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Comparative Study on Shelf Life and Mass Transfer Properties of Dried Pumpkin Pretreated with Sucrose and Brine Solution

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Abstract **- The aim of this work was to compare the shelf life and mass transfer properties of dried pumpkin pre-treated with osmotic solution. The effect of process parameters during osmotic dehydration such as duration of osmosis, solute concentration and temperature of osmotic solution on water loss and solid gain was studied. The water loss and solid gain increased with increase in solute concentration and temperature. The water loss and solid gain during osmosis at 30, 40, 50 and 60°Bx sucrose concentration varied in the range of 51.70 to 71.27 and 16.13 to 19.26 percent and at 5, 6, 7 and 8% NaCl concentration 23.43 to 38.86 and 13.86 to 22.86 percent at 30 and 40°C temperature respectively. The sun drying and pre-treatments had a significant effect on the shelf life and the color was better when dried in 60°Bx sucrose solution at a temperature of 40°C. The quality of sundried product in respect to color and shelf life was superior, which is the principle reason for the cost reduction and energy saving. The pumpkin pre-treated at 60ºBx sucrose solution at 40°C osmosis temperature was more acceptable on the basis of color and shelf life.**

Key Words: shelf life, mass transfer properties, dried pumpkin, sucrose solution, brine solution.

ABBREVIATION

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et al	: And others
etc.	: et cetra
Fig.	: Figure
g	: Gram
h	: Hour
i.e.	: That is
min	: Minute
w/w	: Weight By Weight
Hp	: High pressure
%	: Percent
MPa	:Mega Pascal
^{0}	: Degree
^{0}Bx	: Degree Brix
^{0}C	: Degree Celsius
SG	: Solid Gain
WL	: Water Loss
NaCl	: Sodium chloride

I. INTRODUCTION

Pumpkins (*Cucurbita Spp* L.) are a nutritious vegetable vine plant which dates back many centuries. Pumpkin fruits are consumed both immature and ripe. The flesh of the fruit can be boiled, canned, dried and pickled or processed to obtain juice and pomace [1, 2]. Production of pumpkin is seasonal, during this short time they are produced in greater quantity than the market can absorb, so these pumpkins must be processed and preserved to avoid wastage and it's shelf-life needs to be extended.

Shelf life of fruits and vegetables, as well as seasonal products, is relatively short and taking into account that they are valuable raw materials for food industry, it is very important to increase their sustainability. Most harvested fruits quickly deteriorate due to microbial and biochemical activity. However, different preservation methods are used to extend the shelf-life by a few weeks, one year or more. Consumers generally expect the dried product to have properties close to those of the original material.

Osmotic dehydration is one of the simple and inexpensive alternate processes, which offers a way to make available this low cost, highly perishable and valuable crop available for the regions away from production zones and also during off season. Advantage of this process is quality improvement, Packaging and distribution cost reduction, influence on the principle drying method, product stability during storage, no chemical requirement, shortening of the drying process, resulting in lower energy requirements. During osmotic dehydration, a product is continuously immersed in the osmotic solution, making the process oxygen free. The water content of food is usually very high, typically 80 to 90% for various fruits and vegetables. Removing moisture from food restrain various bacteria from growth and spoilage food.

Mass transfer rate during osmotic dehydration depends upon many factors, such as temperature and concentration of osmotic solution, the size and geometry of the food, solution to food mass ratio and agitation of the solution etc. The application of high pressure (HP) (100-800 MPa) damages the cell wall structure (primarily the non covalent bonds), leaving the cells more permeable resulting in the increase of mass transfer rates during osmotic dehydration compared to untreated samples.

Sun drying is natural drying, which removes moisture from food to aid in preservation. Concentration of sunlight having heat and airflow to reduce the water content of food. Thus, novel thinking in the technology of drying to minimize the energy demand is very important. And sun drying greatly helps in energy conservation and cost reduction in all manners. The objectives of this study were to study the effect of temperature and concentration variation of sucrose and brine solution on osmo pre-treated sundried pumpkin slices and to evaluate & compare the mass transfer properties & shelf life of osmo pretreated sundried Pumpkin.

