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Effect of Pretreatment and Drying Methods on Nutritional Composition of Ripe Pumpkin (*Cucurbita moschata*)

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A B S T R A C T

Value added dried pumpkin cubes and slices were prepared using ripe pumpkin (*Cucurbita moschata* Duch ex Poir). Prior to drying of pumpkin cubes and slices, different pretreatments (blanching, potassium metabisulphite (KMS) treatment, sulphur fumigation) were standardized and among them treatment involving steam blanching for 4 min + 1500 ppm KMS dip for 30 min was observed to be the best, retaining maximum nutritional characteristics and sensory scores. Further both traditional and mechanical drying methods were used to dry pretreated pumpkin cubes and slices viz. sun (T_1), solar (T_2) and mechanical cabinet (T_3). The comparison of different drying modes showed that cubes and slices of treatment T_3 possessed higher values for chemical parameters and received maximum sensory scores. During storage for six months, the maximum retention of chemical constituents like β-carotene (33.99, 33.16 mg/100 g), ascorbic acid (8.54, 8.58 mg/100 g) and total phenols (9.21, 9.17 mg/100 g) was observed in mechanical cabinet dried cubes and slices, respectively. However, the sensory scores were found to decrease during storage but remained well above the acceptable limits. The study indicated that the dried products from ripe pumpkin can be stored safely up to six months with minimal changes in chemical and sensory attributes.

Introduction

Pumpkin, as the marvels of vegetable belongs to the family Cucurbitaceae and the genus *cucurbita.* The name pumpkin was derived from a Greek word *Pepon* which means large melon. This vegetable comes from tropical and subtropical zones of Mexico and South America. When used at ripening stage, it is considered as the cheaper source valuable sources of functional components such as carotenoids, zeaxanthin, vitamin E, ascorbic acid, phytosterols, selenium and linoleic acids. These components acts as antioxidants in human nutrition and therefore protect human beings from certain types of cancer, cardiovascular disease and macular degeneration (Thakur *et al.,* 2019). In addition, ripe pumpkin is also recommended for arthrosclerosis and reduction of cholesterol in people suffering from obesity (Danilchenko *et al.*, 2000). In many countries such as China, Yugoslavia, Argentina, India, Mexico, Brazil and America pumpkin has been used as traditional medicine as well.

Though pumpkin has been appreciated for high yields, nutritional value, fitness in transportation, good storage and longer period of consumption, yet like most vegetables, is a perishable crop whose characteristics are changed with time. Due to its bulkiness and large size, there are chances that it may get spoil early when it is cut open. Further, the large size and heaviness also reduce its consumer acceptance and poses transport problems. Moreover, to make it available throughout the year, it is essential to reduce it to desirable shapes and sizes. Preservation methods are required to increase the shelf life, conserve properties and protect the perishables from insect and microbial growth.

There are various methods like canning, drying and freezing which are used to preserve fruits and vegetables. One of the most commonly used methods for preservation is drying, which is considered to be the oldest and an important method of food preservation. Several studies have been reported on dehydrated fruit and vegetables products like wild pomegranate arils using sun drying, glass solar drying and mechanical cabinet drying (Bhat *et al.*, 2014; Thakur *et al.*, 2020a); sun, solar tunnel dried horse chestnut flour (Kumar, 2017). But prior to drying different pretreatment was done in order to maintain the quality of the product. Sen *et al.*, (2015) studied the effect of SO_2 concentration on the quality and nutritional properties of dried apricot and found that fumigation doses of 3500 ppm SO_2 helps in the retention of β-carotene and total phenolic content. Pretreatment of carrot slices by blanching in hot water for 6-9 min followed by dipping in 0.075 % sodium metabisulphite for one hour prior to drying helped in retaining the ascorbic acid and carotene (Rahman *et al.*, 2010). Further, Sra *et al.*, (2011) also observed that blanching in water at 90 °C for 4 min followed by dipping in 6 % KMS solution improved the rehydration ratio, colour, retention of ascorbic acid and carotenoids content of dried carrot slices. Therefore, keeping in view the nutritional significance of pumpkin and the need of an hour to preserve the pumpkin, the study was under taken to evaluate the effect of pretreatments (blanching) and drying methods on quality of dried pumpkin cubes and slices.

Materials and Methods

Preparation of dried pumpkin cubes and slices

The ripe pumpkin (*Cucurbita moschata* Duch *ex* Poir) was used for pretreatment, drying and dehydration. It was procured from local market of Solan. The ripe pumpkin was washed and cut into halves. After removing the fluffy portion and seeds, the halves were cut into strips. The strips were peeled and divided into two lots. From one lot, the strips were converted into cubes of uniform size of approximately 2.5 cm^3 while other lot was used to prepare slices of approximately 3.0 x 0.7 x 0.6 cm^3.

The cubes and slices thus prepared were subjected to three different pretreatments i.e. steam blanching for 4 min, steam blanching for 4 min followed by dipping in 1500 ppm potassium metabisulphite (KMS) solution for 30 min and sulphur fumigation (steam blanching for 4 min followed by fumigation @ 4 g/kg for 30 min). For control no pretreatment was given to cubes and slices. After pretreatment the best combination selected on the basis of nutritional and sensory characteristics were subjected to drying. The weighed pre-treated pumpkin cubes and slices were spread on the perforated aluminium trays and kept for open sun drying, solar drying and mechanical cabinet drying at 60ºC. Drying was done continuously till the weight of sample become constant. The dried cubes and slices were then evaluated at storage interval of 0, 3 and 6 months at room temperature after packing them in Polyethylene terephthalate (PET) jars. The whole experiment was conducted in the Department of Food Science and Technology, UHF, Nauni, Solan, HP, India.

