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Ritesh Kumar MishraM. Tech. (Agricultural
Processing and Food
Engineering), IGKV,
Raipur, Chhattisgarh, India**Dr. S Patel**Head of Department
(Agricultural Processing and
Food Engineering), IGKV,
Raipur, Chhattisgarh, India

Osmotic dehydration of bottle gourd (*Legeneria siceraria*)

Ritesh Kumar Mishra and Dr. S Patel

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Abstract

Osmotic dehydration of fruits and vegetables an effective method for preservation. The Bottle gourd (*Legeneria siceraria*) belongs to Cucurbitaceous family. Average composition of fresh bottle gourd is constituted by water (96.0%), carbohydrates (2.5%), fibre (0.6%), proteins (0.2%) and calcium (20mg). The bottle gourd is a common vegetable in India subcontinental. It is moderately perishable vegetable. In this report, efforts were made to analyze the effect of different concentration, temperature and mass ratio of fruit to osmotic solution on osmotic dehydration process of bottle gourd cubes. comparative study for different parameters variables (solid gain weight reduction, water loss) was also studies. Five concentration levels of salt solution were 5, 10, 15, 20, and 25% (w/w) used in this study to compare the effect of the concentration of the osmotic agents on osmotic dehydration. Bottle gourd cubes were immersed in the osmotic reagents with a fruit to osmotic solution mass ratio of 10:1, 20:1 and 30:1 soaking experiment were conducted at 40, 50 and 60°C in a 500 ml capacity water bath. The osmotic dehydration was done for a period of 1, 3, 5, 7 and 9 h and replicated thrice. Quality analysis of osmotically dehydrated bottle gourd cubes was done according to ISI (1971) and Ranganna (1991) with 9-point hedonic scale. The moisture content of bottle gourd cubes observed decreases with higher concentration, temperature and mass ratio. The weight reduction, water loss and solid gain were very fast during initial period of osmosis but equilibrium did reach even after 9h. The solid gain, water loss and weight reduction were observed higher for higher temperature, concentration and mass ratio of bottle gourd cubes. The sensory evaluation performed for the approximately central conditions processing parameters gave average scores of 7 or above.

Keywords: *Legeneria siceraria*, osmotic dehydration, solid gain, water loss, weight reduction

1. Introduction

The Bottle gourd (*Legeneria Siceraria*) belongs to Cucurbitaceous family. The centre of origin has been located as the coastal area of Malabar (North Kerala and humid Forest of Deharadun). It has spread to western countries from India and Africa. The fossil records indicate its culture in India even before 2000BC.

The bottle gourd is a common vegetable in India subcontinental. It is yellowish green, having the shape of bottle. It has white pulp, with white seeds embedded in spongy flesh. They were fairly rich in Ca, Fe and P (Herwig, 2004) [5]. The nutritional value of the kernels was equal or better than that of cashew nut and almond kernels. Average composition of fresh bottle gourd (depending on variety, climate and ripeness) is constituted by water (96.0%), carbohydrates (2.5%), fibre (0.6%), proteins (0.2%) and calcium (20mg) (Herwig, 2004) [5]. Bottle gourd mostly cultivated Uttar Pradesh, Gujarat, Assom, Meghalaya and Rajsthan.

The goal of food preservation is to increase the time for keeping food safe while retaining quality and nutrients. Fruits and vegetables are highly perishable due to their high moisture content. Decreasing the moisture content of fresh food to make them less perishable is a simple way to preserve these foods. The removal of moisture presents the moisture-mediated deteriorative reactions. It brings about substantial reduction in weight and volume, minimizing packing, storage and transportation costs and enables storability of the product under ambient temperatures, Dehydration increases the storage ability of fruits and vegetables making them available throughout the year. Dehydrated products also play a great role in processed foods of all kinds (*i.e.*, in soups) and the way to achieve high quality dehydrated products are desired. Practically any fruit and vegetable can be processed, but some important factors which determine whether it is worthwhile are:

Corresponding Author:**Ritesh Kumar Mishra**M. Tech. (Agricultural
Processing and Food
Engineering), IGKV,
Raipur, Chhattisgarh, India

- The demand for a particular fruit or vegetable in the processed form;
- The quality of the raw material, i.e. whether it can withstand processing;
- Regular supplies of the raw material.

