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Standardization of method for osmotic dehydration of pumpkin (*Cucurbita moschata*) cubes in sugar solution

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Abstract
The present study was investigated for the development of osmo dried pumpkin cubes. For osmotic dehydration of pumpkin, combination involving soaking of cubes in 60 °B sugar solution for 6 h at 50 °C prior to dehydration was found to be the best on the basis of sensory evaluation. For storage, four different treatments were given to cubes to maintain the keeping quality. The cubes of treatment T_3 (steam blanching (4 min) + 1.0% citric acid dip (20 min)) was considered as best on the basis of higher retention of nutritional (β-carotene and ascorbic acid 10.26 and 6.05 mg/100g, respectively) and sensory quality. The study indicated that the dried products from ripe pumpkin can be stored safely for six months with minimal changes in chemical and sensory attributes. Hence, it is concluded that ripe pumpkin can be utilized for the production of dried products of remunerative cost.

Keywords: Ripe pumpkin, drying, osmodrying, pretreatment, blanching

Introduction

Cucurbitaceae family includes around 825 species**,** derived from tropical and subtropical regions, including 26 species that are cultivated as vegetables (Henriques *et al*., 2012) [1]. Pumpkin is an angiosperm belonging to this family and is characterized by prostrate or climbing herbaceous vines with tendrils and large fleshy fruits containing numerous seeds (Fedha *et al*., 2010) [2]. In India, the pumpkin is commonly known as '*sitaphal'*, '*kashiphal'* or *'lal kaddu'*. The edible portion of pumpkin fruit contains 1.40 g protein, 50.00 µg carotene, 2.00 mg vitamin C, 0.70 mg iron, 10.00 mg calcium and 30.00 mg phosphorus (Muralidhara *et al.*, 2014) [3]. Due to presence of β-carotene, magnesium, potassium and folate pumpkin posses various therapeutic properties including antioxidant, antibacterial, antiviral, anti-inflammatory, antiallergic, antihepatotoxic, antithrombotic, antiatherogenic, anticarcinogenic, as well as vasodilatory actions and cardioprotective (Bennett *et al.*, 2011) [4].

Though pumpkin has been appreciated for high yields, high nutritive value, good storage, longer period of consumption and fitness in transportation, yet like most vegetables, is a perishable crop whose characteristics are changed with time. Due to its large size and bulkiness, there are chances that it may get spoil once it is cut open. Furthermore, reduces its consumer acceptance and poses transport problems. Therefore, low cost preservation methods are required to increase the shelf life, conserve properties and to protect the perishables from insect and microbial growth. Osmotic dehydration is recommended as a processing method to obtain better quality of food products. It modifies structural, nutritional, sensory and other functional properties of the raw material. Osmotic dehydration is achieved by placing the solid/semi solid, whole or in pieces, in a hypertonic solution (sugar and/or salt) with a simultaneous counter diffusion of solutes from the osmotic solution into the tissues (Aronika and Manimehalai, 2014) [5]. Sagar and Kumar (2009) [6] prepared osmotically dehydrated mango slices by dipping them in sugar solution of 60°B at 60 °C while Patankar *et al*. (2014) [7] used 40 °C temperature for the production of osmo dried pumpkin at similar 60°B sugar solution. Araujo *et al*. (2014) [8] used 50 °B concentration of sucrose at 60 °C for the preparation of osmotically dehydrated carrot slices with immersion time of 60 min. But prior to drying different pretreatment is done in order to maintain the structure and quality of the product. The various pretreatments like blanching, chemical treatments *viz.* sodium metabisulphite, citric acid, calcium chloride, ascorbic acid, etc. are applied prior to drying of food material (Sharma *et al*., 2014) [9]. Pineapple slices were pretreated with 0.2 per cent citric acid and 700 ppm KMS for 24 hours prior to osmo drying as suggested by (Rashmi *et al*., 2005) [10]. Ghosh *et al*. (2006) [11] conducted studies on osmotic dehydration of carrot slices and suggested that the slices (5 mm thick) when soaked in 50 °B sugar solution containing 5 per cent salt and 0.1 per cent KMS for 1 hour followed by drying in hot air at 50 °C were the best on the basis of organoleptic quality and rehydration ratio. Keeping in view the importance of fruit, the present study was undertaken to standardize the optimum process for osmotic dehydration of pumpkin and to evaluate the nutritional and organoleptic quality during processing and storage.

