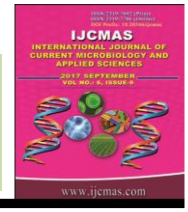
Int.J.Curr.Microbiol.App.Sci (2017) *6*(9): 129-141

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 9 (2017) pp. 129-141**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2017.609.016

Studies on Drying of Osmotically Dehydrated Onion Slices

Gourav Sahu*, N. Vinoda, P. Monisha, Vikas Paradkar and Nirmal Kumar

College of Agricultural Engineering, Bapatla, Andhra Pradesh, India
**Corresponding author*

Keywords

Osmotic dehydration, Water loss, Solid gain, Weight reduction, Drying.

Article Info

Accepted:
04 July 2017
Available Online:
10 September 2017

A B S T R A C T

The present investigation was carried out to study the effect of osmotic solute, solution concentration, immersion time and process temperature on osmotic dehydration of onion slices of 10 mm thickness by using different solution of salt, sugar and sugar-salt combination solution. In this study three sugar (40, 50 and 60°brix), three salt (5,15 and 25°brix) and three sucrose- salt (combine) solutions (40:15, 50:15, and 60:15°brix) were used and solution to sample ratio of 5:1 was maintained for dehydration period of 6 hour at different temperatures of ambient and water bath (30°C and 40°C respectively). The temperature was maintained during the process. After osmosis, the onion slices were dried in tray dryer for 8hour. The maximum water loss and solid gain was 45.66 % and 18.96 % respectively for 60:15°brix sugar-salt combination solution at 40°C while 60°brix sucrose solution gave 34.04 % and 11.04 % and 25°brix salt solution gave 33.78 % and 15.42% water loss and solid gain respectively. The 60:15°brix solution of salt-sugar concentration gave highest solid gain and water loss among all the treatment at both 30°C and 40°C process temperature. It can be concluded from this study that the nature of osmotic solution such as solution concentration, temperature and immersion time of treatment affected the transfer process solid gain, water loss and weight reduction during osmotic dehydration. The losses during storage and handling can be minimised and self-life of the onion can be increased by using combination of osmotic dehydration and drying method.

Introduction

Onion (*Allium cepa L*) is an important vegetable and famous spice grown and consumed in various form all over the world. India's rank second in onion production throughout the world. Onion is an important ingredient of the food in India and adds flavour and taste to foods; it is also consumed in raw form with meals. Due to high nutritional and mediational quality, onion is used as an appetizer, food digester and health promoter.

Processing of onion is required to convert of raw onions into various products such as ketchup, sauce, puree, chutney etc. Onion consumed throughout the year but its production is seasonal and yield depends upon the climatic conditions which causes shortage of onion in the market. Bulk storage of short day's tropical onions is very difficult because of their high moisture content (about 80 per cent), perishable nature and thin skin. The deterioration in quality of onion during storage is mainly due to spoilage caused by organisms and enzymes. Mechanical harvesting and handling operation may cause internal contamination of onions. (BARI 2003) reported that during storage, transportation and marketing, about 40-50 percent of post-harvest losses are occurred in onion. Due to moisture losses and spoilage, harvested onions should be marketed, processed or preserved as early as possible. Hence it is very important to convert the onion into other form such as dried form, or to develop a method for preservation and processing, to increase the self-life and quality.

Drying is done to increase self-life of product. Drying is the process of removal of the moisture or water to desired and predefined level without affecting the loss of taste, flavor, colour and nutrients (Singh and Kumar, 1984). Drying of onion extent the self-life, increase market value, easy to store as well as decreases losses during storage. The microorganisms responsible for food spoilage are prevent by moisture removal. The removal of moisture from fruits and vegetable can be accomplished by drying or dehydration methods. Drying and dehydration are carried out to reduce the moisture content of the product certain level so that growth of food spoilage microorganism can be prevent and at the same time high nutritive value is maintained.

Osmotic dehydration is the process or method commonly used for partial removal of water moisture from fruits and vegetables, by dipping them into solution of higher concentration. In food processing industries the osmotic dehydration is the one of the important process for removal of moisture from fruit and vegetable because osmotic dehydration methods improves the flavor, colour, texture and self-life of final product (Sutar and Gupta 2007; Pokharkar, 2001; Rastogi and Raghavarao, 1997; Karthanos *et al.*,1995). The process parameter such as solution concentration, temperature, immersion time, type of osmotic agent, sample to solution ratio and agitation rate of osmotic solution are influence the rate of water removal and solid gain during osmotic dehydration.