Osmotic dehydration is a useful technique for the concentration of fruit and vegetables, released by placing the solid food, whole or in pieces, in sugars or salts aqueous solution of high osmotic pressure, it gives rise to at least two major simultaneous counter-current flows: a significant water flow out of the food into the solution and a transfer of solute from the solution into the food. The effects of osmotic dehydration as pre-treatment are mainly related to the improvement of some nutritional, organoleptic and functional properties of the product. As osmotic dehydration is effective at ambient temperature, heat damage to colour and flavor is minimized and the high concentration of sugar surrounding fruit and vegetables pieces prevents discoloration.

Keeping this in the mind the present study has been conducted with the following objectives:

- To study the osmotic dehydration characteristics of bottle gourd cubes.
- To study the quality of osmotically dehydrated bottle gourd cubes.

2. Materials and methods

The work was carried out in the Department of Agricultural Processing and Food Engineering, Indira Gandhi Agricultural University, Raipur (C.G.).

2.1 Preparation of the samples and osmotic solution

Bottle gourd fruits were washed well in running water to remove the surface dirt *etc.* Washed fruits were taken out from the water and spread under fan on a paper towel and blotted to remove the surface water. The fruits were then peeled off with the help of a stainless-steel hand peeler and both ends were trimmed off using a stainless-steel knife. Pieces of bottle gourd cubes (1cmx1cmx1cm) were then cut out using a ruler and knife. The cubes so obtained were used immediately for the experimentation.

Common salt (98% of minimum purity in sodium chloride) was used as osmotic agent salt solution of different concentration *viz.* 5%, 10%, 15%, 20% and 25%(w/w) were prepared using distilled water at room temperature (Serenio *et.al.*, 2004)^[12].

2.2 Experimental set up for preliminary osmotic dehydration experiments

The experimental set up consisted of glass beakers of 500 ml capacity, a water bath of heating capacity 110°C having temperature control arrangement ($\pm 2^\circ\text{C}$) and mercury in glass thermometer (10 to 200°C).

2.3 Experimental Procedure

Osmotic dehydration was carried out with commercially available table salt (98% of minimum purity in sodium chloride) as osmotic agent. Five concentration levels of salt solution were used in this study to compare the effect of concentration of osmotic agent on osmotic dehydration. The salt solution with 5, 10, 15, 20, and 25% (w/w) concentration were prepared and bottle gourd cubes were immersed in the osmotic reagents with a fruit to osmotic solution mass ratio of 10:1, 20:1 and 30:1. The temperature of osmotic solution

were 40, 50 and 60°C. The osmotic dehydration done for a period of 1, 3, 5, 7 and 9 h and repeated thrice. Afterwards samples were rinsed and wiped with tissues.

Different concentrations of osmotic solutions were prepared and the solution was mixed with bottle gourd cubes in selected mass ratios. The beaker was placed in hot water-bath maintained at desired temperature for soaking. After every 1, 3, 5, 7 and 9 h sample was taken out and moisture content was determined by standard method (Ranganna 1995)^[10]. Water loss (%), solid gain (%), weight reduction (%) for each sample was calculated.

2.4 Variables and their ranges

In the osmosis process various factors are involved which directly or indirectly affect the osmosis action. Based on the preliminary experiments the following independent and dependent variables are selected in the present investigation. The independent variables are type of osmotic solution salt, initial moisture content, soaking temperature and soaking time, mass ratio and concentration of osmotic agent.

- Type of Osmotic solution: Common salt (minimum 98% of purity)
- Concentration of Osmotic agent: 5, 10, 15, 20, 25%(w/w)
- Time of osmotic dehydration: 1, 3, 5, 7 and 9 h
- Mass ratio (sample to osmotic solution): 1:10, 1:20 and 1:30.
- Temperature of osmotic solution: 40, 50 and 60°C.

The dependent variables studies were,

- Water loss
- Weight reduction
- Solid gain and
- Moisture content after dehydration

2.5 Measurement of dependent variables

2.5.1 Moisture content determination

Test sample of 100g was kept for 24 h in a hot air electric oven maintained at 105°C. After 24 h, sample was drawn from the oven and placed in a desiccator for cooling. After cooling the weight of the sample was taken precisely. The loss was determined and moisture content was calculated using the following expression:

$$\text{M.C., \% (wb)} = \frac{W_m}{W_d + W_m} \times 100$$

Where,

M.C. = Moisture content, %

W_m = Weight of moisture,

W_d = Weight of dry matter.