Quality evaluation

Pumpkin cubes and slices were analysed for moisture, TSS, total sugars, reducing sugars, titratable acidity, β-carotene, ascorbic acid, total phenols, crude protein, crude fat, crude fat, total ash and non-enzymatic browning. The chemical parameters including moisture content, TSS, titratable acidity, total sugars, reducing sugars, ascorbic acid, β-carotene and non-enzymatic browning were evaluated as per the analytical method given by Ranganna (2009). Total phenols were determined using Folin-Ciocalteu reagent (Singleton and Rossi, 1999). For sensory score evaluation, a panel of 10 semi trained judges were subjected to pretreated and dehydrated pumpkins cubes and slices for its colour, texture, flavour and overall acceptability on 9-point hedonic scale ranging from 1 to 9 (Ranganna, 2009).

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).

Results and Discussion

Chemical characteristics of ripe pumpkin

Table 1 highlights the chemical characteristics of ripe pumpkin used in the study. A perusal of data reveals that ripe pumpkin had an average moisture content of 88.90 %. The TSS and titratable acidity was reported to be 10°Brix and 0.066 %, respectively. Further, the data showed that the total and reducing sugars were 4.85 and 2.05 %, respectively. The functional component present in pumpkin was found to possess 13.27 mg/100 g *β*-carotene and 13.37 mg/100 g ascorbic acid. In addition, results also indicated 14.09 mg/100 g of total phenols in ripe pumpkin. The analysis of proximate composition in ripe pumpkin revealed crude protein, fat, fibre and ash content to be 5.04, 0.77, 0.87 and 1.03 %, respectively.

Effect of pre-treatment on ripe pumpkin cubes and slices

A perusal of data in Table 2 indicates that un-treated pumpkin cubes and slices took maximum time (9.07 and 7.84 h) for drying in comparison to treated pumpkin cubes and slices, respectively. The recovery of dried pumpkin cubes were ranged from 14.66 to 14.81% as compared to pumpkin slices i.e. from 14.00 to 14.32 %. Different chemical characteristics of pretreated pumpkin cubes and slices which were analysed after drying them in mechanical cabinet dehydrator at 60 ºC are presented in Table 2. The data elucidate that maximum (7.51 %) value for moisture was observed in U_1 while minimum (7.20 %) in U_3 and U_4 of pumpkin cubes. The pumpkin slices showed maximum (7.23 %) moisture in V_1 and minimum (7.05 %) in V_3 and V_4. Further, the effect of different treatments showed a significant effect on TSS with the highest value (48.25 °B) of pumpkin cubes was noticed in U_4 whereas, in case of slices (48.58°B) was observed in V_3. Similar to TSS, the highest value of total sugars was recorded in U_3 (35.05 %) and V_3 (35.12 %) while reducing sugar in U_1 (25.40 %) and V_1 (23.97 %). The acidity was found to be more in pre-treated cubes and slices with maximum amount of 0.80 % in both treatment U_3 and V_3.

The data for *β*- carotene content of pumpkin cubes indicated the highest (36.28 mg/100 g) value for U_3 and lowest (30.81 mg/100g) for U_1. Similarly in slices the highest (36.30 mg/100 g) value for *β*- carotene was obtained in V_3 and lowest (30.98 mg/100g) in V_1. A significant difference was noticed in ascorbic acid content of different treatments. The maximum value was observed in cubes of treatment U_3 (10.08 mg/100g) and slices of V_3 (10.01 mg/100g). Further, the highest (12.06 mg/100 g) total phenols were recorded in U_1 and lowest (10.69 mg/100 g) in U_2. Similar to cubes, the highest value for total phenols (11.89 mg/100g) were recorded in V_1 lowest (10.62 mg/100g) in V_2 of dried slices.

The data in Table 2 also indicated that the crude protein was highest (4.52 %) in U_3 while lowest in U_1 in cubes and in dried slices it was highest (4.22 %) in V_3. The results for fat and ash content in cubes and slices were found to be non significant and also the values for crude fibre did not show much difference among different treatments. Data depicted the maximum (0.72 OD) non-enzymatic browning in U_1 while minimum (0.12 OD) in U_3. Similarly in slices the highest (0.71 OD) value for non-enzymatic browning was observed in V_1 and lowest (0.13 OD) in V_3.

An appraisal of data (Table 2) for sensory scores of pumpkin cubes revealed that maximum mean score for color (8.70), texture (8.56), flavor (8.56) and overall acceptability (8.66) was awarded to U_3 followed by U_4, U_2 and U_1. In case of pumpkin slices, treatment V_3 recorded the highest score for colour (8.70), texture (8.56), flavor (8.55) and overall acceptability (8.53) followed by V_4, V_2 and V_1.

Among all the treatments, the cubes of treatment U_3 and slices of treatment V_3 (steam blanching for 4 min + 1500 ppm KMS dip for 30 min) was found to be best on the basis of physico-chemical and sensory characteristics, therefore was selected for drying and dehydration by different modes.

Table.1 Chemical and nutritional characteristics of fresh pumpkin

Characteristics	Fresh pumpkin
Moisture (%)	88.9
Total soluble solids (ºB)	10.00
Total sugars (%)	4.85
Reducing sugars (%)	2.05
Titratable acidity (%)	0.066
β-carotene (mg/100g)	13.27
Ascorbic acid (mg/100g)	13.37
Total phenols (mg/100g)	14.09
Crude protein (%)	5.04
Crude fat (%)	0.77
Crude fibre (%)	0.87
Total ash (%)	1.03

Table.2 Chemical and sensory characteristics for standardization of pretreatments for preparation of dried pumpkin cubes and slices