The several numbers of studies are carried out and literatures are available regarding influence of above mansion parameters on the rate of moisture loss and solid gain (Islam and Flink, 1982; Conway *et al.*, 1983; Le Maguer, 1988; Ertekin and Cakaloz, 1996; Rastogi and Raghavarao, 1997; Pokharkar, 2001). Osmotic dehydration method is used as a pre-treatment to many processes such as freeze drying, vacuum drying, air drying and freezing, (Ponting, 1973; Hawkes and Flink, 1978; Dixon *et al.*, 1976; Nanjundaswamy *et al.*, 1978). During osmotic dehydration process, water flows from material to the osmotic solution, whereas osmotic solute is transferred from solution to the material. The rate of transfer of water from material to the solution depends upon several factors such as solution concentration, temperature, shape and size of the material and method of agitation.

The drying of onion by conventional tray drying method cause the unwanted change in texture, colour, flavour and nutrition loss in product. Pre-drying treatments, such as partial dehydration of vegetables are suggested to improve the quality of dried product. Hence combination of osmosis and drying could be a solution to enhance the self-life and quality of dried onion without affecting the colour, texture, flavour and nutritive value. The commonly used solutes for osmotic pre-treatment are sugar, salt and combination of both sugar and salt. The main purpose of drying of onions is to improve storage life, quality and decrease the packaging and handling cost. Osmotic dehydration followed by drying seems to be cost effective method of preservation for the Indian condition and the quality of resultant product is better than the product of obtained by drying only.

The present investigation was carried out with the objectives to study the effect of osmotic solute and solution concentration on onion slices with different temperature and immersion time, to study the drying characteristics of osmotic dehydrated onion slices and to evaluate the quality of dehydrated onions.

Materials and Methods

Sample preparation

Fresh onions of local variety were procured from local market of Baptla, Andhra Pradesh India with an initial moisture content of 87.28%. Healthy and defects free onions were sorted and selected for conducting experiment. The onion were peeled and washed with water to remove adhering dust, dirt and impurities. The peeled onions were cut into circular slices of equal thickness of 10±1 mm with knife and the initial moisture content of raw fresh onions were determined by oven drying method.

The osmotic solutions were prepared by dissolving required and calculated quantity of osmotic agents such as salt, sugar and combination of salt and sugar. Salt, sugar was used as osmotic agents to prepare osmotic solution. The osmotic solution of different concentration such as salt (5%, 15% and 25%), sugar (40, 50 and 60 % Brix) and combination of sugar and salt (40:15, 50:15, 60:15°Brix) on the basis of percent weight by volume were prepared by dissolving calculated quantity of osmotic agent in distilled water.

The onion slices of 10 mm thickness were weight approximately 100 g for each treatment and then immersed into the osmotic solution of different concentration. The ratio of osmotic solute to onion slices was 5:1on weight by weight basis were maintained.

Experimental procedure for Osmotic dehydration and drying

Osmotic dehydration is the process of partial removal of water from fruit and vegetable. In this process the prepared sample of 100 g weight of sliced onion were immersed in a container containing osmotic solution of different osmotic agent and different concentration such as sugar (40, 50, 60 °Brix), salt solution (5,15,25) and combination of both (40:15, 50:15 and 60:15 °Brix). The samples of different concentration were placed at ambient and water bath at temperature of 30°C and 40°C respectively.

To maintain uniform temperature (30 and 40°C) throughout the process, the osmotic solution inside the containers were stirred up manually at regular interval. Each sample was taken out from the container at hourly interval upto 6 hour and were immediately rinsed with water and placed in tissue paper to remove excess solution and moisture from surface of sample. Finally the sample were weight and moisture content, water loss and solute gain of all the samples were determine at every hours upto 6 hours. After osmotic dehydration the treated samples were weighed by weighing balance. The weighed onion samples were spread in the form of thin layer on aluminum trays. These aluminum trays were put in tray dryer at a temperature of 60^{o}C for 8 h. Figure 1 represents the process flow chart of complete procedure of drying of osmotically dehydrated onion slices.

Determination of Moisture Content

Moisture content of raw fresh and osmotically dehydrated onion slices was measured by heating sample in a hot air oven dryer at 65^{0} C for 24 h. (Ranganna, 2000). Initial and final weight was measured by using electronic weighing balance of accuracy of 0.001g. The moisture content was determined and expressed in wet basis by using the following equation.

Moisture content (% WB) $= \frac{(\text{initial weight} - \text{final weight})}{\text{initial weight}} \times 100$

Moisture content on (% DB) $= \frac{MC(\%wb)}{100 - MC(\%wb)} \times 100$

Osmotic dehydration characteristics

The osmotic dehydration process is characterized by solid gain, water loss and the weight reduction from solute to solution during process. The mass transport amount indicates the net exchange of solute and water between the product and osmotic solution.