2.5.2 Determination of solid gain

The solid gain bottle gourd cubes after osmotic dehydration were calculated using following equation (Nieto *et al.*, 2004)^[7].

$$\text{S.G., \%} = \frac{S - S_0}{S_0} \times 100$$

Where,

S.G. = Solid gain (%),

S = mass solids after osmosis (g),

S_0 = mass solids before osmosis (g).

2.5.3 Determination of weight reduction

The weight reduction of bottle gourd cubes after osmotic dehydration were calculated using following equation (Nieto *et al.*, 2004)^[7].

$$\text{W.R., \%} = \frac{W_0 - W_t}{W_t} \times 100$$

Where,

W.R. = Weight reduction (%),

S = initial weight of the sample (g),

S₀ = weight of the sample at time t (g).

2.5.4 Determination of water loss

The water loss of bottle gourd cubes after osmotic dehydration were calculated using following equation (Nieto *et al.*, 2004)^[7].

$$\text{W.L., (\%)} = \text{SG} - \text{WR}$$

2.6 Quality analysis

Quality analysis of osmotically dehydrated bottle gourd cubes was done according to ISI (1971) and Ranganna (1991) with 9-point hedonic scale. The average sensory scores for different attributes, *viz.*, appearance, colour, texture and overall acceptability for the bottle gourd cubes of size 1 cm were given. Quality analysis was performed by the panel of semi-trained judges drawn from the employees and students of Faculty of Agricultural Engineering, Indira Gandhi Agricultural University, Raipur (C.G.). The panelists were provided the product evaluation sheet

3. Results and Discussion

3.1 Osmotic dehydration experiment

Bottle gourd cubes of 1cm size were subjected to osmotic dehydration using commercial salt for osmotic solution of different concentrations. The ranges were temperature 40, 50 and 60°C osmotic dehydration time 1, 3, 5, 7 and 9 h, mass ratio of osmotic solution to the bottle gourd cubes (fruit cube): 30:1, 20:1 and 10:1 and concentration of osmotic solution 5, 10, 15, 20 and 25%.

3.1.1 Moisture studies

The moisture content of bottle gourd cubes was calculated during osmotic dehydration experiment each after 1, 3, 5, 7 and 9 h r respectively. The values of moisture content are presented in Table 3.1 through 3.3.

The effect of dehydration time on loss of moisture indicates that the as the time increases the loss of moisture increases. This was true for all the combination of mass ratio and temperature set. The values of moisture content at 25% concentration of osmotic solution were 68.3%, 67.7%, 68.9% after 1 h dehydration; 54.9%, 60.9%, 60.9% (wb) after 3 h; 53.8%, 56.4% and 55.2% (wb) after 5 h; 51.7%, 50.8% and 53.2% (wb) after 7 h; 50.1%, 49.9% and 46.9% (wb) after 9 h of dehydration for the mass ratio of 10:1, 20:1 and 30:1 respectively for the osmotic temperature of 60°C. The highest removal of moisture was in the initial stage of dehydration *i.e.*, upto 1 h of dehydration as compared to final stage of dehydration *i.e.*, from 3 to 9 h in the case of 60°C and similar trends were followed for 50°C and 40°C. Similarly, while comparing different osmotic temperatures for the same set of mass ratio (30:1) the value of moisture content at 25% concentration of osmotic solution were 46.9% (wb) 60°C; 49.3% at 50°C; 51.7% (wb) at 40°C which were dehydrated for 9 h. this suggested that at same concentration of osmotic solution, higher temperature is responsible for higher removal of moisture from the sample.

Table 3.1: Mean values of moisture content (% ,wb) of osmotically dehydrated bottle gourd at 40 Degree Celsius

T	Mass ratio																			
	10:1					20:1					30:1					Mean				
	Concentration (%)					Concentration (%)					Concentration (%)					Concentration (%)				
	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
0	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3
1	93.4	91.6	85.4	80.1	75.2	93.4	90.2	85.7	80.2	74.8	93.0	84.1	82.3	73.4	67.4	93.3	88.6	84.5	77.9	72.5
3	92.2	88.3	82.8	71.3	62.8	91.4	85.9	82.4	71.9	62.8	91.9	82.8	89.2	72.1	62.6	91.8	85.7	84.8	71.8	62.7
5	91.6	85.3	79.1	75.3	56.4	90.8	84.2	77.5	75.0	58.2	91.4	82.5	78.9	67.2	57.3	91.3	84.0	78.5	72.5	57.3
7	90.6	82.3	75.2	59.6	53.2	90.1	82.2	73.8	65.1	51.7	90.8	82.2	78.1	64.8	52.6	90.5	82.2	75.7	63.2	52.5
9	89.6	80.7	73.2	56.2	53.7	88.8	80.1	72.9	62.5	52.8	84.6	80.3	77.8	65.2	51.7	87.7	80.4	74.6	61.3	52.7
M	92.3	87.4	82.0	73.1	66.3	91.8	86.5	81.4	75.2	66.1	91.3	84.7	83.8	73.2	64.7					