Characteristics	Dried pre-treated pumpkin cubes					Dried pre-treated pumpkin slices				
	U_1	U_2	U_3	U_4	$CD_{0.05}$	V_1	V_2	V_3	V_4	$CD_{0.05}$
Drying time (h)	9.07	8.32	8.10	8.00	0.01	7.84	7.21	7.02	7.07	0.02
Yield (%)	14.81	14.70	14.66	14.67	0.01	14.32	14.12	14.00	14.05	0.01
Moisture (%)	7.51	7.33	7.20	7.20	0.02	7.23	7.12	7.05	7.07	0.01
Total soluble solids (ºB)	48.15	48.20	48.24	48.25	0.01	48.49	48.50	48.58	48.55	0.02
Total sugars (%)	34.89	34.94	35.05	35.05	0.03	34.90	34.97	35.12	35.08	0.02
Reducing sugars (%)	25.40	25.30	25.23	25.24	0.02	23.97	23.89	23.84	23.86	0.02
Titratable acidity (%)	0.76	0.78	0.80	0.79	0.01	0.76	0.77	0.80	0.79	0.01
β-carotene (mg/100g)	30.81	32.13	36.28	36.24	0.02	30.98	32.21	36.30	36.27	0.02
Ascorbic acid (mg/100g)	9.40	8.96	10.08	10.06	0.01	9.30	8.83	10.01	9.99	0.01
Total phenols (mg/100g)	12.06	10.69	10.81	10.79	0.02	11.89	10.62	10.74	10.71	0.02
Crude protein (%)	4.16	4.48	4.52	4.51	0.01	3.81	4.08	4.22	4.20	0.01
Crude fat (%)	1.23	1.24	1.24	1.24	NS	1.23	1.24	1.24	1.24	NS
Crude fibre (%)	1.63	1.61	1.60	1.60	0.02	1.82	1.81	1.81	1.80	0.01
Total ash (%)	4.50	4.51	4.51	4.52	NS	4.96	4.97	4.98	4.97	NS
Non-enzymatic browning (OD at 440 nm)	0.72	0.31	0.12	0.14	0.01	0.71	0.32	0.13	0.15	0.01
Colour	6.63	6.70	8.70	7.36	0.26	6.63	6.70	8.70	7.36	0.26
Texture	6.70	6.76	8.56	7.76	0.32	6.70	6.76	8.56	7.76	0.32
Flavor	6.73	6.86	8.56	7.63	0.46	6.73	6.83	8.55	7.56	0.22
Overall acceptability	6.70	6.86	8.66	7.53	0.38	6.66	6.86	8.53	7.43	0.49

U_1 = Without blanching (control)
U_2 = Steam blanching for 4 min
U_3 =Steam blanching for 4 min + 1500 ppm KMS dip for 30 min
U_4 =Steam blanching for 4 min + Sulphur fumigation @ 4g/kg for 30 min
CD= Critical difference

V_1 = Without blanching (control)
V_2 = Steam blanching for 4 min
V_3 = Steam blanching for 4 min + 1500 ppm KMS dip for 30 min
V_4 = Steam blanching for 4 min + Sulphur fumigation @ 4g/kg for 30 min

Table.3 Effect of different drying modes on physical characteristics of pumpkin cubes and slices

Characteristics	Pumpkin cubes				Pumpkin slices			
	T_1	T_2	T_3	$CD_{0.05}$	T_1	T_2	T_3	$CD_{0.05}$
Dehydration ratio	1:0.80	1:0.82	1:0.85	0.007	1:0.80	1:0.84	1:0.86	0.01
Drying time (hrs)	51	39.33	8.1	2.73	44.00	35.29	7.00	0.34
Product recovery (%)	19.66	18.00	14.66	0.08	17.50	16.00	14.00	0.01
Shrinkage (%)	90.20	92.50	94.81	0.11	95.00	95.87	97.20	0.07
T_1= Sun drying, T_2= Solar drying and T_3= mechanical cabinet drier, CD= Critical difference								

Table.4 Effect of different drying modes on chemical characteristics of dried slices during storage

Parameter	Drying mode	Pumpkin cubes					Pumpkin slices				
		0 month	3 months	6 months	Mean	$CD_{0.05}$	0 month	3 months	6 months	Mean	$CD_{0.05}$
Moisture	T_1	14.82	15.30	15.82	15.31	T=0.05 S=0.05 TxS=0.09	14.55	15.08	15.57	15.06	T=0.15 S=0.15 TxS=NS
	T_2	10.52	11.44	12.25	11.40		10.25	10.74	11.21	10.73	
	T_3	7.20	8.12	8.40	7.91		7.05	7.48	7.95	7.49	
	Mean	10.85	11.62	12.16	**11.54**		10.61	11.10	11.57	**11.09**	
Water activity	T_1	0.53	0.55	0.56	0.54	T=NS S=NS TxS=NS	0.52	0.54	0.55	0.54	T=NS S=NS TxS=NS
	T_2	0.44	0.45	0.47	0.45		0.43	0.44	0.44	0.44	
	T_3	0.37	0.38	0.40	0.38		0.36	0.37	0.38	0.37	
	Mean	0.45	0.46	0.48	**0.46**		0.44	0.45	0.46	**0.45**	
TSS (°B)	T_1	40.46	40.27	40.03	40.25	T=0.18 S=0.18 TxS=NS	40.80	38.59	35.98	38.46	T=0.37 S=0.37 TxS=0.65
	T_2	42.36	42.21	42.07	42.21		42.36	41.90	39.25	41.17	
	T_3	48.24	48.18	48.00	48.14		48.58	47.47	45.53	47.19	
	Mean	43.69	43.55	43.36	**43.53**		43.91	42.65	40.25	**42.27**	
Total sugars (%)	T_1	32.06	31.91	31.28	31.75	T=0.09 S=0.09 TxS=0.16	32.26	29.94	28.69	30.29	T=0.08 S=0.08 TxS=0.14
	T_2	33.56	33.27	32.16	32.99		33.56	32.12	30.96	32.22	
	T_3	35.05	34.88	34.61	34.85		35.12	33.92	33.00	34.01	
	Mean	33.56	33.35	32.68	**33.20**		33.65	31.99	30.88	**33.18**	
Reducing sugars (%)	T_1	23.20	24.80	25.66	24.57	T=0.04	21.82	23.04	24.32	23.06	T=0.01

