Osmotic Dehydration Of Beet Root In Salt Solution

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Abstract- *Response surface methodology was used for quantitative investigation of Water and solids transfer during osmotic dehydration of beetroot in aqueous solution of salt. Effects of temperature (25 – 45oC), processing time (30-150 min), salt concentration (5-25%,W/W) and solution to sample ratio (5:1 -25:1) on osmotic dehydration of beetroot were estimated. Quadratic regression equations describing the effects of these factors on the water loss and solids gain were developed. It was found that effects of temperature and salt concentrations were more significant on the water loss than the effects of processing time and solution to sample ratio. As for solids gain processing time and salt concentration were the most significant factors. Osmotic dehydration process was optimized for water loss, solute gain, weight reduction, moisture content. The optimum conditions were found to be: temperature : 35oC, processing time – 90min. This project is about comparative study between sun drying, hot air oven drying and micro oven drying.*

Keywords- Discrete event simulation, queuing system, size delay function

I. INTRODUCTION

BETA VULGARIS, commonly known as beetroot or beet which is the common American English term for the vegetable, is a flowering plant species in the family

CHENOPODIACEAE. Several 7 are valued around the world as edible root vegetables, fodder (mangel) and sugar production beet (Wikipedia). Beetroot can be peeled, steamed, and then eaten warm with butter as a delicacy; cooked, pickled, and then eaten cold as a condiment; or peeled, shredded raw, and then eaten as a salad. Pickled beets are a traditional food of the American south. It is also common in traditional food of the south. It is also common in Australia and New Zealand for pickled beetroot to be consumed on a burger.

One increasingly popular preparation involves tossing peeled and diced beets with a small amount of oil and seasoning, then roasting in the oven until tender. Garden beet juice is a popular health food. Betanins, obtained from the roots, are used industrially as red food colourants, e.g. to improve the colour of tomato paste, sauces, desserts, jams and jellies, ice cream, sweets and cereals. Red beet also makes a rich, red, Burgundy style wine. The Romans used beetroot as a treatment for fevers and constipation, Amongst other ailments. Beta vulgaris roots contain significant amounts of vitamin C, Whilst the leaves are an excellent source of vitamin A. They are also high in folate, Soluble and insoluble dietary fibre and antioxidants .It is among the sweetest of vegetables, containing more sugar even than carrots or sweet corn. The content of sugar in beetroot is no more than 10%.

Osmotic dehydration is a water removal process involving soaking foods, mostly fruits and vegetables, in a hypertonic solution such as concentrated suger syrup. Two major simultaneous counter-current flows occur during osmotic dehydration: and important water flow out of the food in to the solution and a simultaneous transfer of solute from the solution in to the food. Osmotic dehydration is used as a pre-treatment for many process used to improve nutritional, sensorial and functional properties of food with out changing its integrity. It generally precedes process such a freezing, freeze-drying, vacuum drying or air drying .It also increases sugar to acid ratio ,and improves texture and stability of pigments during dehydration and storage. It is effective around ambient colour and flavour can be minimized. The other major application is to reduce the water activity of food materials so that microbial growth will be inhibited. since most food material contain large amount of water, they are cost intensive to ship, pack and store.

RSM is a collection of statistical techniques for designing experiment, building models, evaluating the effects of factors and searching for the optimum conditions. It is widely used for multivariable optimization studies in several biotechnological processes such as optimization of media, process conditions, catalyzed reaction conditions, oxidation, production, fermentation, bio sorption of metals etc. It has also been used to determine the optimal values for process parameters in various processes. In RSM, several factors are simultaneously varied. The multivariate approach reduces the number of experiments, improves statistical interpretation possibilities, and evaluates the relative significance of several affecting factors even in the presence of complex interactions.

It is employed for multiple regression analysis using quantitative data obtained from properly designed experiments to solve multivariable equations simultaneously. There are several work has been carried out on optimization of vegetables by RSM method. However, no information is available on the statistical modeling of beetroot drying by osmotic dehydration. Hence this study focuses on the modelling of the water loss, solid gain and weight reduction as a function of the process variables and to find the optimum operating conditions that maximize water loss and weight reduction and minimize the solid gain using response surface methodology.

1. Objectives:

Keeping above factors in mind, the present study was under taken with the following specific objectives:

1) To study the comparative analysis of sun drying, micro oven drying, hot air oven drying of beetroot pieces.
2) To study the moisture content, water loss, solute gain and weight reduction.
3) To study the sensitive analysis of dehydrated beetroots.