Table 3.2: Mean values of moisture content (% ,wb) of osmotically dehydrated bottle gourd at 50 Degree Celsius

T	Mass ratio																			
	10:1					20:1					30:1					Mean				
	Concentration (%)					Concentration (%)					Concentration (%)					Concentration (%)				
	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0
1	92.2	88.8	85.1	80.5	75.6	92.6	88.1	85.3	79.2	75.5	92.1	83.7	81.6	73.8	65.9	92.3	86.9	84.0	77.8	72.3
3	90.6	86.6	81.8	72.2	62.1	91.6	86.3	81.9	72.0	61.8	91.3	81.2	78.4	71.2	60.5	91.2	84.7	80.7	71.8	61.5
5	90.6	84.5	77.3	66.3	58.3	90.3	84.3	78.2	63.3	67.4	92.3	81.5	75.2	78.2	65.6	91.1	83.4	76.9	69.3	63.8
7	89.6	82.2	74.3	59.2	51.9	88.6	82.4	73.8	59.1	51.7	88.0	81.7	72.8	65.1	51.2	88.7	82.1	73.6	61.1	51.6
9	88.6	80.5	72.1	55.8	52.3	89.3	80.4	73.1	56.5	51.2	84.3	80.2	72.3	60.6	49.3	87.4	80.4	72.5	57.6	50.9
M	91.3	86.4	81.1	71.7	66.0	91.4	86.3	81.4	71.0	67.3	90.7	84.1	79.4	74.2	64.8					

Table 3.3: Mean values of moisture content (% , wb) of osmotically dehydrated bottle gourd at 60 Degree Celsius

T	Mass ratio																			
	10:1					20:1					30:1					Mean				
	Concentration (%)					Concentration (%)					Concentration (%)					Concentration (%)				
	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
0	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6
1	92.2	88.5	85.6	82.1	68.3	91.3	87.5	84.8	76.8	67.7	89.0	82.3	70.8	70.4	68.9	90.8	86.1	80.4	76.4	68.3
3	91.4	87.3	81.9	71.2	54.9	90.1	86.4	81.2	71.9	60.9	89.2	80.0	76.3	69.0	60.9	90.2	84.6	79.8	70.7	58.9
5	89.3	84.2	78.3	66.3	53.8	88.6	84.2	76.6	74.4	56.4	88.5	80.4	74.4	63.7	55.2	88.8	82.9	76.4	68.1	55.1
7	87.5	82.2	73.9	56.8	51.7	86.5	81.9	74.2	59.1	50.8	88.1	80.2	72.3	59.3	53.2	87.4	81.4	73.5	58.4	51.9
9	89.1	81.3	71.9	54.6	50.1	86.8	79.8	72.2	55.0	49.9	82.1	78.2	69.1	51.4	46.9	86.0	79.8	71.1	53.7	49.0
M	90.9	86.5	81.2	71.1	62.4	89.8	85.9	80.8	72.1	63.6	88.8	82.8	76.4	68.2	63.5					

3.1.2 Solid gain

The solid gain of bottle gourd cubes was calculated during osmotic dehydration experiment for each after 1, 3, 5, 7, and 9

h respectively. The mean values of solid gain for the different set of experiments are presented in Table 3.4 through 3.6.

Table 4.4: Mean values of solid gain (%) of osmotically dehydrated bottle gourd at 40 Degree Celcius