II. MATERIALS AND METHODS

Raw Materials

Fresh, good quality, well ripe, fully matured pumpkins were purchased from the local market. The average moisture content was 95.34% on a wet basis. Pumpkins were sliced in 3mm thickness for osmotic dehydration. As osmotic agent commercial white sugar and salt were procured from a local supermarket.

Experimental Design and Statistical Analysis

In this study, four level design was adapted. Osmotic solution was prepared into specific concentration using commercial sucrose and distilled water. The concentration of osmotic solution was monitored using a refractometer and held in a water bath to achieve required solution temperature. Samples were dipped in sucrose solution of a specified concentration for an assigned time. The pumpkin:solution ratio was fixed at 1:10 (w/w) throughout the experiment. The osmotic medium and content was agitated manually at every 30 min interval to avoid localize dilution of sucrose solution. After osmotic dehydration treatment, the samples were withdrawn from the solution and blotted with tissue paper to remove adhering sugar solution.

After that, the osmo dehydrated pumpkin was dried in sunlight until reaching 10% final moisture content. Observations were made on water loss and solid gain based on sugar concentration with immersion temperature and immersion time. And the shelf life for the sun dried pumpkin slices were estimated with yeast/mold count.

Analysis of variance was made with two way classification using F Test (variance ratio) for means separation at a significance level of 5%.

Determination of water loss (WL) and solid gain (SG)

Osmotic dehydrated samples were blotted with tissue paper and later weighed for determination of *WL* and *SG* as shown by the following equation [3]:

$$WL = \frac{W_{WO} - W_{W}}{Mo} \times 100 \qquad (1)$$

$$SG = \frac{W_{S} - W_{SO}}{Mo} \times 100 \qquad (2)$$

where, WL and SG are water loss and solid gain in %, respectively. Wwo is the initial water mass, Ww is the mass of water at time t, W_S is the solid mass at time t (after blotting), Wso is the initial solid mass, and Mo is the initial weight (water + solid) of the fresh pumpkin (prior to osmotic dehydration treatment).

III. RESULTS AND DISCUSSION

Effect of concentration of osmotic solutions and temperature on water loss

The water loss by pumpkin slices during osmosis as calculated by mass balance is given in the Table 1 and 2,the water loss after osmotic dehydration was found to be in the range of 51.70 to 71.27%, corresponding to experiments at low level (30ºBx 30ºC after 120 min) and high level (60^{o}Bx 40^{o}C after 120 min) for sugar, and for salt the water loss after osmotic dehydration was found to be in the range of 23.43 to 38.86%, corresponding to experiments at low level (5% 30^{o}C after 120 min) and high level (8% 40^{o}C after 120 min). It can be observed when solution temperature was increased from 30 to 40^{o}C for 60^{o}Bx of sugar solution and 8% of salt solution, water loss increased from 70.62 to 71.27 and 34.97 to 38.86 respectively. After two hour of osmotic dehydration causing approximately 0.65% and 3.89% point increment in sugar & salt respectively. Similarly for 50^{o}Bx of sugar and 7% of salt, the water loss increased from 64.61 to 68.81 and 32.25 to 36.57% when solution temperature was increased from 30 to 40^{o}C resulting into 4.2 and 4.32 percent increment respectively. Similar trend was obtained for 40^{o}Bx of sugar and 6% of salt the water loss increased from 55.04 to 63.63 and 31.78 to 35.92% when solution temperature was increased from 30 to 40^{o}C resulting into 8.59 and 4.14% point increment respectively. It also similar for 30^{o}Bx of sugar and 5% of salt where the water loss increased from 51.70 to 55.04 and 23.43 to 32.15% when solution temperature increased from 30 to 40^{o}C resulting into 3.34 and 8.72% point increment respectively.