Water loss

Water loss is the amount of water removed by food product during osmotic dehydration process. The water loss is estimated on the basis of net weight loss from onion slices during osmosis (Hawkes and Flink, 1978).

$$WL = \frac{Wi \times Xi - Wt \times Xt}{Wi} \times 100$$

Solid gain

During osmotic dehydration process the diffusion of solute and solution is takes place which cause the adding of solid and removal of water by onion slices. The loss of water from sample leads to increase in solid content during transfer phase.

Solid gain is the net amount of solid uptake by onion slices during osmotic dehydration and it is expressed on initial weight basis.

$$SG = \frac{Wt(1 - Xt) - Wi(1 - Xi)}{Wi} \times 100$$

Weight reduction

Weight reduction is the total exchange of solid and liquid from the sample during osmotic dehydration and will affect the final weight of the sample. The weight reduction (WR) is defined as the net loss in weight of the fruit on initial weight basis. It is determine by the following formula

$$WR = \frac{Wi - Wt}{Wi} \times 100$$

or

Weight reduction (WR) =Water loss – Solid gain

Where,

WL = Water loss (g water/ 100 g initial mass of onion slices), %

SG = Sugar gain (g/100 g initial mass of onion slices), %

W_t = Mass of onion slices after time t, g

X_t= Water content as a fraction of mass of onion slices at time t

W_i = Initial mass of onion slices, g

X_i= Water content as a fraction of initial mass of onion slices.

Sensory evaluation of osmotically dried onion slices

The final dried onion product obtained from osmotically dehydration followed by drying was evaluated for acceptability by sensory evaluation. The sensory evaluation was done by a panel of members, trained to score the quality aspects of onion slices. Samples were scored for overall quality on basis of tease and appearance by using a hedonic scale.

Results and Discussion

Effect of osmotic solutes and concentrations of onion slices

The different solution such as sugar, salt and combination of sugar-salt and its concentrations are the important factors which affect solid gain from and the water loss by onion slices.

Effects of sugar solution concentration on solid gain and water loss

Water loss and solid gain by the onion slices with different solution concentration (40, 50 and 60^0Brix) of sugar solution against different immersion time of osmosis can be observed from the figures 1 and 2 respectively. It is observed from the figure that water loss (WL) from and solid gain percent by onion sample were increases as the sugar concentration increases with respective immersion time. The percentage of water loss is more than solid gain percent at respective similar solution concentration.

With increase in immersion time during osmotic dehydration at same sugar concentration the solid gain by and water loss from onion sample also increases this shows that immersion time have significant effect on solid gain and water removal during transport process.

During 6 hours of osmotic dehydration it can be observed from the figures 1 and 2 that the solution of higher concentration (60^0Brix sugar) have highest water loss of 24.24% as well as solid gain of 15.24% and then decreases with decreasing solution concentration which is next followed by 50^0Brix sugar solution with water loss of 22.51% and 10.51% solid gain, while at lowest solution concentration (40^0Brix sugar) water loss and solid gain decreases further and it is recorded to 15.32% and 732% respectively. The similar observation and behavior were reported by Bohuon *et al.*, 1997; Falade, 2003 and Alam *et al.*, 2013 regarding weight reduction and water loss.

Effect of different salt solution concentrations on solid gain and water loss

The salt solution of different concentration (5, 15 and 25°Brix) and immersion time influences the solid gain and water loss by onion slices and results obtained from 6 hours of osmotic drying were presented in figure 3 and 4.

It was observed that water loss and solid gain were more at higher solution concentration and significantly decreases with decreasing salt concentration. From the experimentation results the solid gain were 13.25, 11.25 and 6.93% and water loss were 33.44, 20.53 and 14.93% for 25°B, 15°B and 5°B respectively for 6 hour of osmotic drying this is due to solute and water activity gradient increased with increasing solution concentration. Krokida *et al.*, 2000; and Ravaskar, 2007 also reported that with increase in salt or sugar content in solution concentration the water loss and solid gain also increases with given processed immersion time.

Effect of different combination of sugar-salt solution concentrations on solid gain and water loss

The different combination of sugar-salt solution concentration say 40:15, 50:15 and 60:15°Brix were used to observed the change in solid gain and water loss by onion slices and it is clearly seen from the figures 5 and 6 that for all the combination of solution solid gain and water loss increases with the increased in immersion time. Initially the rate of water loss and solid gain is more and rapid up to first four hour, after that the rate decrease due to reduction in osmotic potential gradient and equilibrium is being achieved which cause reduction in transfer of solute and solvent. The solution concentrations affect to achieve equilibrium stage with time. The results obtained from the study shows that at higher concentration required more time to achieve equilibrium stage this is due to higher viscous nature of concentrated solution. Nieuwenhuijzen *et al.,* 2001; also reported that the mass transfer coefficient is affected by solution concentration and as the solution concentration increases the mass transfer resistance also increases which cause increase in time to achieve equilibrium. Water loss and solid gain for 6 hours of osmotic dehydration time increases with higher solution concentration and it was found to be 35.66% and 20.67% respectively for 60:15 sugar-salt solution, whereas the lowest value of water loss and solid gain was 30.22% and 12.65% for solution concentration of 40:15 sugar-salt solution.