II. LITERATURE REVIEW

Osmotic dehydration studies on beet root

A number of researchers have conducted drying of fruits and vegetables, so that the moisture content can be reduced and other value added product can be prepared further. Many works has been done on osmotic dehydration of beetroot pieces. Some of these are discussed below :

Valle et al. (1998) proved that HTST (High Temperature Short Time) blanching of apple pieces caused PPO (Poly Phenol Oxidase) inactivation and softening. PPO inactivation was minimal during immersion in water at 40 °C, but it increased with temperature after 15 min exposure at 55–65 °C. Softening decreased with adding 0. 6% CaCl is added to the blanching medium. Vacuum infiltration of apple pieces caused cellular damage that increased with applied pressure. Texture improved by the use of aqueous CaCl solution instead of distilled water. HTS T blanched apple pieces showed extensive material loss and poor texture on osmotic dehydration.

Rosa and Giroux (2001) studied on the problems related to the solution management in Osmotic treatments. They concluded that implementation of osmotic treatments (O T) of plant or animal materials in concentrated solutions (called also dehydration-impregnation b y soaking process, DIS) presents a critical factor due to the management of the concentrated sugar/salt solutions. They studied on the following factors. Solution mass and dilution loss of solutes and particles from food, concentration restoring and solution recycling, reconditioning of solution by membrane processing, microbial contamination of the solution, solution preservation during process stop time, microbial contamination of foodstuffs due to food/solution contact, sanitation of the solution, resistance of the solution to the thermal treatments, condition to determine the end-point of the working solution, possible utilisation of spent solutions for different use and problems related to the discharge of the spent solutions.

Fragoso et al. (2002) proposed a set up of pilot plant for osmotic deh ydration of apple cubes of 1 cm . They showed that suitable pilot plant should consist of novel agitation system, immersion device, a bag filter and vacuum evapor ator. The experiment was done at 50 °C in 60 °B of sucrose syrup and sugar/fruit r atio of 5. The concentr ation was maintained at 60 °B b y re-concentrating in the evaporator. The osmo-dehydrated cubes were comp arable with laboratory scale products.

According to Sharma et al. (2003) during osmotic deh ydration always water loss is favored over solid uptak e that leads to mass loss of pear fruit. A ccording to their experiment all these par ameters depends on concentr ation of syrup and syrup to fruit ratio. It was found that with increase in syrup concentr ation from 35 to 45 °B and syrup fruit r atio from 1 to 2, there was consider able change in water loss from 18.09% to 23.18%, mass loss from 9.26% to 20.06% and solid gain from 13.59 to 16.38%.70 °B sugar syrup was found effective in removal of moisture from giant k ew, a variety of pineapp le. On the basis of sensory scores maximum dry fruit yield, lower moisture, higher ascorbic citric acid and carotenoid content, the 60 °Brix sugar syrup with 0.2% critic acid and 700 ppm KMS (Potassium meta bi sulphite) was best for osmotic dehydration for the period of 24 h. The studies were done both before and after stor age of 6 month at ambient conditions (Rashmi et al. 2005).

Machewad et al. (2003) studied the drying properties of vegetables and their suitability for producing various value added products. Chemical properties of vegetables indicated their suitability for drying and the feasibility of using beetroot shreds for further processing. Leaching losses were observed in reducing sugars and total sugars during pre-treatments and an adverse effect was seen in all samples. Reconstitution ratio of dried beetroot shreds was higher in pre-treated samples than untreated. Beetroot shreds dried in open air had a lower reconstitution ratio. It was suggested that dried beetroot shreds could be used as a base material for preparation of carrot halwa (halva).

Litvin et al. (1998) determined the optimal conditions for drying of beetroot pieces using a combination of an initial period of freeze drying, a short microwave treatment and a final period of vacuum or air drying. A 2 h freeze drying at a plate temperature of 30°C followed by 2 h at 55°C reduced the moisture content of beetroot pieces to about 40%. Subsequent microwave treatment (50 s) and vacuum or air drying reduced the moisture content further to 5%. When the method was used with a final air drying step, the quality characteristics (colour, dimensions and rehydration ratio) of beetroots were similar to those of beetroots dried by freeze drying alone. However, when final drying was performed in a vacuum oven, the colour quality of beetroots was improved and the overall quality of beetroots after rehydration was similar to that of freshly cooked beetroot pieces. It was concluded that the method may be useful for reducing the time, and hence the cost, of freeze drying beetroots.