	T_2	24.30	25.35	25.98	25.21	S=0.04 TxS=0.07	22.73	23.94	25.15	23.94	S=0.01 TxS=0.01
	T_3	25.23	26.03	26.56	25.94		23.84	24.98	26.18	25.00	
	Mean	24.24	25.41	26.06	**25.24**		22.79	23.98	25.21	**24.00**	
Titratable acidity (%)	**T_1**	0.64	0.58	0.45	0.56	T=0.01 S=0.01 TxS=0.02	0.64	0.58	0.45	0.56	T=0.01 S=0.01 TxS=0.02
	T_2	0.75	0.69	0.65	0.69		0.75	0.69	0.65	0.69	
	T_3	0.80	0.77	0.72	0.76		0.80	0.77	0.72	0.76	
	Mean	0.73	0.68	0.61	**0.67**		0.73	0.68	0.61	**0.67**	
β-carotene (mg/100g)	**T_1**	5.20	3.85	1.94	3.66	T=0.05 S=0.05 TxS=0.09	5.26	3.85	1.94	3.68	T=0.10 S=0.10 TxS=0.17
	T_2	28.64	23.92	19.62	24.06		28.64	23.49	18.62	23.58	
	T_3	36.28	34.92	30.77	33.99		36.30	33.92	29.27	33.16	
	Mean	23.37	20.89	17.44	**20.57**		23.40	20.42	16.61	**20.14**	
Ascorbic acid (mg/100g)	**T_1**	7.66	5.72	4.21	5.86	T=0.05 S=0.05 TxS=0.10	7.62	5.67	4.18	5.82	T=0.01 S=0.01 TxS=0.02
	T_2	8.33	6.47	4.57	6.45		8.29	6.41	5.31	6.67	
	T_3	10.08	8.50	7.04	8.54		10.01	8.55	7.18	8.58	
	Mean	8.69	6.90	5.27	**6.95**		8.69	6.88	5.55	**7.02**	
Total phenols (mg/100g)	**T_1**	7.55	5.72	4.14	5.80	T=0.01 S=0.01 TxS=0.01	7.58	5.72	4.12	5.80	T=0.01 S=0.01 TxS=0.01
	T_2	8.13	6.36	4.81	6.43		8.13	6.41	4.83	6.45	
	T_3	10.81	9.14	7.69	9.21		10.74	9.11	7.65	9.17	
	Mean	8.83	7.07	5.54	**7.15**		8.81	7.08	5.53	**7.14**	
Non-enzymatic browning (OD at 440 nm)	**T_1**	1.21	1.23	1.26	1.23	T=0.01 S=0.01 TxS=NS	1.20	1.23	1.26	1.23	T=0.01 S=0.01 TxS=NS
	T_2	0.71	0.74	0.75	0.73		0.71	0.74	0.75	0.73	
	T_3	0.12	0.16	0.19	0.16		0.13	0.16	0.19	0.16	
	Mean	0.68	0.71	0.73	**0.71**		0.69	0.71	0.73	**0.71**	
Rehydration ratio	**T_1**	6.26	5.90	5.23	5.80	T=0.09 S=0.09 TxS=0.16	6.26	5.90	5.46	5.87	T=0.13 S=0.13 TxS=NS
	T_2	7.10	6.80	6.50	6.80		7.10	6.80	6.80	6.80	
	T_3	8.0	7.80	7.33	7.71		8.16	7.80	7.36	7.77	
	Mean	7.12	6.83	6.35	**6.77**		7.17	6.83	6.83	**6.81**	

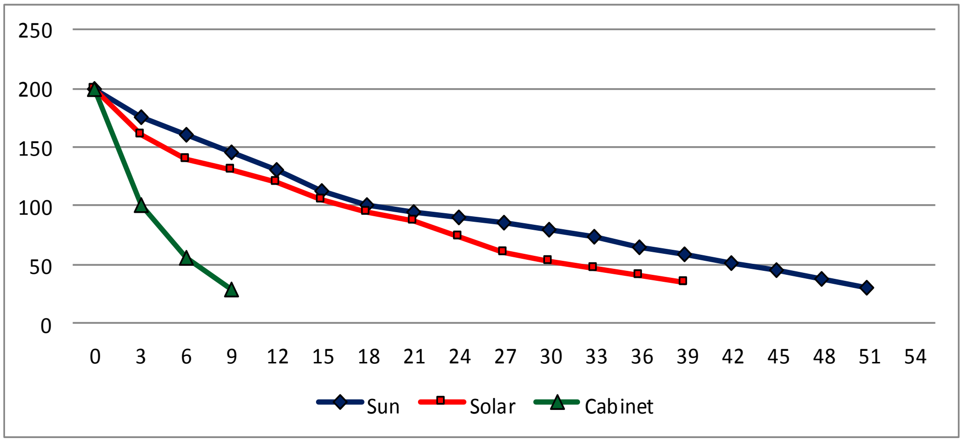
T_1= Sun drying, T_2= Solar drying and T_3= mechanical cabinet drier, T= Treatment, S= Storage interval, NS= non-significant, CD= Critical difference

Table.5 Effect of different drying modes on sensory score of dried slices during storage