It can also be observed the from figures 5 and 6 that solid gain and water loss for 50:15°brix (sugar-salt) osmotic sample for 6 hour was 15.23% and 33.45% respectively and from figures 1 and 2 the water loss and solid gain was 24.24 and 15.24% respectively for 60°brix sugar solution. The solutions of sugar-salt combination (50:15°brix) and sugar solution of 60°brix contain same amount of solute concentration that is 60%. Due to presence of higher sugar proportion, the 60°brix solution is more viscous than 50:15°brix sugar-salt solution therefore the resistance to mass flow is more and higher in 60°brix as compare to 50:15°brix sugar- salt solution combination.

Highest water loss and solid gain at same solute concentration was obtained by 50:15°brix (sugar-salt) solutions and it is probably due membrane effectiveness and highest solution concentration.

Effects of change in temperature on osmotic dehydration behaviour

The studies were conducted to observe the effect of change in temperature for all the solution concentration during osmotic dehydration of onion slices. According to the results obtained from the osmotic dehydration of different sample at ambient temperature (30°C) the solution which have maximum water loss and solid gain (60°brix sugar, 25°brix salt and 60:15°brix sugar- salt solutions) were compared at two different temperature (30 and 40°C) were present in table 1. From the result obtained, it was found that moisture content decreases as temperature of solution increases with given osmotic time for similar concentration. This shows that the change in temperature affect the mass transfer rate. Thus as the temperature increases the solid gain as well as water loss also increases for given osmotic time and solution. The maximum water loss and solid gain were observed for both the temperature that is at ambient (30°C) and water bath (40°C) temperature. The results obtained from the study shows that the maximum water loss for sugar-salt combination solution of 60:15°brix was 45.66% whereas lowest value of water loss was 33.78% for 25°brix salt solution at same temperature of 40°C. The value of solid gain was found to be highest at 40°C for 60:15°brix sugar-salt solution was 18.96% followed by 25°brix salt-solution was15.42% and minimum value of solid gain was 11.04% for 60% sugar solution concentration. In case of 30°C temperature water loss was 34.67%, 30.44% and 24.24% whereas solid gain was 17.20%, 13.25% and 9.40% for 60:15°brix sugar-salt, 25°brix salt and 60°brix sugar solutions concentration respectively. Osmotic dehydration is the two way mass transfer diffusion process and it is strongly affected by processed temperature and time of immersion Farkas and Lazar (1969); Hope and Vital

(1972); Beristain *et al.*, (1990); Alam *et al.*, (2013). Temperature can be one of the advantageous factors to complete osmotic dehydration rapidly but same time higher temperature affects colour and flavor of product. Pointing *et al.,* (1966) suggested that the maximum temperature of 49°C was suitable for osmotic dehydration to achieve maximum advantage of process without affecting its colour and flavor.

Fig.1 Effect of sugar concentration and immersion time on water loss from onion sample

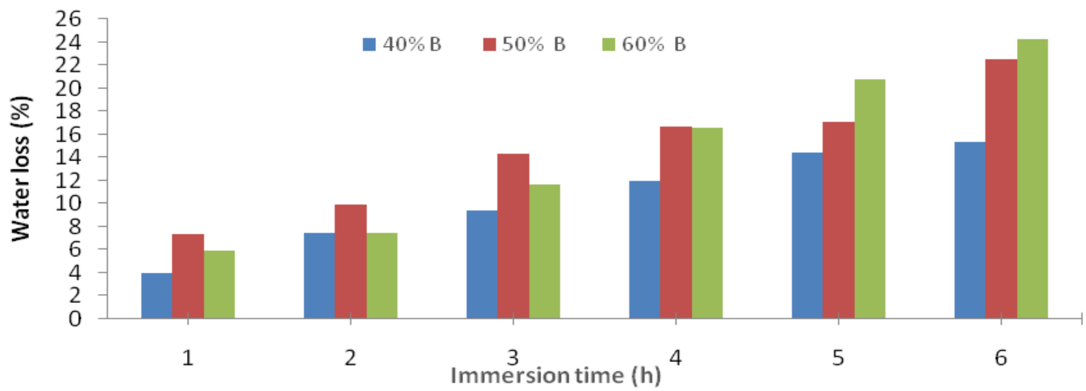


Fig.2 Effect of sugar concentration and immersion time on solid gain by onion sample