This is due to rise on fruit membrane permeability caused by higher temperatures that promotes swelling and plasticization of cell membrane, favoring mass transfer [4, 5, 6]. Higher temperatures promote faster water loss through swelling and plasticizing of cell membranes as well as the better water transfer characteristics on the product surface due to lower viscosity of the osmotic medium/ Thus, high temperature would release trapped air from the tissue resulting in more effective removal of water by osmotic pressure.

The effect of sugar concentration levels (30, 40, 50, 60^{o}Bx) and temperature levels (30 and 40^{o}C), salt concentration levels (5, 6, 7, 8%) and temperature levels (30 and 40^{o}C) on moisture loss with respect to time of osmosis are shown in Fig. 1 and 2. It was observed from these figures that the moisture loss increased nonlinearly with time at all concentration and temperature. Moisture loss was fast in the initial period of osmosis and then the rate decreased. A high initial rate of water removal followed by a slower removal in the later stages was observed. Several research groups have published similar curves for osmotic dehydration of foods [7, 8, 9].

Effect of temperature and concentrations of osmotic solutions on solid gain

The solid gain by pumpkin slices during osmosis as calculated by mass balance is given in the Table 3 and 4. The solid gain after osmotic dehydration for sugar solution was found to be in the range of 16.13 to 19.26%, corresponding to experiment at low level (30^{o}Bx, 30^{o}C after 120 min) and high level (60^{o}Bx, 40^{o}C after 120 min). And solid gain after osmotic dehydration for salt solution was found to be in the range of 13.86 to 22.86%, corresponding to experiment at low level (5%, 30^{o}C after 2 h) and high level (8%, 40^{o}C, after 120 min). It can be observed that when solution temperature increased from 30 to 40^{o}C for 60^{o}Bx of sugar solution and 8% of salt solution, solid gain increased from 18.22 to 19.26 and 21.77 to 22.86% after two hour of osmotic dehydration causing approximately 1.04% and 1.09% point increment in sugar & salt respectively. Similarly for 50^{o}Bx of sugar and 7% of salt, the sugar and salt (solid) gain increased from 17.69 to 18.85 and 21.09 to 21.95% when solution temperature increased from 30 to 40^{o}C resulting into 1.16 and 0.86% point increment respectively. Similar for 40^{o}Bx of sugar and 6% of salt the solid gain increased from 16.26 to 17.43 and 14.82 to 21.95% when solution temperature increased from 30 to 40^{o}C resulting into 1.17 and 7.13% point increase respectively. In the same way for 30^{o}Bx of sugar and 5% of salt the solid gain increased from 16.13 to 17.21 and 13.86 to 21% when solution temperature increased from 30 to 40^{o}C resulting into 1.08 and 7.14% point increment respectively. It was revealed that solid gain increased with duration of osmosis and did not approach the equilibrium after 2 hour of osmotic dehydration. The solid gain also increased with the concentration of the solution as shown in Fig. 3 and 4. This is because of the increased concentration difference between pumpkin and solution with increase in solution concentration. The solid gain also increased with increase in osmotic solution temperature. It may be due to collapse of the cell membrane at higher temperatures. Similar results have also been reported by [10] for peas and blueberries respectively.

In several studies, it has been concluded that cell membrane destruction at higher temperature lead to higher solid uptake by plant based materials during osmosis treatment [11, 12, 13, 14]. Previous research findings revealed higher amount of WL & SG in more concentrated solution due to the more osmotic pressure gradients [15, 16]. In addition to this, increasing temperature caused a reduction on solution viscosity, lowering external resistance to mass transfer and making water & solution transport easier. Similar results were obtained by [17, 18, 19] in osmotically dehydrated Cantaloupe cylinders, mango slices & pomegranate arils respectively. The experimental values for water loss & solid gain under different treatment conditions showed that water removal was always higher than the solid gain, in agreement with the results of other workers [4].