Material and method

Preparation of osmo dried pumpkin cubes:

The ripe pumpkin (*Cucurbita moschata* Duch *ex* Poir) fruits were used for pretreatment and osmotic dehydration. It was acquired from local market of Solan. The ripe pumpkin was washed and cut into halves. The fluffy portion and seeds were removed and halves were cut into strips. Further the strips were peeled and converted into cubes of uniform size of approximately 2.5 cm^3. The cubes were blanched and subjected to different treatments for osmotic dehydration. The different combinations of sugar concentration (40, 50, 60 and 70 ºBrix), temperature of solution (45, 50 and 55 ºC) and dipping time for osmotic dehydration (4, 6, 8 and 12 h) were used. The syrup was then drained and cubes were dried in a mechanical cabinet drier (60 ± 2 ˚C) up to constant weight. These cubes were then subjected to sensory evaluation by a panel of judges in order to select the best combination. The standardized osmotic treatment was further used to select the pretreatments method to maintain the storage quality of the osmo dried pumpkin cubes. The cubes were steam blanched for 4 min, for citric acid treatment cubes were first steam blanching for 4 min followed by dipping in 1% citric acid solution for 20 min. Another treatment involve calcium chloride treatment in which cubes were steam blanching for 4 min followed by dip in 1% calcium chloride for 2 h. In case of control no pretreatment was given to cubes. After pretreatment the best combination was selected on the basis of mathematical calculation, nutritional composition and sensory score. The whole experiment was conducted in the Department of Food Science and Technology, UHF, Nauni, Solan, HP, India.

Mathematical calculations

Rehydration ratio (RR): Five gram of osmo dried sample was taken in a 100 ml beaker and 50 ml water was added to it. The content was boiled for 5 min. The excess water was drained off and drained weight was recorded using a physical balance and ratio was calculated as given by (Ranganna, 2009) [12].

$$\text{Rehydration ratio} = \frac{\text{Weight of dehydrated sample}}{\text{Drained weight of rehydrated sample}}$$

Water loss (WL): It is the net loss at time (T) on an initial mass basis (Rahman and Lamb, 1990) [13]. Water loss in fruits of osmotic dip expressed as in percentage and was calculated using the formula

$$\text{Water loss (\%)} = \frac{\text{IW x WL (T)}}{\text{IM}} \text{ x } 100$$

Where, IW= Initial water content; WL (T)= Water loss at time T; IM= Initial mass of the sample

Weight Reduction (WR): Similar to water loss, weight reduction (WR) is the net weight reduction of the sample on an initial weight basis and expressed in percentage (Rahman and Lamb, 1990) [13]. It was calculated using the formula

$$\text{Weight reduction (\%)} = \frac{\text{IW x WT}}{\text{IW}} \text{ x } 100$$

Where, IW= Initial weight of sample; WT= Weight of sample at time T

Solid Gain (SG): It is the net sugar transported into the fruits on an initial mass basis and expressed in percentage
Per cent solid gain (SG) = Per cent WL – Per cent WR

Nutritional analysis

Osmo dried pumpkin cubes were analysed for moisture, water activity, TSS, titrable acidity, total sugars, reducing sugars, β-carotene, ascorbic acid and non-enzymatic browning. The chemical parameters include moisture content, TSS, titrable acidity, total sugars, reducing sugars, ascorbic acid, β-carotene and non-enzymatic browning were evaluated as per the analytical method (Ranganna, 2009) [12]. Water activity was estimated by computer digital water activity meter (HW_3 model, Rotronic International, Switzerland), where direct measurements were taken at room temperature. For sensory score evaluation, a panel of 10 semi trained judges were subjected to dehydrated pumpkins for its colour, texture, flavour and overall acceptability on 9-point Hedonic scale ranging from 1 to 9 (Ranganna, 2009) [12]. All the experiments were performed in three replications and the results of those replicate were determined with standard deviations. The data for quantitative analysis of various chemical attributes during storage were analysed by Completely Randomized Design (CRD) while the data pertaining to sensory evaluation were analysed by Randomized Block Design (RBD).