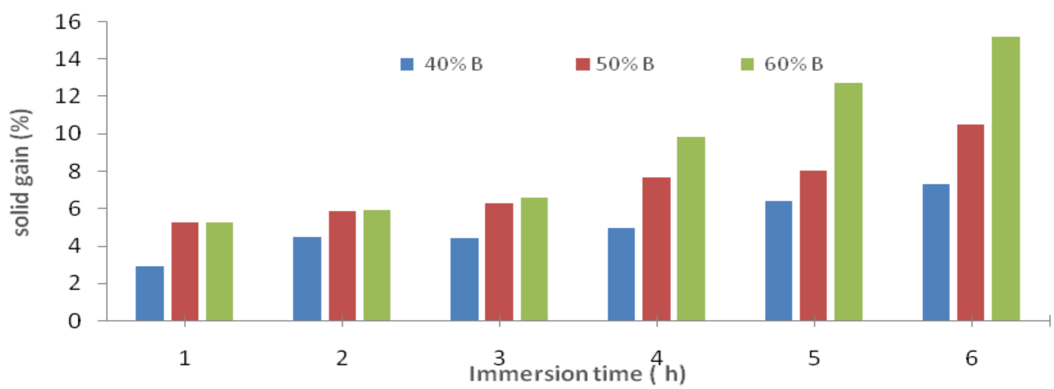


Fig.3 Effect of salt solution concentration and immersion time on solid gain by onion sample

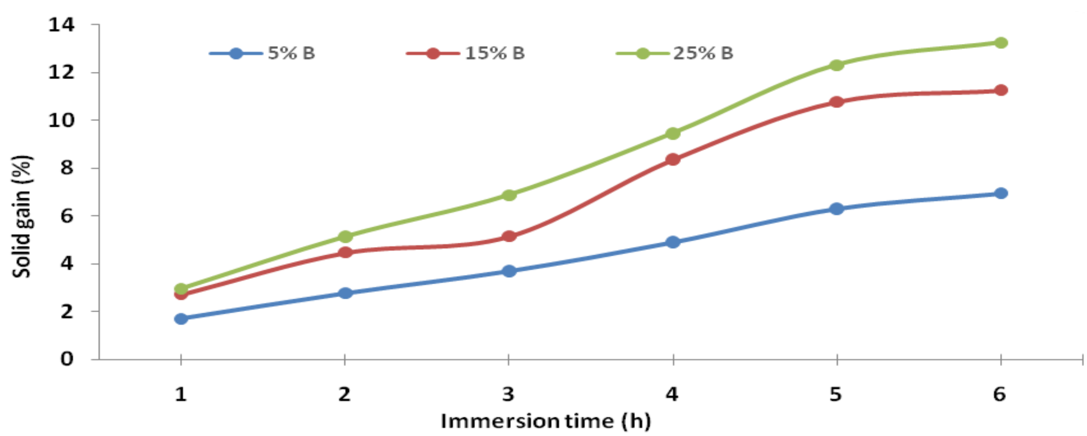


Fig.4 Effect of salt solution concentration and immersion time on water loss from onion sample

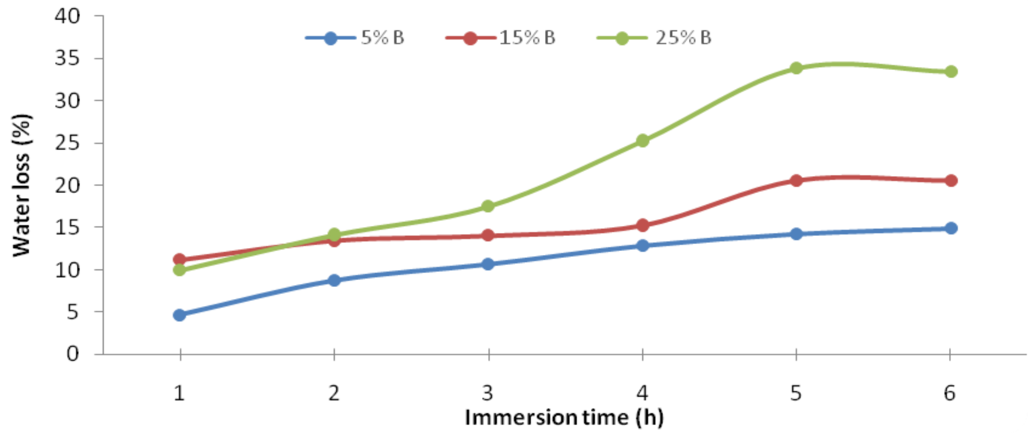


Fig.5 Effect of sugar salt combination solution concentration and immersion time on solid gain by onion sample