Camacho (1983) studied the air and freeze drying of beetroot. Beetroot were peeled, cut into 1 mm cubes and sulphited. Batches were then air-dried at 71° or 88°C, or freeze-dried at initial temperature of -1° , -18° or -40° C. Rehydration, density, colour, texture, beta-carotene content and flavour of the products was evaluated. It was reported that the rehydration coefficient of air dried and freeze dried carrots decreased with increasing drying temperature. The beta-carotene retention, colour, texture and flavor was reported as better in case of freeze-drying in comparison to air dried samples.

Grishin et al. (1973) studied the kinetics of dehydrating vegetables and changes in the main chemical constituents (ascorbic acid, carotenes, essential oils, total sugars) due to drying process. It was recommended that diced carrots (cubes 5-8 mm) should be dried at 160°C. Carrots and onions were suggested to be used as basic ingredients of the snacks.

Andreotti et al. (1981) dried diced carrot to 50% of their initial weight by hot air at 80° and 100° C respectively, followed by freeze-drying,and compared with conventionally freeze-dried products. The results revealed that the products occupied only about 1/2 the volume of freeze-dried products, but had similar rehydration properties except for a deeper colour. The process allows savings in energy, as well as storage, packaging and transport costs

Basantpure et al. (2003) conducted experiments to develop dehydrated carrot halwa and studied the effect of milk to carrot ratio, sugar, sodium metabisulphite, and temperature on the quality of dehydrated halwa. Central composite rotatable design was used at five levels of independent variables.

III. METHODOLOGY

1) Raw materials:

Fresh beetroots purchased locally, were thoroughly washed with water to remove adhering soil and other debris. Then, they were cut into square pieces of 3mm thickness. The average moisture content of the beetroot was found to be 89% on a wet basis. Salt, the osmotic agent, was purchased from a local supermarket. The osmotic solution is prepared by mixing the salt with proper amount of pure water. And also some other equipments or materials required are salt water (osmotic agent), knives, polythene sheet, tissue paper, micro oven, hot air oven, aluminium boxes.

Figure 1. Fresh Beetroots

2) Osmotic agent:

Salt was used as osmotic agent and was procured from local market to prepare osmotic solution of 10%, 15% and 20% concentrations on the basis of (%w/v).

3) Preparation of osmotic agent:

Osmotic agent was prepared by dissolving calculated amount of salt in distilled water so as to obtain required concentration at that temperature in hot water bath.

4) Preparation of sample for osmotic dehydration of beetroots:

Procured beetroots were thoroughly washed with water to remove dust and dirt particles adhering to the surface. After washing beetroots were peeled by scraping with a sharp steel peeler by manually and washed again to remove the scraped material on beetroots. The peeled beetroots were cut into 3 mm thickness and 1 to 2 cm length and its breadth manually by using sharp stainless steel knife.

Figure 2. Cutting of beetroots

5) Experimental procedure for osmotic dehydration:

Beetroot pieces were dipped in osmotic solution, in a solution to sample ratio of 10:1, 15:1 and 20:1 at 10% and 15% and 20% concentrations respectively in a period of 90 minutes at atemperature of 60oc in the induction cooker or hot water bath.The temperature was maintained during the process. After specified immersion time, samples were taken out from the solution and wiped with tissue paper to remove traces of osmotic solution adhering to carrot slices and then dried in different drying methods such as micro oven drying, hot air oven drying and sun drying.

6) Sun drying:

Sun drying works best in areas such as the south western states of India and the central plane of the U.S. and Canada where dry, clear weather is normal at the height of the produce harvest. Indoor dehydration is the rule for cloudy or highly polluted localities. In regions like the south east, where strong sun is offset by moist air, evaporation is high.

A surprising quality of foods can be sun dried, especially produce, which should be chosen for top quality, picked over, and washed well. After that beetroots were cut into pieces.

The beetroots are spread without crowding on paper lined trays or preferably cloth covered wooden frames, protected with cheese cloth if insects are a problem, and left in the sun to dry with the aid of occasion turning. The trays should be moved under shelter and geared from dampness at night. If wet weather sets in, the batch can be saved from spoilage by oven drying.