Parameter	Drying mode	Pumpkin cubes					Pumpkin slices				
		0 month	3 months	6 months	Mean	$CD_{0.05}$	0 month	3 months	6 months	Mean	$CD_{0.05}$
Colour	T_1	4.83	4.38	4.18	4.46	T=0.10 S=0.10 TxS=NS	5.16	4.41	4.18	4.59	T=0.09 S=0.09 TxS=NS
	T_2	7.43	6.79	6.42	6.88		7.40	6.80	6.42	6.87	
	T_3	8.46	7.88	7.59	7.98		8.43	7.88	7.59	7.97	
	Mean	6.91	6.35	6.06	**6.44**		7.00	6.36	6.06	**6.47**	
Texture	T_1	5.03	4.42	4.27	4.57	T=0.16 S=0.16 TxS=NS	5.26	4.42	4.27	4.65	T=0.17 S=0.17 TxS=0.30
	T_2	7.30	6.44	6.19	6.64		6.63	6.44	6.19	6.42	
	T_3	8.60	7.97	7.58	8.05		8.43	7.97	7.58	7.99	
	Mean	6.97	6.28	6.01	**6.42**		6.77	6.28	6.01	**6.35**	
Flavour	T_1	5.43	4.84	4.05	4.77	T=0.15 S=0.15 TxS=NS	5.10	4.84	4.05	4.66	T=0.21 S=0.21 TxS=NS
	T_2	7.26	6.60	6.17	6.68		6.90	6.63	6.20	6.58	
	T_3	8.56	7.92	7.23	7.90		8.60	7.92	7.23	7.91	
	Mean	7.08	6.45	5.81	**6.45**		6.86	6.46	5.82	**6.38**	
Overall acceptability	T_1	6.26	5.43	4.69	5.46	T=0.15 S=0.15 TxS=NS	5.16	5.07	4.69	4.97	T=0.17 S=0.17 TxS=0.29
	T_2	7.36	7.14	6.82	7.17		7.03	6.84	6.82	6.89	
	T_3	8.60	7.81	7.32	7.91		8.36	7.79	7.32	7.83	
	Mean	7.41	6.79	6.28	**6.83**		6.85	6.56	6.28	**6.56**	

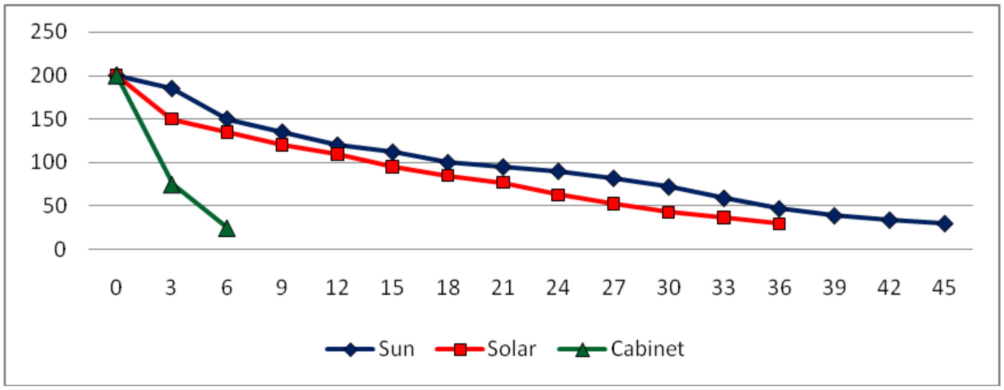
T_1= Sun drying, T_2= Solar drying and T_3= mechanical cabinet drier, T= Treatment, S= Storage interval, NS= non-significant, CD= Critical difference

Fig.1 Drying curve for pumpkin cubes dried by different methods



where x-axis is Time (h) and y-axis is Weight of cubes (g)

Fig.2 Drying curve for pumpkin slices dried by different methods



where x-axis is time (h) and y-axis is weight of cubes (g)

Fig.3 Effect of storage on β-carotene, ascorbic acid and total phenols of dried pumpkin cubes

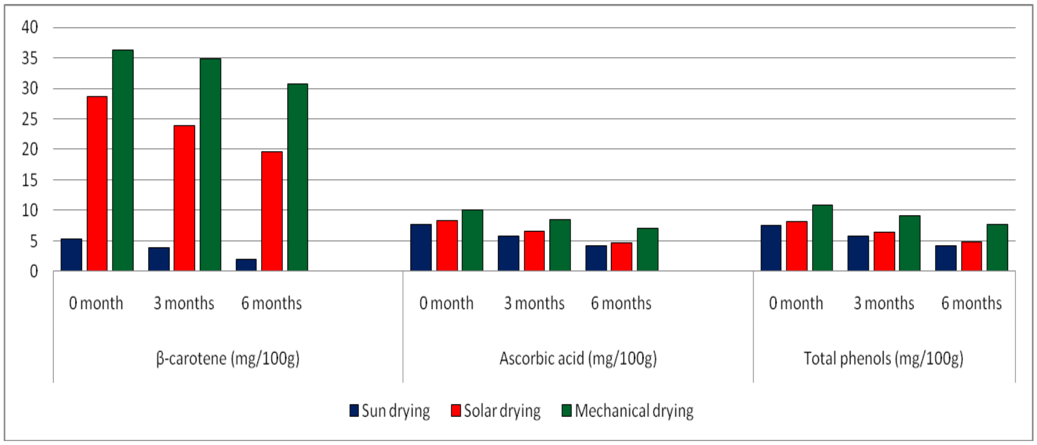
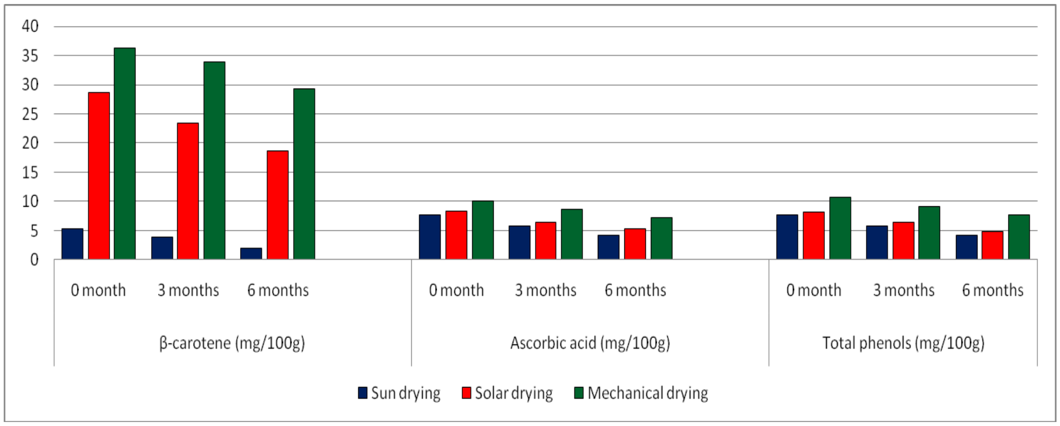