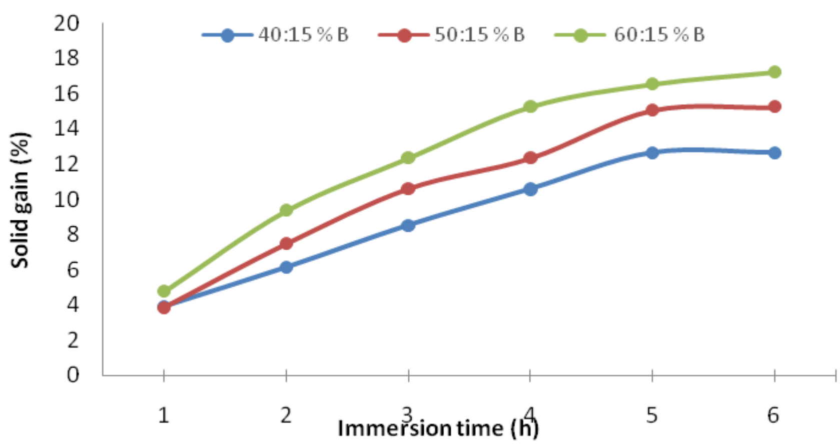


Fig.6 Effect of sugar salt combination solution concentration and immersion time on solid gain by onion sample