Result and Discussion

Standardization of treatments of pumpkin cubes for osmotic dehydration

Data pertaining to Table 1 and 2 reflects the sensory the score for osmo dried cubes that ranged from 5 to 9. The cubes were found to be liked by the panelist therefore these combinations can be used for the preparation of osmo dried pumpkin cubes. In case of ten different combinations of varying sugar concentration, sugar syrup of 60 and 70°B have higher acceptability in comparison to 40 and 50°B sugar syrup. The dipping time of 6 h and 50 °C temperature of solution for pumpkin cubes were found to be the best. In case of osmo dried pumpkin cubes prepared using 40 °B sugar concentration, the highest scores for different parameters such as colour (6.74), flavor (6.73), texture (5.58) and overall acceptability (6.77) were received by C_8 (40°B sugar concentration + dip for 8 hrs at 50 °C). Also for 50 °B sugar concentrations, C_8 (50 °B sugar concentration + dip for 8 hrs at 50 °C) received the highest scores for all the sensory attributes such as color (7.36), flavor (7.28), texture (7.19) and overall acceptability (7.26). On the other hand, the osmo dried pumpkin cubes prepared using 60 °B sugar concentration have highest scores for color (8.32), flavor (8.52), texture (8.52) and overall acceptability (8.55) for C_5 (60 °B sugar concentration + dip for 6 hrs at 50 °C). A critical look at the data revealed that higher scores for color (8.31), flavor (8.52), texture (8.51) and overall acceptability (8.55) by C_5 (70 °B sugar concentration + dip for 6 hrs at 50 °C). Therefore, among all the combination, C_5 with 60 °B sugar concentration + dip for 6 hrs at 50 °C was found to be the best for further studies. The results were observed to be very similar with Sagar and Kumar (2009) [6] who used four different concentrations (40, 50, 60 and 70 °B) of sugar syrup at temperature of 40, 50, 60 and 70 °C for the preparation of osmotically dehydrated mango slices and the best results was obtained with 60 °B at 60 °C. Also in evidence to this, Patankar *et al*. (2014) [7] used four different concentrations of sugar (30, 40, 50 and 60 °B) at temperature of 30 and 40 °C and concluded that pumpkin pretreated with 60 °B at 40 °C osmosis temperature was more acceptable on the basis of colour and shelf life. Araujo *et al*. (2014) [5] suggested that used 50 °B concentration of sucrose at two temperature levels for the preparation of osmotically dehydrated carrot slices can be achieved best using osmotic solution of 50 °B at 60 °C with immersion time of 60 min.

Mathematical calculations of osmo dried pumpkin cubes

A perusal of data (Table 3) revealed that cubes treated with steam blanching for 4 min + 1% citric acid dip for 20 min causes maximum water loss whereas, minimum water loss was recorded in treatment T_1. Similarly, maximum solid gain was observed in treatment T_3 while minimum solid gain was recorded in treatment T_1. The data highlight that maximum and minimum weight reduction was recorded in treatment T_1 (27.75%) and T_2 (25.80%), respectively. It means that treatment T_3 was observed to the best for osmotic dehydration of pumpkin cubes.