Fig.4 Effect of storage on β-carotene, ascorbic acid and total phenols of dried pumpkin slices



Standardization of drying method for pumpkin cubes and slices

The maximum time taken to dry 5 kg of pumpkin cubes and slices in mechanical cabinet drier (T_3) was 8.01, 7.00 h, whereas, it was 51.00, 44.00 h and 39.33, 35.29 h for sun drying (T_1) and solar drying (T_2), respectively (Figure 1 and 2). Further, the yield of dried cubes and slices was recorded maximum (19.66 and 17.50 %) in T_1 while minimum (14.66 and 14.00 %) was observed in T_3, respectively (Table 3). In addition, due to faster drying rate of mechanical cabinet drying the dehydration ratio and shrinkage was maximum in T_3 while minimum in T_1 in case of both dried cubes and slices.

Effect of storage on quality characteristics of dried pumpkin cubes and slices

The storage stability of dried pumpkin cubes and slices were evaluated at storage interval of 0, 3 and 6 months under room temperature after packing them in Polyethylene terephthalate (PET) jars. The data presented in Table 4 revealed a significant increase in moisture content during storage. Among different treatments, mean maximum value of 15.31 and 15.06 % was recorded in T_1 and minimum of 7.91 and 7.49 % in T_3 after 6 months of storage of both dried cubes and slices. An interaction of treatments and storage interval revealed significant difference in dried cubes while non-significant difference in dried slices during 6 months of storage. The water activity for both dried cubes and slices had non-significant effect for treatment as well storage period. Further the mean TSS was found to decrease from 43.69 to 43.36 ˚B and from 43.91 to 40.25 ˚B during 6 months of storage of dried cubes and slices. The mean maximum value of TSS was observed to be highest in T_3 and lowest in T_1. An interaction of treatments and storage interval indicated significant effect for dried slices during 6 months of storage. Further, mean total sugars and titratable acidity found to decrease while reducing sugars was increased during storage. The interaction effect of treatment and storage had significant on total and reducing sugars and titratable acidity as well. Among different treatments, mean maximum value of 34.85 and 25.94 % was recorded in dried cubes of treatment T_3 and minimum value 31.75 and 24.57 % in T_1 for total and reducing sugars, respectively. On the other hand, in dried slices mean maximum value of 34.01 and 25.00 % was recorded in T_3 and minimum (30.29 and 23.06 %) in T_1 for total and reducing sugars, respectively. Further the mean total sugars found to decrease from 33.56 to 32.64 % and from 33.65 to 30.88 % in dried cubes and slices, respectively during a period of 6 months. An interaction of treatment and storage interval revealed significant effect on both total and reducing sugars. Maximum (0.80 %) titratable acidity was observed in T_3 and minimum (0.64 %) in T_1 were found in both dried cubes and slices at 0 day of storage. Further the mean titratable acidity was found to decrease from an initial value of 0.73 to 0.61 % during a period of 6 months.

An appraisal of data depicts a highly significant difference in β-carotene, ascorbic acid and total phenol content of dried pumpkin cubes and slices of different treatments (Figure 3 and 4). The maximum (33.99 and 33.16 mg/100g) value in T_3 and minimum (3.66 and 3.68 mg/100g) in T_1 was observed in dried cubes and slices when stored for 6 months. The overall effect of storage period recorded a significant decrease in *β*-carotene from 23.37 to 17.44 and from 23.40 to 16.61 mg/100 g during storage for 6 months in dried cubes and slices, respectively. The ascorbic acid content of cubes of different treatments at 0 day had maximum (10.08 mg/100 g) value in T_3 followed by T_2 (8.33 mg/100 g) and T_1 (7.66 mg/100 g) while slices had mean maximum (10.01 mg/100 g) value in T_3 followed by T_2 (8.29 mg/100 g) and T_1 (7.62 mg/100 g). Further, the mean ascorbic acid content was found to decrease from an initial value of 8.69 to 5.27 and 5.55 mg/100 g after 6 months of storage, respectively in dried cubes and slices. Highly significant differences were observed in total phenols of different treatments with maximum content in T_3 (9.21 and 9.17 mg/100 g) and minimum in T_1 (5.80 and 5.80 mg/100 g) during storage for 6 months in dried cubes and slice, respectively. The overall effect of storage shows decrease in total phenols from 8.83 to 5.54 mg/100 g and from 8.81 to 5.53 mg/100 g in dried cubes and slices, respectively during a storage period of 6 months.

The data presented for NEB elucidate that mechanical cabinet dried cubes and slices had minimum (0.16 OD), whereas sun dried had maximum (1.23 OD) value. The combined effect of NEB was found to be non significant. In case of rehydration ratio, maximum value in the dried cubes and slices was recorded in T_3 (7.71 and 7.77) and minimum in T_1 (5.80 and 5.87) among different drying modes. The rehydration ratio was decreased with 6 month storage interval. The combined effect of treatments and storage interval on rehydration ratio was found to be non significant.