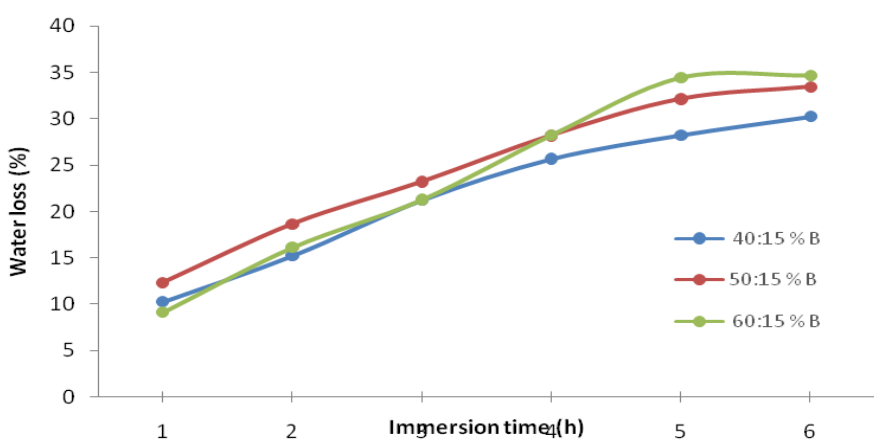


Fig.7 Effect of drying on weight reduction of salt treated onion slice

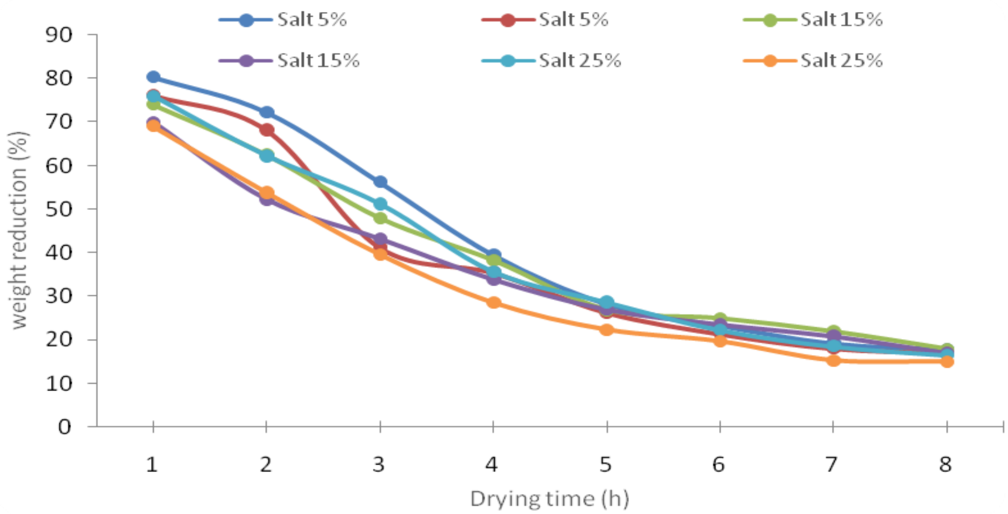
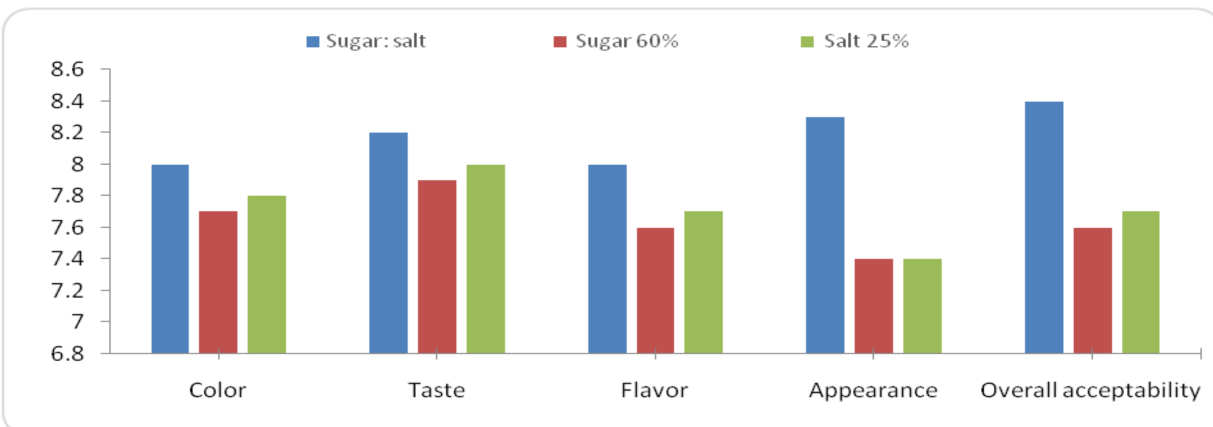


Fig.8 Sensory evaluation of osmotic treated onion slices at different concentration of sugar, salt and combination of sugar and salt



Raw onions
↓
Peeling
↓
Washing
↓
Slicing (10 mm)
↓
Osmotic dehydration for 6h
(Ambient 30°C and 40°C)
↓
Tray drying (60°C for 8-10 h)
↓
Quality evaluation

Fig.1. Process flowchart for drying of onion slices

Table.1 Effect of immersion time and osmotic solution concentration on behaviour of onion slices at different temperature

Temperature (^{0} C)	Immersion time (h)	Initial solid (%)	Water loss WL (%)			Solid gain SG (%)		
			60% sugar	25% salt	60:15°brix sugar-salt	60% sugar	25% salt	60:15°brix sugar-salt
30	1	12.72	5.82	9.98	9.15	2.82	2.98	4.78
	2		7.43	14.15	16.14	3.93	5.15	9.35
	3		11.60	17.52	21.28	4.32	6.89	12.33
	4		16.54	25.25	28.23	5.02	9.47	15.23
	5		20.74	28.82	32.43	7.41	12.3	16.52
	6		24.24	30.44	34.67	9.40	13.2	17.20
40	1	12.72	12.55	9.48	12.02	3.55	3.34	4.56
	2		17.93	15.23	21.73	4.32	5.86	10.73
	3		22.23	16.95	25.22	5.10	6.95	13.22
	4		27.10	24.13	29.30	6.33	12.1	15.00
	5		29.33	29.73	38.32	8.33	13.4	17.51
	6		34.04	33.78	45.66	11.04	15.4	18.96

Table.2 Effect of drying on weight reduction on sugar treated onion slices

Time(h)	**Sugar 40%**		**Sugar 50%**		**Sugar 60%**	
	Ambient	**40^{0}C**	**Ambient**	**40^{0}C**	**Ambient**	**40^{0}C**
0	92	86	88	75	87	74
1	74	74	76.28	64	70	67
2	56.56	52	53	52.00	59	55.23
3	43	42	42.23	43	49.00	45
4	32.33	34	35	38	38.59	36
5	25	28	29.53	34	32.82	28.00
6	23.22	22.52	25	26.00	25.52	22
7	21.00	18.00	21	22	21	17.5
8	18.5	18.54	19.88	18.53	19.00	14.56

Table.3 Effect of drying on weight reduction on sugar: salt treated onion slices

Time(h)	**Sugar : salt 40:15%**		**Sugar : salt 50:15%**		**Sugar : salt 60:15%**	
	Ambient	**40^{0}C**	**Ambient**	**40^{0}C**	**Ambient**	**40^{0}C**
0	79	78	76	75	75	74
1	71.00	71	72.00	68	70	67.33
2	56.32	52	54	51	53	52.26
3	42.20	42.23	43	42.21	42	42.25
4	35.20	31.22	36	36	33	31
5	28.52	25.25	27	29	26	25.53
6	25.36	22	22	21.00	21	21.23
7	22.00	18.00	18.12	18.52	17	18.55
8	19.50	17.50	15	15.5	14.52	14.22

Drying characteristics of osmotic dehydrated onion slices

Effect of drying on weight reduction of onion slices at different salt concentrations and at different temperatures

The osmotically treated onion slices were dried in tray dryer at 60^0C for 8 h at different sugar, salt and combination of both sugar and salt concentrations for given immersion temperatures of 30^0C and 40^0C. The weight reduction was calculated at different drying time intervals and data were analysed.