Figure 3. Sun drying Method

7) Hot air oven drying:

This method is more common in foodstuffs drying (Akpinar et al, 2006). The capacity of air in removing of moisture depends on temperature and the moisture amount of air. When air pass over a wet foodstuff, Heat transfers to surface and leads to vapour of latent heat vaporization. The difference pressure between surface and inner parts of foodstuff may consider as another reason of removing a part of moisture by steam (Fatemi, 2003; Taherigeravandet al, 2010).When food places in the dryer, reaches to humid temperature in short time. Drying process continues with a uniform rate (constant drying stage) which means equivalence in removing and absorbing of moisture in foodstuff. On the other hand in constant rate, an air layer containing saturated steam is available on the food surface. Basically this stage is independence from solid particles of food system (Fatemi, 2003).

Here the beetroot pieces can be dipped in osmotic solution means salt concentration at 10%, 15%, 20% and heat this osmotic solution with the help of cooker or stove at a temperature at 60oc with a time period of 90mins.After that take out the beetroot pieces, let it be dry and clean with tissue paper.

Place the beetroot pieces in aluminium cans or trays. So that place the trays at hot air oven and adjust the temperature at 55oc and leave it until the pieces get bone dry condition. And note down the readings for every 1hour whether the pieces loose their moisture due to heat.

Figure 4. Bone dry condition of beetroots after completion of hot air oven method

IV. RESULTS AND DISCUSSIONS

1. SUN DRYING:

10% Osmotic agent :

Initial weight (w1) = 100 gms

Weight of after osmosis = 84 gms

Table 1.

S.N	Date March 2017	Max temp	Min temp	Avg Temp	Initial Value	Final Value	Moisture content
1	2	33	27	30	84	59.9	28.6
2	3	33	26	29.5	59.9	49.8	16.86
3	4	32	27	29.5	45.4	40.9	2.6
4	5	31	25	28	40.9	38.6	2.3
5	6	30	26	28	33.8	30.9	1.9
6	7	32	27	29.5	30.9	28.2	1.7
7	8	31	27	29	20.1	18.5	0.5
8	9	33	26	29.5	18.5	17.1	0.6
9	10	33	25	29	17.1	16	0.6

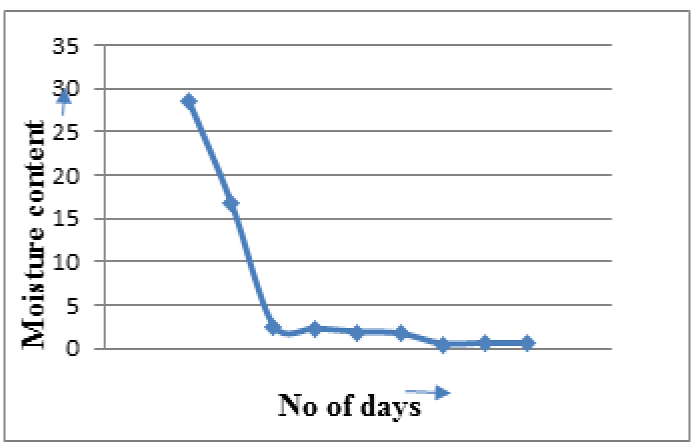

Figure 5. Graph for sun drying method in 10% salt concentration

15% Osmotic agent:

Initial weight (w1) = 100 gms

Weight of after osmosis = 84 gms

Table 2. Table for sun drying method values in 15% salt concentration

S.N	Date	Max temp	Min temp	Avg Temp	Initial Value	Final Value	Moisture content
1	2/3/2017	33	27	30	82	59.6	27.3
2	3/3/2017	33	26	29.5	59.6	45.3	23.9
3	4/3/2017	32	27	29.5	55.4	32.2	7.0
4	5/3/2017	31	25	28	32.2	28.9	6.8
5	6/3/2017	30	26	28	25.9	22.8	4.6
6	7/3/2017	32	27	29.5	22.8	3.9	3.9
7	8/3/2017	31	27	29	15.3	13.0	0.9
8	9/3/2017	33	26	29.5	13.0	10.2	0.5
9	10/3/2017	33	25	29	10.2	10	0.0