The sensory quality of dried cubes and slices evaluated for various attributes during storage is presented in table 5. The score for all sensory quality of dried cubes and slices ranged from 4.0 to 8.0 out of 9.0. During storage, T_3 recorded the maximum (8.46 and 8.43) scores for colour followed by T_2 (7.43 and 7.40) and T_1 (4.83 and 5.16) in dried cubes and slices at 0 day of storage, respectively. Among different drying modes mean maximum (7.98 and 7.97) scores for colour was recorded in dried cubes and slices of T_3 and minimum in T_1 (4.46 and 4.59). Further the mean score for texture was found to decrease from 6.97 to 6.01 and from 6.77 to 6.01 during 6 months of storage of dried cubes and slices. The mean maximum value was observed to be highest in T_3 and lowest in T_1. Further, among different treatments, mean maximum value of 7.90 and 7.91 was recorded in dried cubes and slices of T_3 and minimum (4.77 and 4.66) in T_1 for flavor, respectively. On the other hand, the score for overall acceptability in dried cubes and slices decreased from 7.41 to 6.28 and from 6.85 to 6.28, respectively. An interaction of treatment and storage interval revealed non-significant effect on score of sensory attributes except for texture and overall acceptability of dried slices.

The variation in different chemical characteristics of ripe pumpkin in the present study and earlier reported by different researchers may be due to the due to varied agroclimatic conditions. These findings of chemical characteristics are near to the values analyzed by Dhiman *et al.,* (2009) and in accordance with the range given by Noelia *et al.,* (2011), Fedha *et al.,* (2010), Olurin *et al.,* (2012), Bhat and Bhat (2013) and Dhiman *et al.,* (2018).

A perusal of data (Table 2) reflects the effect of pretreatment on ripe pumpkin cubes and slices and indicated that pumpkin slices were more efficient in removal of moisture due to its higher surface to volume ratio. The recovery of dried slices was lesser than cubes which may be due to thin layer of slices causing more solid losses during blanching. Comparing different pretreatments, KMS and SO_2 were able to maintain the quality of pumpkin cubes and slices to great extent when subjected further to drying. The minimum moisture in KMS pretreated cubes and slices might be due to the combined effect of blanching and sulphiting, which reduces the moisture content by means of exposing the cells by rupturing their membrane, thus facilitating their plasmolysis due to heat (Karki 2009). Taiwo and Adeyemi (2009) also noticed that blanching of banana at 60 °C for 10 min resulted in better moisture loss from the samples as compared to the control (without blanching). Also, the lower values for reducing sugars in KMS treated cubes and slices might be due to the protective effect of sulphites towards hydrolysis and inversion of non-reducing to reducing sugars (Sra *et al.,* 2011). In accordance to present finding, Prajapati *et al.,* (2011) studied the effect of pretreatment on quality of value-added dried aonla (*Emblica officinalis Gaertn*) shreds and stated that product with 0.1 % KMS blanching followed by addition of 3 % salt was found to be the best in terms of nutritional parameters *viz.* acidity, total and reducing sugars as compared to the other treatments. Also, the retention of different quality attributes such as moisture, ascorbic acid, reducing and total sugars were found optimum when tomato halves were dried by applying the treatment of blanching at 95 °C for 1 min followed by dipping in 6 % KMS solution for 10 min (Shilpa *et al.,* 2008). Even Kumar *et al.,* (2018) also reported that pre-treatment comprising of steam blanching followed by 2000 ppm KMS dip for 60 min was found to be best for carrot roundels.

The elucidation of data reveals that β-carotene has increased to 36.28 % in pumpkin cubes while 36.30 % in case of pumpkin slices, as slices have more heat penetration. The higher retention of β-carotene in KMS pretreated cubes and slices might be due to the antioxidant properties of SO_2**.** A significant difference was noticed in ascorbic acid content of different treatments. Although the ascorbic acid content was reduced but was more in case of slices due to high surface to volume ratio, reflects greater heat penetration. Further, KMS pretreated samples minimize the losses of ascorbic acid in dried fruits due to higher retention of SO_2 (Sra *et al.,* 2011). Negi and Roy (2001) while studying the effect of blanching on quality attributes of dehydrated carrot slices revealed that blanching in hot water for 90 seconds followed by dipping in 0.50 % KMS solution for 60 seconds contained higher β-carotene but lower ascorbic acid to that of unblanched part after cabinet drying. On the other hand, Rahman *et al.,* (2010) revealed that pretreatment of carrot slices by blanching in hot water for 6-9 min followed by dipping in 0.075 % sodium metabisulphite for one hour prior to drying helped in retaining the ascorbic acid and β-carotene. Sen *et al.,* (2015) studied the effect of SO_2 concentration on the quality and nutritional properties of dried apricot and found that fumigation doses of 3500 ppm SO_2 helps in the retention of β-carotene and total phenolic content.

The higher amount of proximate composition in cubes and slices was due to loss in moisture content when dried after pretreatment. In case of non enzymatic browning, the less browning in KMS and SO_2 pretreated cubes and slices might be due to the action of KMS and SO_2 as an antioxidant that helps in preventing cubes and slices from browning. Similar pattern of NEB in dried tomato halves and dried carrot slices has been reported, respectively by Shilpa *et al.,* (2008) and Sra *et al.,* (2014).

In similarity to present investigation, different researchers have also noticed that pretreatment have significant effect on the sensory quality of the dried products. Use of KMS and SO_2 has improved the colour characteristics of the dried pumpkin cubes and slices. Similar results are reported by Verma and Gupta (2004) who observed that pretreatment with KMS or blanching prior to drying prevent discoloration and maintain better texture of aonla flakes. Latapi and Barrett (2006) found that sodium metabisulphite treated sun dried tomatoes had significantly better color and carotenoids content as compared to gas sulphur (SO_2) treated sun dried tomatoes. Shrivastava and Kumar (2007) reported that SO_2 fumes act as a disinfectant and prevent the oxidation and darkening of fruits on exposure and thus retain their colour. Prajapati *et al.,* (2009) also reported that blanching of aonla shreds with hot water or with KMS before drying improves the colour and texture.