The variation in weight reduction of onion slices at different solution concentrations and different temperatures is shown in figure 7. It was observed that the weight reduction was more rapid in first 4 h after that drying rate gradually decreased and almost reached a constant weight in all solution concentrations. The weight reduction of osmotic dehydrated onion samples was observed more at 25% salt concentration and 40^0C immersion temperature and that is from 85g to 15g and it takes less time to get constant weight reduction compared to other salt concentrations.

Effect of drying on weight reduction of onion slices at different sugar concentrations and at different temperatures

The osmotically treated onion slices were dried in tray dryer at 60^0C for 8h at different salt concentrations of 40, 50 and 60% and at immersion temperatures of ambient and 40^0C. The weight reduction was calculated at different drying time intervals and data were analyzed.

The variation in weight reduction of onion slices at different sugar concentrations and at different temperatures is shown in table 2. It was observed that the weight reduction was more rapid in first 4 h after that drying rate gradually decreased and almost reached a constant weight in all sugar concentrations. The weight reduction of osmotic dehydrated onion samples was observed more at 60% sugar concentration and 40^0C immersion temperature *i.e.*, from 74g to 14.56g and it takes less time to get constant weight reduction as shown in table 2.

Effect of drying on weight reduction of onion slices at different combination of sugar and salt concentrations and at different temperatures

The osmotically treated onion slices were dried in tray dryer at 60^0C for 8 h at different combination of sugar and salt concentrations of 40:15, 50:15 and 60:15% and at immersion temperatures of ambient and 40^0C. The weight reduction was calculated at different drying time intervals and data were analyzed.

The variation in weight reduction of onion slices at different sugar concentrations and at different temperatures is shown in table 3. It was observed that the weight reduction was more rapid in first 4 h after that drying rate gradually decreased and almost reached a constant weight in all sugar-salt concentrations. The weight reduction of osmotic dehydrated onion samples was observed more at 60:15% sugar-salt concentration and 40^0C immersion temperature *i.e.*, from 74g to 14.22g and it takes less time to get constant weight reduction as shown in table 3.

Quality of stored onion slices based on sensory evaluation

A sensory evaluation method adopted for the analysis of acceptability of the osmotic dehydrated onion slices with the help of a hedonic scale. The data obtained from sensory evaluation of osmotic dehydrated onion slices by panel members is shown in figure 8. Finally it can be concluded that the color, taste, flavor, appearance and overall acceptability is observed a high rating in 60:15% sugar and salt followed by 25 % salt and 60% sugar concentrations.

The osmotic dehydration of onion slices was done at different concentrations of osmotic solution of salt, sugar and combination of sugar and salt concentrations for dehydration periods of 6 h at different immersion temperatures of 30^{o}C and 40^{o}C in the hot water bath. The osmotically treated onion slices were dried in tray dryer upto the moisture level of 10%. The maximum water loss and solid gain of 45.66 % 18.96 % were observed at 40°C for 60:15°brix sugar- salt solutions. While for 60°brix sugar solution concentration water loss and solid gain were 34.04 % and 11.04 % 25°brix salt solution gave 33.78 % and 15.42% water loss and solid gain respectively. Whereas lowest water loss and solid gain were observed to 14.93 % and 6.93% respectively for 30°C immersion temperature. From the study it can be concluded that solution concentration, sample immersion time and solution temperature were the most prominent factors which affects the solid gain, water loss and moisture loss during osmotic dehydration of onion samples. Finally, it was concluded that the quality of osmotic dehydrated onion slices was best at 60:15% of sugar-salt concentration at ambient temperature. By processing of onion post-harvest losses during handling and storage can be reduced, its self-life, product quality, market value and production can be maximized.

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How to cite this article:

Gourav Sahu, N. Vinoda, P. Monisha, Vikas Paradkar and Nirmal Kumar. 2017. Studies on Drying of Osmotically Dehydrated Onion Slices. *Int.J.Curr.Microbiol.App.Sci.* 6(9): 129-141.
doi: https://doi.org/10.20546/ijcmas.2017.609.016