T	Mass ratio																			
	10:1					20:1					30:1					Mean				
	Concentration (%)					Concentration (%)					Concentration (%)					Concentration (%)				
	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
1	4.7	5.0	5.8	6.5	8.2	4.7	5.8	6.1	6.4	8.1	6.4	9.8	7.0	7.0	9.1	5.2	6.8	6.3	6.6	8.4
3	5.1	6.0	5.9	7.2	8.8	4.7	5.9	6.2	7.2	9.2	6.6	7.9	8.1	9.1	10.1	5.5	6.6	6.7	7.8	9.4
5	5.0	6.0	8.0	10.0	11.6	5.0	5.9	7.8	9.5	11.4	7.3	8.1	11.6	12.7	14.4	5.8	6.7	9.1	10.7	12.5
7	5.3	6.0	9.4	12.6	14.0	5.7	6.1	9.9	12.1	13.9	8.3	9.0	14.1	12.8	18.5	6.4	7.0	11.1	12.5	15.5
9	5.9	8.1	11.7	12.7	19.5	6.5	8.2	11.7	16.9	19.6	10.3	12.3	15.6	17.8	19.8	7.6	9.5	13.0	15.8	19.6
M	5.2	6.2	8.2	9.8	12.4	5.3	6.4	8.3	10.4	12.4	7.8	9.4	11.3	11.9	14.4					

Table 4.5: Mean values of solid gain (%) of osmotically dehydrated bottle gourd at 50 Degree Celcius

T	Mass ratio																			
	10:1					20:1					30:1					Mean				
	Concentration (%)					Concentration (%)					Concentration (%)					Concentration (%)				
	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
1	5.3	5.8	6.4	6.8	8.6	5.7	6.3	6.7	6.9	8.8	6.4	8.3	7.0	7.0	9.2	5.8	6.8	6.7	6.9	8.8
3	5.7	6.3	6.9	8.2	9.4	5.8	6.6	7.1	8.2	10.2	6.7	8.0	8.4	9.1	10.7	6.1	7.0	7.4	8.5	10.1
5	6.2	7.0	8.3	10.1	12.9	6.7	7.5	10.0	11.2	12.8	7.8	8.6	12.0	13.1	15.0	6.9	7.7	10.1	11.5	13.6
7	6.7	7.3	10.5	12.6	15.8	7.9	8.5	12.1	14.4	16.2	9.4	10.4	14.5	12.9	18.9	8.0	8.7	12.4	13.3	16.9
9	8.1	9.9	12.0	13.3	20.3	8.6	10.3	13.7	17.5	20.4	11.1	13.3	16.1	18.1	20.6	9.2	11.1	13.9	16.3	20.4
M	6.4	7.3	8.8	10.2	13.4	6.9	7.8	9.9	11.6	13.7	8.3	9.7	11.6	12.0	14.9					

Table 4.6: Mean values of solid gain (%) of osmotically dehydrated bottle gourd at 60 Degree Celcius

T	Mass ratio																			
	10:1					20:1					30:1					Mean				
	Concentration (%)					Concentration (%)					Concentration (%)					Concentration (%)				
	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
1	5.9	6.6	7.1	7.2	9.0	6.7	6.8	7.3	7.5	9.5	6.5	6.8	7.1	7.1	9.3	6.4	6.7	7.1	7.2	9.3
3	6.3	6.7	7.8	9.2	10.0	6.8	7.4	8.1	9.2	11.2	6.9	8.0	8.6	9.1	11.3	6.7	7.4	8.2	9.2	10.8
5	7.4	8.0	8.6	10.3	14.1	8.4	9.0	12.2	12.9	14.2	8.2	9.2	12.4	13.4	15.6	8.0	8.7	11.1	12.2	14.6
7	8.1	8.7	10.8	12.6	17.5	10.1	10.9	14.3	16.7	18.5	10.6	11.7	14.9	13.3	19.2	9.6	10.4	13.3	14.2	18.4
9	10.3	11.6	12.2	14.8	20.6	10.6	12.5	15.6	17.9	20.8	11.8	14.2	16.6	18.3	21.4	10.9	12.8	14.8	17.0	20.9
M	7.6	8.3	9.3	10.8	14.2	8.5	9.3	11.5	12.8	14.8	8.8	10.0	11.9	12.2	15.4					

The effect of dehydration time on solid gain indicates that as the time increases the solid gain increases. This was true for all the combination of mass ratio and temperature set. While comparing different osmotic temperatures for the same set of mass ratio (30:1) the value of solid gain at 25% concentration of osmotic solution were 21.4% (wb) at 60°C, 20.6% (wb) at 50°C, 19.8% (wb) at 40°C which were dehydrated for 9 h. This suggests that at same concentration of osmotic solution, higher temperature is responsible for increasing solid gain. The same trends were obtained three mass ratio 10:1, 20:1 and 30:1. As can be seen the values of solid gain at 25% concentration of osmotic solution were 20.6%, 20.8% and

21.4% at 60°C, 20.3%, 20.4% and 20.6% at 50°C, 19.5%, 19.6% and 19.8% at 40°C for the mass ratio of 10:1, 20:1 and 30:1 respectively which were dehydrated for 9 h. the solid gain for samples dehydrated at 30:1 mass ratio were more to samples dehydrated at 10:1 mass ratio comparatively, keeping other variables constant. It might be due to higher mobility of viscous liquid.