Table 3 indicated that sun drying took maximum time for complete drying of cubes and slices in comparison to solar drying and mechanical cabinet drying. Drying was more efficient in case of pumpkin slices as compared to pumpkin cubes. Similar results were obtained by Bhat *et al.,* (2014) and Sharma (2016) in dried wild pomegranate arils and Kumar (2017) in sun, solar tunnel dried horse chestnut flour. Further, the effect of different drying modes *viz.* solar tunnel drying and mechanical cabinet drying on various physico-chemical and sensory characteristics of wild pomegranate fruits were evaluated by Thakur *et al.,* (2020b). He concluded that mechanical cabinet drying to be the best drying mode and recommended 60 °C temperatures for preparation of good quality *anardana.*

During storage, difference in the moisture content under different drying methods might be due to the fast and efficient moisture removal in the mechanical cabinet drier (T_3) because of the continuous air movement and controlled temperature as compared to the fluctuating and low temperature in solar drier (T_2) and open sun (T_3) as has been reported by Sharma (2016). The increase in moisture during storage might have occurred due to the hygroscopic nature of the dried product as revealed by Sra *et al.,* (2014). The changes were more in dried pumpkin slices as compared to dried pumpkin cubes. Maximum retention of total sugars and titratable acidity were found in T_3 due to the reduced rate of involvement of these chemical constituents in the formation of NEB, HMF and furfural because of the faster drying and lower moisture retention in the dried cubes and slices (Sharma 2016). The increase in reducing sugars during storage might be due to slow inversion of non reducing sugars and starch in to reducing sugars. Similar trend of decrease in total sugars and titratable acidity and increase in moisture content and reducing sugars was noticed by Sharma *et al.,* (2006) in dehydrated apple rings, Shilpa *et al.,* (2008) in dried tomato halves and Sharma (2016) in dried wild pomegranate arils during storage.

Among different treatments maximum retention of β- carotene and total phenols in dried cubes and slices of treatment T_3 might be due to controlled drying conditions and no exposure of cubes and slices to intermittent drying cycles. Also, photo-oxidation of the β-carotene of dried cubes and slices in open sun might have contributed towards their degradation. These results are in conformity with the findings of Thakur *et al.,* (2020b) and Sharma (2016) in wild pomegranate arils. Further ascorbic acid was observed to be retained more in case of dried slices in comparison to dried cubes as slices cause efficient drying, lesser exposure to heat. Also, higher retention of ascorbic acid in T_3 followed by T_2 and T_1 might be due to reduced loss because of fast drying rate and less exposure time of cubes for oxidation as has been revealed by Sharma (2016). According to Sra *et al.,* (2014) loss in ascorbic acid during storage might be due to its oxidation to dehydroascorbic acid followed by further degradation to 2, 3-diketogluconic acid and finally to furfural compounds which enter browning reactions. Loss of total phenols during storage may be due to oxidation and polymerization of phenolic compounds as reported by Kapoor and Aggarwal (2015) in dried carrot slices. A significant increase in NEB of dried cubes and slices during storage including maillard reaction might be attributed due to reduction in residual SO_2 during storage (Shilpa *et al.,* 2008). Similar findings were revealed by Sharma *et al.,* (2006) in dehydrated apple rings, Sagar and Kumar (2006) in dehydrated aonla shreds, Sra *et al.,* (2014) in dried carrot slices and Kumar *et al.,* (2020). During storage, the decline in the rehydration ratio might be due to changes in macromolecular components including cellulose, pectin, hemicelluloses and protein content (Sra *et al.,* 2014).

Among all drying method, mechanical cabinet drying was able to retain maximum sensory quality due to less browning experienced in dried cubes and slices while drying. The decrease in colour scores during storage might be due to oxidative biochemical reactions which might have affected the colour of cubes. Similar decreasing trend in colour of dried cubes during storage was reported by Sagar and Kumar (2006) in dried aonla shreds and Shilpa *et al.,* (2008) in dried tomato halves. A slight decrease in texture scores upon storage may be attributed to the degradation of pectic substances and picking of moisture (Sharma *et al.,* 2004). The decrease in flavor scores might be due to the oxidation of the compounds. A significant decreasing trend in texture and flavor has also been observed by Sagar and Kumar (2006) in dried aonla shreds, Shilpa *et al.,* (2008) in dried tomato halves, Sra *et al.,* (2014) in dried carrot slices and Thakur *et al.,* (2020a).

In conclusion the study showed that pretreatment, have a significant effect on the quality characteristics of dried products. The steam blanching for 4 min + 1500 ppm KMS dip in water for 30 min was found to be the best for drying of pumpkin cubes as well as slices on the basis of different chemical and sensory attributes. Pretreated pumpkin cubes and slices dried in the mechanical cabinet drier were found to possess better quality and were awarded higher sensory scores as compared to solar and open sun. During storage the maximum retention of chemical and sensory quality was observed in cubes dried in mechanical cabinet drier. Similar trend was observed in slices during six months of storage. The dried cubes and slices can be utilized for the production of excellent quality pickle and sauted vegetable, etc. Therefore, it is concluded that ripe pumpkin which otherwise is not extensively utilized for processing, can be used for the production of dried cubes and slices. The products can be safely stored for more than a period of six months under ambient conditions when packed in appropriate packaging material.

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Conflict of interest

The authors declare that there are no conflicts of interest in the course of conducting the research. All the authors had final decision regarding the manuscript and decision to submit the findings for publication.

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