Table 1: Sensory evaluation of pumpkin cubes soaked in 40 and 50 °B sugar solution with different combinations of immersion time and temperature of osmotic solution

Description	Colour	Flavor	Texture	Overall acceptability	Description	Colour	Flavor	Texture	Overall acceptability
C_1: 40°B sugar concentration + soaking for 4 h at 45 °C	5.36	5.29	5.40	5.29	C_1: 50°B sugar concentration + soaking for 4 h at 45 °C	6.71	6.29	6.71	6.31
C_2: 40°B sugar concentration + soaking for 4 h at 50 °C	5.36	5.31	5.47	5.31	C_2: 50°B sugar concentration + soaking for 4 h at 50 °C	6.72	6.32	6.72	6.32
C_3: 40°B sugar concentration + soaking for 4 h at 55 °C	5.42	5.41	5.40	5.43	C_3: 50°B sugar concentration + soaking for 4 h at 55 °C	6.71	6.31	6.73	6.30
C_4: 40°B sugar concentration + soaking for 6 h at 45 °C	5.56	5.46	5.50	5.46	C_4:50°B sugar concentration + soaking for 6 h at 45 °C	7.22	7.19	7.12	7.17
C_5: 40°B sugar concentration + soaking for 6 h at 50 °C	5.61	6.75	5.51	6.74	C_5: 50°B sugar concentration + soaking for 6 h at 50 °C	7.35	7.26	7.18	7.25
C_6: 40°B sugar concentration + soaking for 6 h at 55 °C	5.59	6.71	5.51	6.70	C_6: 50°B sugar concentration + soaking for 6 h at 55 °C	7.24	7.20	7.15	7.21
C_7: 40°B sugar concentration + soaking for 8 h at 45 °C	6.74	6.72	5.57	6.76	C_7: 50°B sugar concentration + soaking for 8 h at 45 °C	7.32	6.91	7.06	6.94
C_8: 40°B sugar concentration + soaking for 8 h at 50 °C	6.74	6.73	5.58	6.77	C_8: 50°B sugar concentration + soaking for 8 h at 50 °C	7.36	7.28	7.19	7.26
C_9: 40°B sugar concentration + soaking for 8 h at 55 °C	6.72	6.71	5.56	6.75	C_9: 50°B sugar concentration + soaking for 8 h at 55 °C	7.31	6.97	7.10	6.97
C_{10}: 40°B sugar concentration + soaking for 12 h at room temperature	6.70	6.66	5.31	6.66	C_{10}: 50°B sugar concentration + soaking for 12 h at room temperature	7.11	7.01	7.11	7.03
$CD_{0.05}$	0.02	0.03	0.02	0.02		0.02	0.03	0.02	0.01

Table 2: Sensory evaluation of pumpkin cubes soaked in 40 and 50 °B sugar solution with different combinations of immersion time and temperature of osmotic solution

Description	Colour	Flavor	Texture	Overall acceptability	Description	Colour	Flavor	Texture	Overall acceptability
C_1: 60°B sugar concentration + soaking for 4 h at 45 °C	7.72	7.12	7.62	7.13	C_1: 70°B sugar concentration + soaking for 4 h at 45 °C	7.92	7.25	7.62	7.25
C_2: 60°B sugar concentration + soaking for 4 h at 50 °C	7.72	7.34	7.63	7.33	C_2: 70°B sugar concentration + soaking for 4 h at 50 °C	7.94	7.31	7.63	7.31
C_3: 60°B sugar concentration + soaking for 4 h at 55 °C	7.71	7.31	7.65	7.30	C_3: 70°B sugar concentration + soaking for 4 h at 55 °C	7.97	7.32	7.64	7.34
C_4: 60°B sugar concentration + soaking for 6 h at 45 °C	8.32	8.52	8.51	8.54	C_4: 70°B sugar concentration + soaking for 6 h at 45 °C	8.30	8.51	8.50	8.53
C_5: 60°B sugar concentration + soaking for 6 h at 50 °C	8.32	8.52	8.52	8.55	C_5: 70°B sugar concentration + soaking for 6 h at 50 °C	8.31	8.52	8.51	8.55
C_6: 60°B sugar concentration + soaking for 6 h at 55 °C	8.29	8.51	8.48	8.51	C_6: 70°B sugar concentration + soaking for 6 h at 55 °C	8.31	8.51	8.50	8.54
C_7: 60°B sugar concentration + soaking for 8 h at 45 °C	8.31	8.40	8.47	8.43	C_7: 70°B sugar concentration + soaking for 8 h at 45 °C	8.28	8.36	8.46	8.36
C_8: 60°B sugar concentration + soaking for 8 h at 50 °C	8.30	8.42	8.50	8.41	C_8: 70°B sugar concentration + soaking for 8 h at 50 °C	8.30	8.41	8.48	8.41
C_9: 60°B sugar concentration + soaking for 8 h at 55 °C	8.30	8.43	8.49	8.42	C_9: 70°B sugar concentration + soaking for 8 h at 55 °C	8.28	8.38	8.48	8.38
C_{10}: 60°B sugar concentration + soaking for 12 h at room temperature	8.32	7.42	7.21	7.43	C_{10}: 70°B sugar concentration + soaking for 12 h at room temperature	7.27	7.35	7.35	7.34
$CD_{0.05}$	0.02	0.03	0.02	0.01	$CD_{0.05}$	0.02	0.03	0.02	0.01