3.1.3 Water loss

The kinetic of water loss at different process conditions was obtained. The mean value of water loss for the different set of experiments for presented in Table 3.7 through 3.9.

It can be depicted that the increase in the concentration of osmotic solution the loss of water is the removal of water increased. The maximum water loss was 59.9% found for samples osmotically dehydrated at 60°C for 9 h at 30:1 fruit to

osmotic solution of 25% concentration. The minimum 14.60% water loss was found for samples osmotically dehydrated at 40°C for 1 h at 10:1 fruit to osmotic solution of 5% concentration.

Table 3.7: Mean values of water loss (%) of osmotically dehydrated bottle gourd at 40 Degree Celsius

T	Mass ratio																			
	10:1					20:1					30:1					Mean				
	Concentration (%)					Concentration (%)					Concentration (%)					Concentration (%)				
	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
1	14.6	15.9	17.8	18.7	23.4	17.6	20.6	21.4	22.7	25.8	19.5	22.2	23.8	23.6	27.5	17.2	19.6	21.0	21.7	25.6
3	16.9	18.5	20.1	22.9	25.5	18.4	22.3	24.1	28.2	31.0	22.3	25.7	27.5	30.6	32.8	19.2	22.2	23.9	27.2	29.8
5	18.2	20.4	23.8	27.5	31.3	20.2	25.3	31.1	34.3	36.6	25.8	29.3	34.6	38.4	43.5	21.4	25.0	29.8	33.4	37.1
7	17.4	19.2	22.2	24.9	28.2	19.5	23.8	27.0	30.9	34.0	23.3	26.5	30.2	33.1	38.8	20.1	23.2	26.5	29.6	33.7
9	19.9	23.2	27.3	31.4	37.6	22.5	28.4	32.8	40.3	43.5	27.6	31.5	36.4	41.2	44.9	23.3	27.7	32.2	37.6	42.0
M	17.4	19.4	22.2	25.1	29.2	19.6	24.1	27.3	31.3	34.2	23.7	27.0	30.5	33.4	37.5					

Table 3.8: Mean values of water loss (%) of osmotically dehydrated bottle gourd at 50 Degree Celsius

T	Mass ratio																			
	10:1					20:1					30:1					Mean				
	Concentration (%)					Concentration (%)					Concentration (%)					Concentration (%)				
	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
1	15.6	19.6	23.8	26.5	29.1	18.3	21.2	25.1	25.9	30.7	20.9	24.1	26.2	26.8	33.1	18.3	21.6	25.0	26.4	31.0
3	20.5	22.7	24.2	28.9	31.4	22.5	25.7	28.5	30.2	33.4	24.8	29.1	31.1	32.0	36.8	22.6	25.8	27.9	30.4	33.9
5	21.5	23.7	26.7	31.4	36.3	24.5	27.5	32.3	34.4	37.3	27.9	31.4	38.9	39.7	43.2	24.6	27.5	32.6	35.2	38.9
7	23.2	25.5	29.2	34.5	40.9	28.2	30.6	35.7	38.1	41.2	32.3	34.8	45.0	46.7	51.3	27.9	30.3	36.6	39.8	44.5
9	24.5	27.9	32.5	36.4	44.5	30.3	33.4	38.2	44.5	48.1	30.5	39.3	47.5	49.6	53.4	28.4	33.5	39.4	43.5	48.7
M	21.1	23.9	27.3	31.5	36.4	24.8	27.7	32.0	34.6	38.1	27.3	31.7	37.7	39.0	43.6					

Table 3.9: Mean values of water loss (%) of osmotically dehydrated bottle gourd at 60 Degree Celsius

