at these conditions.

Beet at 50^{0}C

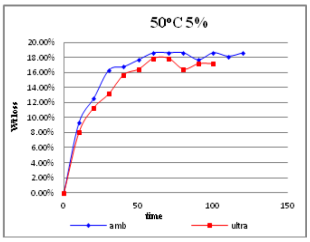


Figure 28

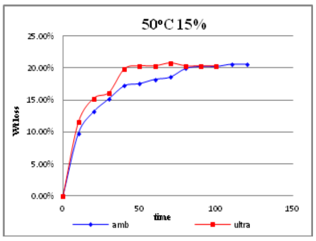


Figure 29

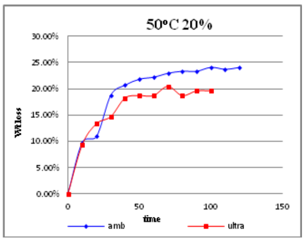


Figure 30

By observing figures 28, 29 and 30 it can be said that there is little effect of sonication on water loss for beet at 50^0C and 15% concentration but finally the water loss at ambient conditions exceeds.

- **<u>Optimization using RSM</u>**

Carrot at ambient conditions

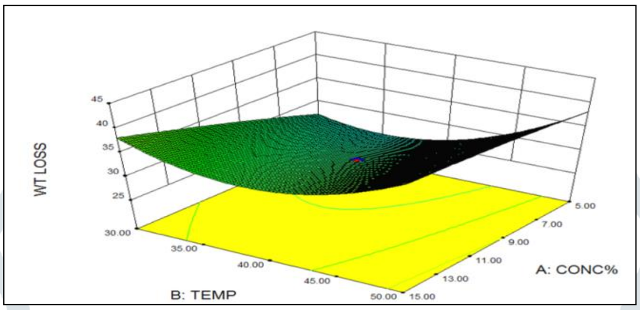


Figure 31

From fig. 31 we can wee that maximum water loss of 30.54% is obtained at 10% concentration, 40^0C temperatures in 120 minutes.

Beet at ambient conditions

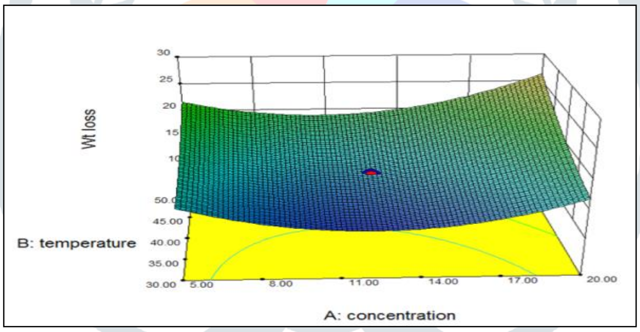


Figure 32

From fig. 32 we can wee that maximum water loss of 21.20% is obtained at 12.5% concentration, 40^0C temperature in 135 minutes.

Carrot at ultrasonic conditions

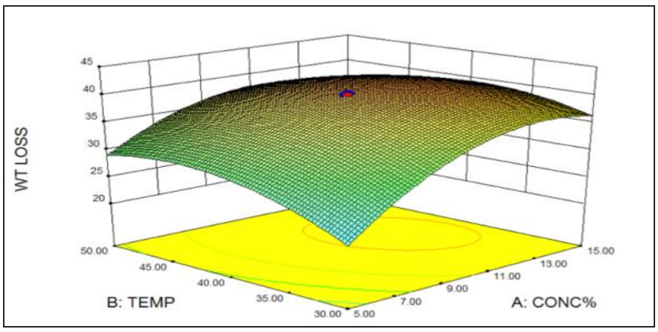


Figure 33

From fig 33, the optimum conditions under sonication for maximum water loss of 40 % are 10% concentration and 40^0C in 90 minutes.