Table 3: Effect of different treatments on water loss (%), solid gain (%) and weight reduction (%) during osmotic process of pumpkin cubes

Characteristics	T_1	T_2	T_3	T_4	$CD_{0.05}$
Water loss (%)	45.25	46.30	48.00	46.75	0.03
Solid gain (%)	17.50	20.50	21.72	20.75	0.01
Weight reduction (%)	27.75	25.80	26.28	26.00	0.01

Table 4: Effect of different treatments on nutritional characteristics of osmo dried pumpkin cubes during storage

Parameters	Packaging material	Storage interval (month)				Mean	$CD_{0.05}$
		T_1	T_2	T_3	T_4		
Moisture (%)	0	8.32	8.31	8.33	8.51	8.36	T=0.04
	3	8.73	8.87	8.75	8.83	8.79	S=0.03
	6	10.05	9.26	10.13	10.15	9.90	S×T=0.06
	Mean	9.03	8.81	9.07	9.16	9.02	
Water activity	0	0.53	0.52	0.54	0.56	0.54	T=NS
	3	0.54	0.54	0.56	0.57	0.55	S=NS
	6	0.55	0.54	0.57	0.58	0.56	S×T=NS
	Mean	0.54	0.53	0.56	0.57	0.55	
Total soluble solids (ºBrix)	0	80.31	82.05	84.54	83.81	82.67	T=0.11
	3	78.56	80.54	83.28	82.48	81.21	S=0.09
	6	76.85	78.98	82.04	81.51	79.75	S×T=0.19
	Mean	78.57	80.52	83.28	82.48	81.21	
Titrable acidity (%)	0	0.41	0.39	0.46	0.40	0.41	T=0.006
	3	0.37	0.33	0.43	0.35	0.37	S=0.005
	6	0.32	0.29	0.41	0.32	0.33	S×T=0.11
	Mean	0.36	0.33	0.43	0.35	0.37	
Total sugars (%)	0	60.33	62.17	63.53	62.84	62.22	T=0.04
	3	60.77	61.82	63.32	62.53	62.11	S=0.03
	6	59.57	61.39	63.04	62.14	61.53	S×T=0.07
	Mean	60.22	61.79	63.29	62.50	61.95	
Reducing sugars (%)	0	37.25	39.03	41.65	39.74	39.41	T=0.01
	3	38.45	39.74	43.44	40.64	40.57	S=0.01
	6	39.65	40.54	45.35	41.54	41.77	S×T=0.02
	Mean	38.45	39.77	43.48	40.64	40.58	
β-carotene (mg/100g)	0	8.59	9.11	10.78	10.04	9.63	T=0.01
	3	7.51	8.88	10.33	9.06	8.94	S=0.01
	6	5.33	7.12	9.67	8.23	7.58	S×T=0.01
	Mean	7.14	8.37	10.26	9.11	8.72	
Ascorbic acid (mg/100g)	0	7.24	6.56	7.85	6.78	7.11	T=0.01
	3	5.06	4.15	5.85	4.75	4.95	S=0.01
	6	3.55	2.48	4.47	3.28	3.44	S×T=0.01
	Mean	5.28	4.40	6.05	4.94	5.17	
non enzymatic browning (OD)	0	0.96	0.54	0.45	0.46	0.60	T=0.04
	3	1.16	0.62	0.50	0.55	0.71	S=0.03
	6	1.36	0.70	0.58	0.63	0.81	S×T=0.06
	Mean	1.16	0.62	0.51	0.55	0.71	