T	Mass ratio																			
	10:1					20:1					30:1					Mean				
	Concentration (%)					Concentration (%)					Concentration (%)					Concentration (%)				
	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
1	20.6	21.5	25.2	26.5	20.1	21.6	22.5	25.4	27.7	31.2	24.6	25.9	26.4	28.8	32.6	22.3	23.3	25.7	27.7	28.0
3	21.6	23.8	26.4	28.0	31.4	22.1	25.4	27.2	31.5	33.8	25.5	28.1	32.2	33.4	37.8	23.1	25.8	28.6	31.0	34.3
5	22.4	24.6	28.8	31.4	36.3	25.2	28.3	31.5	35.3	37.5	31.2	34.2	39.2	41.4	46.0	26.3	29.0	33.2	36.0	39.9
7	23.8	26.5	31.3	34.5	40.9	28.2	30.9	37.3	38.5	41.6	36.3	36.8	49.2	50.3	54.9	29.4	31.4	39.3	41.1	45.8
9	26.7	27.9	33.1	36.4	44.5	29.9	34.6	39.1	44.6	50.1	40.3	45.2	50.8	54.5	59.5	32.3	35.9	41.0	45.2	51.4
M	23.0	24.9	29.0	31.4	34.6	25.4	28.3	32.1	35.5	38.8	31.6	34.0	39.6	41.7	46.2					

3.1.4 Weight reduction

The results of weight reduction of bottle gourd cubes during the osmotic dehydration process for each after 1, 3, 5, 7 and 9 h, respectively. The mean values of weight reduction for the different set of experiments for presented in Table 3.10 through 3.12.

The maximum weight reduction was 38.9% for samples osmotically dehydrate at 60°C for 9 h at 30:1 fruit to osmotic solution with 25% concentration. Whereas the minimum

reduction in weight was found to be 10.7% for the samples osmotically dehydrated at 40°C for 1 h at 10:1 fruit to osmotic solution of 5% concentration. As can be observed that as the concentration of osmotic solution increased the weight reduction increased. This suggests that at same concentration of osmotic solution, higher temperature is responsible for increasing weight reduction. The same trends have been shown for three mass ratio 10:1, 20:1 and 30:1 (Table 3.10, 3.11 and 3.12.).

Table 3.10: Mean values of weight reduction (%) of osmotically dehydrated bottle gourd at 40 Degree Celsius

T	Mass ratio																			
	10:1					20:1					30:1					Mean				
	Concentration (%)					Concentration (%)					Concentration (%)					Concentration (%)				
	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
1	10.7	10.7	12.2	12.8	16.5	13.6	15.8	16.2	17.7	18.9	13.5	15.7	16.1	16.8	18.8	12.6	14.1	14.8	15.8	18.1
3	12.8	12.8	15.2	16.4	17.4	15.0	18.3	19.5	22.1	23.5	16.4	18.5	19.9	22.4	23.8	14.7	16.5	18.2	20.3	21.6
5	12.3	12.3	15.1	16.0	17.0	14.6	17.5	18.7	21.6	23.0	15.8	17.6	19.6	21.5	22.4	14.2	15.8	17.8	19.7	20.8
7	13.8	13.8	15.5	16.9	18.2	16.1	19.0	21.5	22.5	23.9	17.7	19.8	20.3	23.2	25.3	15.9	17.5	19.1	20.9	22.5
9	14.5	14.5	16.4	17.5	18.4	16.9	21.8	21.8	23.1	24.4	17.7	19.8	21.6	23.6	25.4	16.4	18.7	19.9	21.4	22.7
M	12.8	12.8	14.9	15.9	17.5	15.2	18.5	19.5	21.4	22.7	16.2	18.3	19.5	21.5	23.1					

Table 3.11: Mean values of weight reduction (%) of osmotically dehydrated bottle gourd at 50 Degree Celsius

T	Mass ratio																			
	10:1					20:1					30:1					Mean				
	Concentration (%)					Concentration (%)					Concentration (%)					Concentration (%)				
	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
1	11.3	14.8	17.0	18.1	19.5	14.2	15.7	18.2	19.0	23.4	14.6	16.9	18.7	19.5	23.7	13.4	15.8	18.0	18.9	22.2
3	15.4	17.0	18.3	19.2	19.8	17.6	20.8	22.4	23.3	24.8	18.5	20.6	22.5	23.8	25.5	17.2	19.5	21.1	22.1	23.4
5	16.3	17.8	18.7	19.8	20.2	19.4	21.8	23.5	24.8	25.4	20.5	22.7	26.4	27.2	27.0	18.7	20.8	22.9	23.9	24.2
7	17.9	19.0	19.5	20.5	20.3	22.6	24.5	26.1	26.6	26.6	23.8	26.1	31.8	32.3	29.8	21.4	23.2	25.8	26.5	25.6
9	18.7	19.8	20.3	20.9	21.1	24.8	25.1	26.8	27.7	27.9	24.1	27.6	31.8	32.5	30.3	22.5	24.2	26.3	27.0	26.4
M	15.9	17.7	18.8	19.7	20.2	19.7	21.6	23.4	24.3	25.6	20.3	22.8	26.2	27.1	27.3					