Beet at ultrasonic conditions

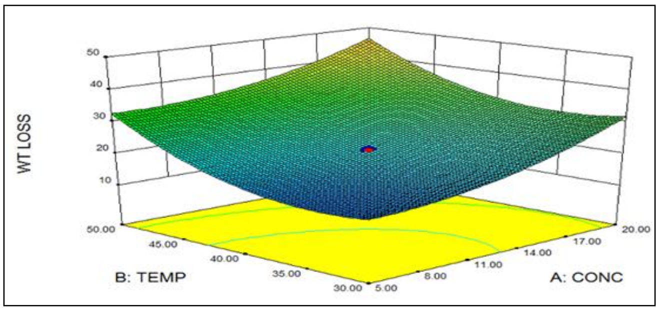


Figure 34

From fig 34, the optimum conditions under sonication for maximum water loss of 21.20 % are 12.5% concentration and 40^{0}C in 135 minutes.

VI. CONCLUSION

- It can be concluded from this project study that solution temperature, time and concentration were the most pronounced factors affecting solid gain, water loss on carrot, beet cubes during osmotic dehydration. While for certain products, it would be desirable to use single solute such as sucrose, salt etc., there would be other products where mixed solutes such as salt-sucrose would be even more desirable from the view point of product throughput.
- We can also conclude about ultrasound effect that at low temperatures like 30^{0}C and 40^{0}C there is no considerable effect of sonication on water loss as well as no effect at low concentrations by osmotic dehydration. But at higher temperatures like 50^{0}C and higher concentrations above 15% the effect can be seen.

VII. REFERENCES

[1] Phisut, N. Faculty of Agricultural Product Innovation and Technology, SrinakharinwirotUniversity, Sukhumvit 23, Bangkok, 10110, Thailand " MiniReview Factors affecting mass transfer during osmotic dehydration of fruits" International Food Research Journal 19(1): 7-18 (2012)

[2] "Importance of fruits and vegetables in India", B.Sc. Agriculture, lecture 11.

[3] M. Burhan Uddin, Paul Ainsworth, Senol Ibanogllu "Evaluation of mass exchange during osmotic dehydration of carrots using response surface methodology" Journal of food engineering 65 (2004) 473-477

[4] Charles Tortoe1, John Orchard2 and Anthony Beezer3 "Multilinear Regression Approach in Predicting Osmo-Dehydration Processes of Apple, Banana and Potato" J Food Process Technol Volume 2 Issue 5 1000122 ISSN:2157-7110 JFPT, an open access journal

[5] Alam, M.M., Islam, M. N. and Islam, M.N. (2013) "Effect of process parameters on the effectiveness of osmotic dehydration of summer onion" International Food Research Journal 20(1): 391-396

[6] Rastogi, N.K., Raghavarao, K.S.M.S., Niranjan, K. And Knorr, D. 2002. "Recent developments in osmotic dehydration: methods to enhance mass transfer" Trends in Food Science and Technology 13: 48-59.

[7] Shi, J. and Xue, J.S. 2009. Application and development of osmotic dehydration technology in food processing. In Ratti, C. (Ed). Advances in food dehydration. CRCPress. USA.

[8] P. Phongsomboon and Pilairuk Intipunya, "Comparative study on drying of osmotic treated carrot slices" As. J. Food Ag-Ind. 2009, 2(04), 448-456

[9] Moazzam Rafiq Khan "Osmotic dehydration technique for fruits preservation-A review" PAK. J. FOOD SCI., 22(2), 2012:71-85

[10] Erasmo Herman-Laraa, Cecilia E. Martinez-Sancheza, Hermelinda Pacheco-Anguloa, Roselis Carmona-Garcia a, Hector Ruiz-Espinosab (2012) "Mass transfer modeling of equilibrium and dynamic periods during osmotic dehydration of radish in NaCl solutions", Irving I. Ruiz-Lopezb, food and bioproducts processing.

[11] Bahadur Singh a, Parmjit S. Panesar a, Vikas Nanda a, John F. Kennedy b, "Optimisation of osmotic dehydration process of carrot cubes in mixtures of sucrose and sodium chloride solutions" Food Chemistry 123 (2010) 590–600

[12] Duduyemi Oladejo, 2, Ade-Omowaye B. I. O., Abioye Adekanmi. O (2013) "Experimental Study on Kinetics, Modeling and Optimisation of Osmotic Dehydration of Mango (Mangifera Indica L)", The International Journal Of Engineering And Science (IJES) Volume2 Issue 4 Pages 01-08