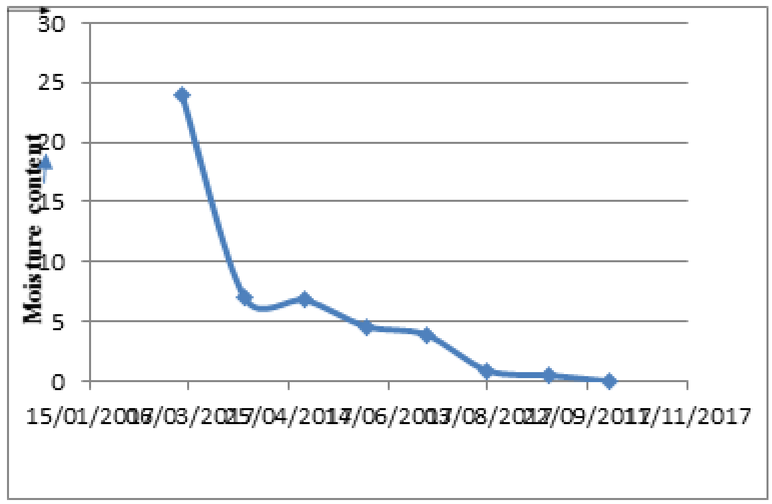

Figure 6. Graph 2: Graph for sun drying method in 15% salt concentration

20% Osmotic agent :

Initial weight (w1) = 100 gms

Weight of after osmosis = 80 gms

Table 3.

S.N	Date	Max temp	Min temp	Avg Temp	Initial Value	Final Value	Moisture content
1	2/3/2017	33	27	30	80	65.9	17.6
2	3/3/2017	33	26	29.5	65.9	60.8	7.7
3	4/3/2017	32	27	29.5	56.2	50.3	2.1
4	5/3/2017	31	25	28	50.3	45.3	1.9
5	6/3/2017	30	26	28	40.9	38.6	1.3
6	7/3/2017	32	27	29.5	38.6	27.8	1.2
7	8/3/2017	31	27	29	15.1	15.0	0.6
8	9/3/2017	33	26	29.5	15.0	14.9	0.6
9	10/3/2017	33	25	29	14.9	14	0.6

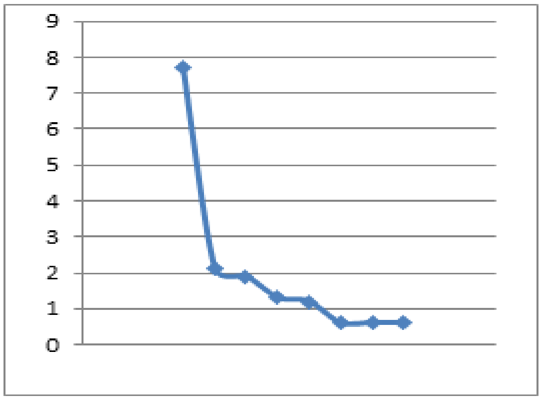

Figure 7. Graph 3: Graph for sun drying method in 20% salt concentration

2. HOT AIR OVEN DRYING:

10% Osmotic agent :

Initial weight (w1) = 100 gms
Weight of after osmosis = 90 gms

Table 4.

S. N	Temp(°c)	No. of hours	Initial weight	Final weight	Moisture content
1	55	1	90	75.8	15.77
2	55	2	75.8	69.9	7.78
3	55	3	69.9	57.3	6.9
4	55	4	57.3	44.6	5.3
5	55	5	44.6	39.8	4.2
6	55	6	39.8	30.6	3.9
7	55	7	30.6	25.3	2.8
8	55	8	25.3	21.9	2.5
9	55	9	21.9	14.3	1.9
10	55	10	14.3	14.1	1.3
11	55	11	14.1	14.0	0.7
12	55	12	14.0	14.0	0.7

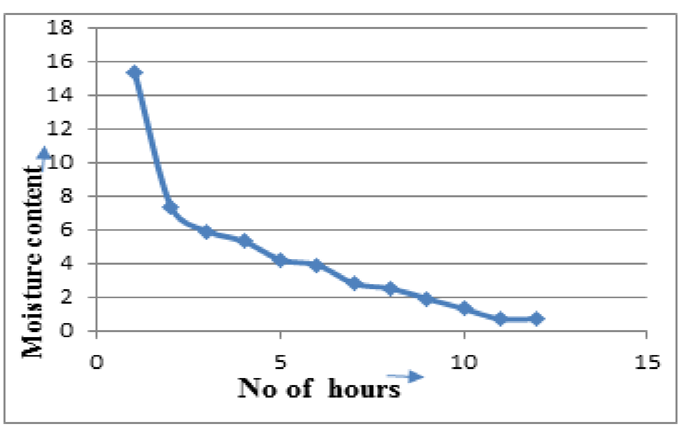

Figure 8. Graph4:Graph for hot air oven method in 10% salt concentration

3. MICRO OVEN METHOD:

10% Osmotic agent :

Initial weight (w1) = 100 gms
Weight of after osmosis = 85 gms

Table 5.