Table 3.12: Mean values of weight reduction (%) of osmotically dehydrated bottle gourd at 60 Degree Celsius

T	Mass ratio																			
	10:1					20:1					30:1					Mean				
	Concentration (%)					Concentration (%)					Concentration (%)					Concentration (%)				
	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
1	15.1	16.3	18.2	20.6	22.5	15.5	16.4	18.9	20.6	22.9	17.9	18.6	18.1	19.6	22.5	16.2	17.1	18.4	20.3	22.6
3	15.4	18.5	19.4	21.6	22.8	15.7	18.6	19.5	22.4	23.0	18.6	21.5	23.4	23.5	26.9	16.6	19.5	20.8	22.5	24.2
5	16.9	19.4	20.8	22.4	23.1	16.8	19.2	20.7	27.8	23.1	22.5	23.3	27.8	28.2	30.9	18.7	20.6	23.1	26.1	25.7
7	18.2	20.4	22.3	22.8	23.7	18.4	20.9	22.3	23.1	24.4	26.1	26.9	34.3	34.4	35.7	20.9	22.7	26.3	26.8	27.9
9	19.4	22.8	23.4	27.0	28.9	19.6	22.4	23.6	27.9	29.2	28.2	31.1	34.5	36.2	38.9	22.4	25.4	27.2	30.4	32.3
M	17.0	19.5	20.8	22.9	24.2	17.2	19.5	21.0	24.4	24.5	22.7	24.3	27.6	28.4	31.0					

3.3 Sensory evaluation

Samples of osmotically dehydrated cubes prepared with the approximately central conditions of processing parameters (50°C, 15% concentration, 6 h and 20:1 mass ratio) were subjected to sensory evaluation to get an idea about the liking/disliking sample by the penalist. Sensory evaluation was performed in accordance with the nine-point hedonic scale. The average sensory score for different attributes, viz., appearance, colour, texture and overall acceptability for the bottle gourd cubes of size 1 cm are given in Table 4.13. it can be seen that average score obtained by each attribute is either 7 or above, this indicates that the sample was liked moderate or liked very much in respective attributes by the judges.

Table 4.13: Average score for different sensory attributes of osmotically dehydrated bottle gourd cubes.

Appearance	Colour	Texture	Overall acceptability
7.5	7	7.7	7.6

4. Conclusion

Based on the result, following conclusions were drawn

- The maximum moisture content observed was 93.4% (wb) for samples osmotically dehydrated at 40°C for 1 h at 10:1 fruit to osmotic solution at 5% concentration. The minimum moisture content was 46.9 % (wb) for samples osmotically dehydrated at 60°C for 9 h at 30:1 fruit to osmotic solution at 25% concentration.
- As the duration increases, the weight reduction, water loss and solid gain of cubes were also increased for all the values of temperature and concentration. However, weight reduction, water loss and solid gain were very fast during the initial period of osmosis but equilibrium did reach even after 9h.
- The solid gain varies from 21.4% (9h, 25% concentration, 60°C, 30:1 mass ratio) to from 4.7% (1h, 5% concentration, 40°C, 10:1 mass ratio).
- The maximum water loss was 59.5% observed for samples osmotically dehydrated at 60°C for 9 h at 30:1 fruit to osmotic solution of 25% concentration. The minimum water loss was observed 14.5% for samples

osmotically dehydrated at 40°C for 1 h at 10:1 fruit to osmotic solution of 5% concentration.

- Weight reduction varies from 38.9% for samples osmotically dehydrated at 60°C for 9 h at 30:1 fruit to osmotic solution of 25% concentration to 10.7% for samples osmotically dehydrated at 40°C for 1 h at 10:1 fruit to osmotic solution of 5% concentration.
- The sensory evaluation performed for the approximately central conditions processing parameters (50°C, 15% concentration, 6 h, 20:1 mass ratio) gave average scores of 7 or above.

The work contributes to the control of dehydration (WL) and impregnation (SG) process and given insights on the handling of solids and water profiles inside the products. Temperature was found to have a proportional effect on the water loss and the dry matter gain of osmotically dehydrates cubes. in order to satisfy the growing osmotic dehydration that produces intermediate moisture food will be increasingly used.

5. References

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