Table 5: Effect of different treatments on sensory score of osmo dried pumpkin cubes during storage

Parameters	Packaging material	Storage interval (month)				Mean	$CD_{0.05}$
		T_1	T_2	T_3	T_4		
Colour	0	5.50	7.51	8.50	8.31	7.45	T=0.01
	3	5.35	7.45	8.47	8.27	7.38	S=0.01
	6	5.21	7.40	8.40	8.25	7.31	S×T=0.02
	Mean	5.35	7.45	8.45	8.28	7.38	
Texture	0	6.51	7.24	8.30	8.53	7.64	T=0.01
	3	6.46	7.20	8.24	8.51	7.60	S=0.004
	6	6.41	7.06	8.12	8.47	7.51	S×T=0.01
	Mean	6.46	7.17	8.22	8.50	7.59	
Flavor	0	5.90	7.54	8.51	8.44	7.59	T=0.01
	3	5.76	7.34	8.46	8.34	7.50	S=0.01
	6	5.23	7.20	8.40	8.30	7.28	S×T=0.01
	Mean	5.63	7.36	8.45	8.36	7.46	
Overall acceptability	0	5.50	7.52	8.50	8.32	7.46	T=0.01
	3	5.35	7.45	8.47	8.27	7.38	S=0.01
	6	5.21	7.40	8.40	8.25	7.31	S×T=0.01
	Mean	5.35	7.45	8.46	8.28	7.38	