Table I. Mass transfer kinetics data for % water loss at 30°C

Sample	Concentration	Time (min)				
		0	30	60	90	120
T_1	**30°Bx**	0	13.06	30.98	40.40	51.70
T_2	**40°Bx**	0	15.45	36.97	51.09	55.4
T_3	**50°Bx**	0	19.91	42.24	57.19	64.61
T_4	**60°Bx**	0	24.67	45.08	60.46	70.62
T_5	**5%**	0	1.91	12.26	18.78	23.43
T_6	**6%**	0	6.31	15.58	25.32	31.78
T_7	**7%**	0	8.99	17.5	25.71	32.25
T_8	**8%**	0	9.71	18.01	25.91	34.97

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Table II. Mass transfer kinetics data for % water loss at 40°C

Sample	Concentration	Time (min)				
		0	30	60	90	120
T_1	**30°Bx**	0	16.21	31.23	45.09	55.04
T_2	**40°Bx**	0	19.33	40.36	53.81	63.63
T_3	**50°Bx**	0	17.79	41.06	55.91	68.81
T_4	**60°Bx**	0	25.58	46.91	61.07	71.27
T_5	**5%**	0	8.41	17.94	25.82	32.15
T_6	**6%**	0	8.99	18.86	27.34	35.92
T_7	**7%**	0	11.04	20.63	29.83	36.57
T_8	**8%**	0	11.89	23.37	31.96	38.86

Table III. Mass transfer kinetics data for % Solid gain at 30°C temperature

Sample	**Concentration**	**Time (min)**				
		0	**30**	**60**	**90**	**120**
T_1	**30°Bx**	0	3.24	7	15.09	16.13
T_2	**40°Bx**	0	4.01	8.87	14.27	16.26
T_3	**50°Bx**	0	6.17	12.42	17.19	17.69
T_4	**60°Bx**	0	8.08	13.62	17.56	18.22
T_5	**5%**	0	2.07	6.40	10.77	13.86
T_6	**6%**	0	4.81	8.85	12.09	14.82
T_7	**7%**	0	5.27	10.75	15.87	21.09
T_8	**8%**	0	5.84	11.04	16.53	21.77

Table IV. Mass transfer kinetics data for % Solid gain at 40°C temperature

Sample	**Concentration**	**Time (min)**				
		0	**30**	**60**	**90**	**120**
T_1	**30°Bx**	0	3.55	8.72	15.42	17.21
T_2	**40°Bx**	0	5.29	10.51	16.71	17.43
T_3	**50°Bx**	0	7.13	12.28	17.33	18.85
T_4	**60°Bx**	0	8.36	14.04	17.70	19.26
T_5	**5%**	0	3.43	10.50	16.61	21.00
T_6	**6%**	0	4.07	10.60	16.71	21.95
T_7	**7%**	0	6.31	11.66	18.09	22.47
T_8	**8%**	0	6.48	12.47	18.34	22.86

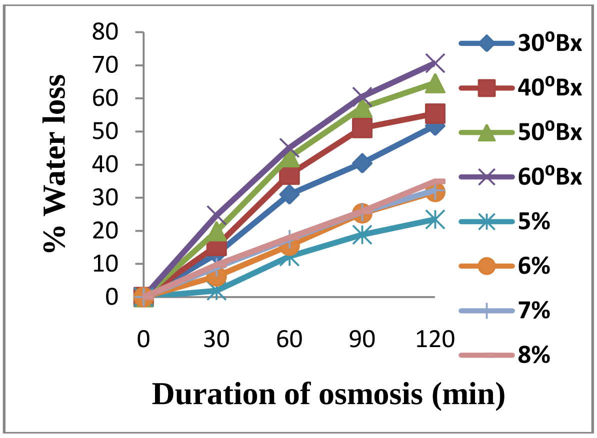

Fig 3. Effect of Temperature of osmotic solution on solid gain at different sucrose and salt concentration at 30ºC .