S. No	Temperature(°c)	No. of hours	Initial weight	Final weight	Moisture content
1	55	1	85	60.5	28.8
2	55	2	60.5	58.3	3.6
3	55	3	58.3	50.1	3.1
4	55	4	50.1	43.6	2.8
5	55	5	43.6	38.3	2.6
6	55	6	38.3	20.1	1.9
7	55	7	20.1	20	0.4
8	55	8	20	19.9	0.4

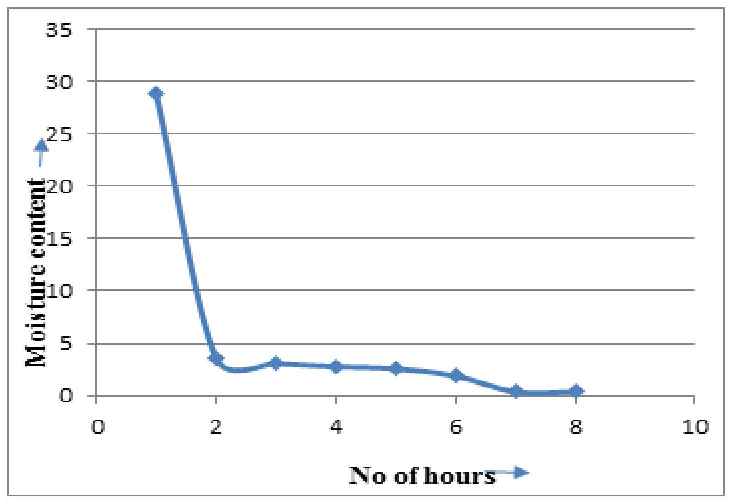

Figure 9. Graph 7: Graph for microwave oven method in 10% in salt concentration

Effect of solution temperature:

The temperature of osmotic solution also play great role in kinetics of mass transfer during osmotic dehydration. The effect of changing solution temperature on water loss, solute gain and weight reduction has been shown in Figure 2. It was observed that the all the response variables i.e water loss, solute gain and weight reduction increased with increase in solution temperature. This might be due to swelling and plasticizing of cell membrane that promote faster diffusion of water from sample to solution and in the same time higher temperature reduced the solution viscosity of the osmotic medium and resulted in better water transfer characteristics at the product surface.

On the other hand, solute transfer within product was found to increase with increase in solution temperature but at slower rate in comparison to water loss. This might be probably due to high molecular weight of solute and concentration of osmotic medium. Although increase in solution temperature promotes higher water removal from sample, but temperature above 60 °C modify the tissue structure and results impregnation phenomenon. Further higher temperature also results enzymatic browning and flavor deterioration as reported by Lenart and Flink (1984). Therefore, best processing temperature should be decided on the basis of food tissue structure

V. CONCLUSION

- In this study, RSM was used to determine the optimum operating conditions that yield maximum water loss and weight reduction and minimum solid gain in osmotic dehydration of beetroot.
- Analysis of variance has shown that the effects of all the process variables including temperature, time, salt concentration and solution to sample ratio were statistically significant.
- Second order polynomial models were obtained for predicting water loss, solid gain and weight reduction.
- The optimum conditions were found to be: temperature–55OC, processing time – 90 min, salt concentration – 14.31% and solution to sample ratio 8.5:1.
- At these optimum values, water loss, solid gain and weight reduction were found to be 30.86 (g/100 g initial sample), 9.43 (g/100 g initial sample) and 21.43 (g/100 g initial sample) respectively.
- Based on the observations, results & discussion, it can be said that, beetroot slices can be partially dewatered by osmotic dehydration in salt solution and percent weight loss is from 10 to 29 % depending upon the operating parameters like salt solution concentration, solution temperature and time for osmosis.
- The favoured operating parameters were salt solution concentration of 10%, temperature of 45ºC and time duration of osmosis around 30 minutes for which the maximum weight loss of 29.03% is obtained.
- It can be concluded that the developed for correlating the parameters was successful with high accuracy level with an average percentage error of 0.255 acceptable.

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