Storage studies of osmo dried pumpkin cubes

The storage stability of osmo dried pumpkin cubes were evaluated at storage interval of 0, 3 and 6 months under ambient conditions after packing them in ALP. There was a slight decrease in TSS, titrable acidity, total sugars, *β*-carotene, ascorbic acid while slight increase in moisture content, water activity, reducing sugars and non enzymatic browning during six months storage of osmo dried pumpkin cubes. The data presented in the Table 4 revealed a significant increase in per cent moisture content from 8.36 to 10.66% and non-significant difference in water activity of osmo dried pumpkin cubes during storage. During six months of storage mean maximum value of 10.34 per cent was recorded in T_4 and minimum of 8.81 per cent in T_2. The increase in moisture content during storage period can be attributed to permeability of packaging material to moisture as has been revealed by Sagar and Kumar (2009) [6]. Similar increasing trend in moisture was reported by Sharma *et al*. (2004) [14] in osmo dehydrated apricot, Sagar and Kumar (2009) [6] in osmo dehydrated mango slices, Swain *et al*. (2013) [15] in osmo dehydrated sweet pepper and Patil *et al*. (2014) [16] in dehydrated jack fruit chips. The TSS was found to be decreased during storage which might be due to increase in the moisture content. Similar decrease in TSS was recorded by shilpa *et al.* (2008) [17] in dried tomato halves and Sra *et al*. (2014) [18] in dried carrot slices during storage. Treatment T_4 showed lowest decrease in TSS content in comparison to other treatment. A significant decrease in titrable acidity was found in osmo dried pumpkin cubes of different treatment. The mean titrable acidity was found to decrease from mean value 0.41 to 0.33 per cent during a period of six months. The decrease in titrable acidity during storage might be due to utilization of acids for conversion of non reducing sugars to reducing sugars and in non enzymatic reactions (Sharma *et al*., 2004) [14]. Similar decreasing trend has been reported by Naikwadi *et al*. (2010) [19] in dehydrated figs, Ahmed *et al*. (2014) [20] in osmo dried peach slices and Devi (2014) [21] in osmo dried wild pear halves. The reduction in total sugars during storage might be due to their participation in biochemical and browning reactions (Sra *et al*., 2014) [18]. Total sugars (63.29%) and reducing sugars (43.48%) were found maximum in treatment T_3. The increase in reducing sugars during storage might be due to slow inversion of non reducing sugars and starch into reducing sugars. Dar *et al*. (2011) [22] and Ahmed *et al*. (2014) [20] have also observed a decrease in total sugar and an increase in reducing sugars of cherry candy and osmo dried peach slices, respectively during 6 months of storage. Osmo dried pumpkin cubes contain mean value of 8.72 mg/100g for *β*-carotene and 5.17 mg/100g for ascorbic acid during 6 months of storage. An interaction of treatments and storage interval revealed that minimum β-carotene was retained in T_2 and maximum in T_3. The decline in *β*-carotene might be due to the photosensitive nature, isomerization and epoxide forming nature of carotene and oxidative degradation of carotenoids during storage. Decreasing trend in β- carotene during storage has also been noticed by Muzzaffar (2006) [23] in pumpkin candy, Sagar and Kumar (2009) [6] in osmo dehydrated mango slices and Swain *et al*. (2013) [15] in osmo dehydrated sweet pepper. For ascorbic acid of osmo dehydrated pumpkin cubes it was observed that there was a significant difference among all the treatments. The mean maximum (6.05mg/100 g) value was obtained in T_3 and minimum (4.40 mg/100 g) in T2 during storage. The decrease in ascorbic acid during storage might be due to its oxidation (Sharma *et al*., 2000) [24]. Similar results were noticed by Rashmi *et al*. (2005) [10] in osmo-dehydrated pineapple, Muzzaffar (2006) [23] in pumpkin candy, Sharma *et al*. (2006) [25] in dehydrated apple rings. The overall effect of storage period on the NEB of osmo dried pumpkin cubes indicates that it increased from 0.60 to 0.81 OD during 6 months. Among different treatments, maximum (1.16 OD) was obtained in T_1 and minimum (0.51 OD) in T_3 during storage. A significant increase in NEB during storage may be attributed to more degradation of ascorbic acid and formation of brown colour in products (Sagar and Kumar, 2009) [6]. Similar findings were revealed by Sharma *et al*. (2006) in dehydrated apple rings, Sagar and Kumar (2009) [6] in osmo dehydrated mango slices and Ahmed *et al*. (2014) [20] in osmo dried peach slices.

The data in Table 5 of sensory quality measured on 9-point-hedonic scale for osmo dried pumpkin cubes was liked slightly by the panelist indicate that colour, texture, flavor and overall acceptability were 8.45, 8.22, 8.45 and 8.46, respectively for different treatment at 0 day of storage. It is clear from the data that during three months storage, T_3 was found to be best with maximum mean value 8.45, 8.22, 8.45 and 8.46, respectively. The decreasing trend in scores of colour might be due to enzymatic and non enzymatic oxidation process (Sagar and Kumar, 2009) [6]. Slight change in the texture upon storage may be attributed to the degradation of pectic substances and picking of moisture by the polyethylene pouches (Sharma *et al*., 2004) [14]. The loss in flavor during storage might be due to the oxidation of the compounds. Similar decreasing trend in sensory score during storage was reported by Sharma *et al*. (2004) [14] in osmo dehydrated apricot, Muzzaffar (2006) [23] in pumpkin candy, Ankita *et al*. (2014) [26] in osmo dehydrated papaya cubes, Khan *et al*. (2014) [27] in osmo dehydrated strawberry.

Conclusion

The study reveals that ripe pumpkin may be utilized for the development of good quality and nutritionally enriched osmo dried cubes of remunerative cost. Furthermore, it was also observed that the osmo dried pumpkin cubes can be stored safely under ambient condition with better retention of functional components. This work may also provide major contribution in the development of nutritious pumpkin bar at industrial scale level.

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