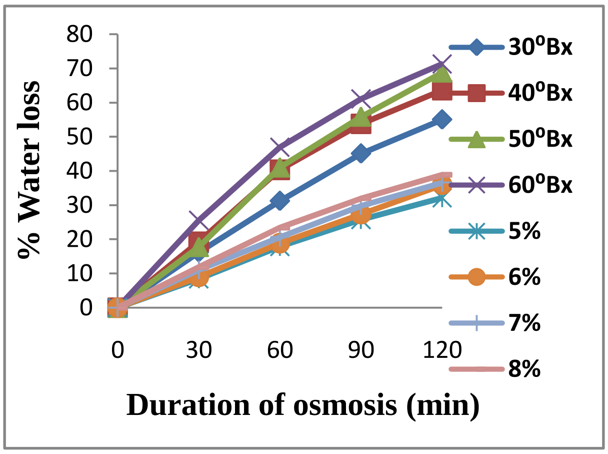

Fig4.Effect of temperature of osmotic solution on solid gain at different sucrose and salt concentration at 40ºC.

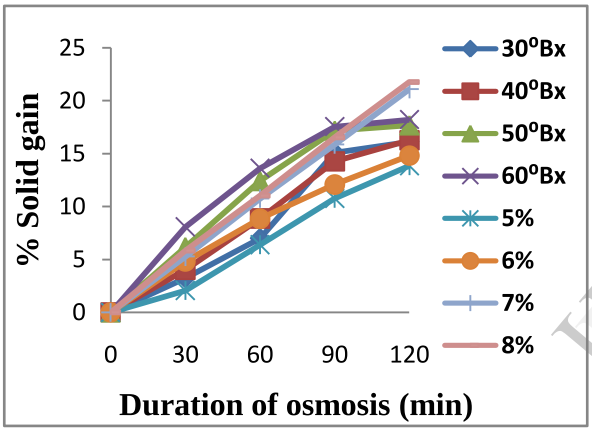

Fig3. Effect of temperature of osmotic on solid gain at different sucrose and salt concentration at 30ºC .

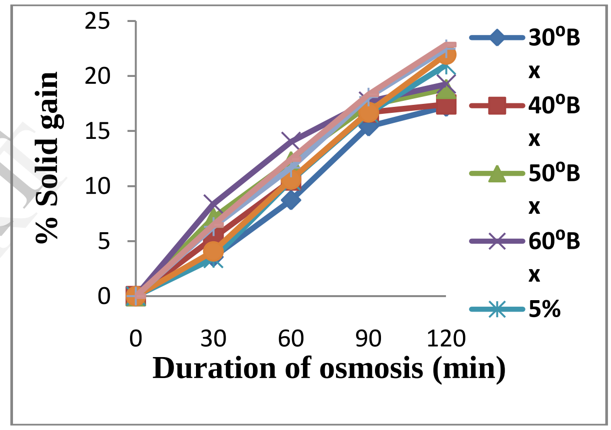

Fig4.Effect of temperature of osmotic solution solution on solid gain at different sucrose and salt concentration at 40ºC.

In case of shelf life analysis it was observed that those samples having more solid gain and water loss they performs greatly for large time and indicates more shelf life because of low moisture content there was low microbial growth in the final product as compare to others.

IV. CONCLUSION

On the basis of analysis and shelf life study of all samples, following conclusions were drawn. Solution temperature, Sucrose/NaCl concentration and duration of osmosis were the most pronounced factors affecting solid gain and water loss of pumpkin slices during osmotic dehydration. The water loss ranged from 51.70% to 71.27% for sucrose and 23.43% to 38.86% for NaCl and solid gain from 16.13% to 19.26 % for sucrose and 13.86% to 22.86% for NaCl. Results obtained evident that the effect of the application of the osmotic dehydration pre-treatment was significant on the initial moisture content of the pumpkin slices, thus allowing a drying time reduction, which may lead to decreases in energy consumption. Osmotic dehydration using Sucrose and NaCl solution prior to sun drying was able to improve the quality of pumpkin slices. The dehydrated samples in sunlight with osmotic pre-treatment were more appreciable in comparable to samples without osmotic treatment on the basis of color and cost reduction.

The pumpkin dehydration was more appreciable at 60°Bx Sucrose concentration at 40°C osmotic temperature, on the basis of color, moisture content, microbial count and mass transfer ratio.

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