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Changes on Nutritional Quality of Ripe Persimmon When Pre-Treated with Different Pre-Treatments and Drying Methods

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A B S T R A C T

Persimmon is also known as Japaniphal (*Diospyros kaki* L.) used for preparing dehydrated persimmon slices. Among different pre-treatments (blanching, potassium metabisulphite, citric acid, ascorbic acid) used prior to drying, the steam blanching for 3 min + KMS (300 ppm) + citric acid (0.3 %) immersed for 20 minutes in water found to be highest sensory scores therefore considered best. The pretreated slices of persimmon were further dried using different drying techniques sun (T1), solar (T2) and mechanical cabinet (T3). The best drying method was mechanical cabinet (T3) based on highest value of chemical characteristics and greatest scores for sensory. When stored for six months, the decrease in constituents like ascorbic acid and β-carotene (8.96 to 8.66 and 17.92 to 13.47 mg/100 g), fibre content (1.25 to 1.04 %), antioxidant activity (63.19 to 59.59 %) and total phenols (14.05 to 10.30 mg/100 g) was minimum in slices dried in dehydrator (mechanical cabinet) in contrast with dryer (solar tunnel and solar glass). The sensory scores showed acceptable limit but remained decreased during storage. The minimal changes in both (chemical and sensory) attributes generally with the result ensured that dried persimmon slices prepared surely be stored safely for the duration of 6 months.

Introduction

The persimmon (*Diospyros kaki* L.) commonly called as Japanese persimmon is a deciduous plant. It is being known to have different meaning (*Dios* means God, pyros means grain or food) beacuse it comes under *Diospyros* genus and Ebony family. It is locally known as Japaniphal is the most important temperature deciduous tree (Singh *et al.*, 2011). The warm regions of different countries (China, Korea and Japan) are well suited for cultivation of persimmon (Yesiloglu *et al.*, 2018). The fruit growth has steadily increased to more than 50 per cent from 2007 to 2017 with an annual production of 5.53 MMT in the year 2017 (FAO, 2019).

As per FAOSTAT, 2020 in the year 2019 China stood in first place in production of persimmon around world, with an annual production of 2.19 MMT followed by Japan 0.25 MMT. Persimmon is one of the richest sources of different bioactive compounds as carotenoids, ascorbic acid, sugars, dietary fibre, minerals, essential trace elements and phenolics compounds (Karaman *et al.,* 2014). According to Gautam *et al.,* (2020) functional components like ascorbic acid 15.90 and 14.99 mg, beta carotene 15.90 and 14.99 mg, total phenolic content 250.00 and 190.00 µg and antioxidant to be 49.13 and 45.82 per cent per 100 g of fruit were noticed in Fuyu fruits with and without peel, respectively.

The pigment in persimmon consists of carotenoid that increased with maturity whereas lutein and lycopene found to be decreased with maturity. The highest (50%) content of carotenoid was noticed in β-cryptoxanthin thereafter lutein (5%) zeaxanthin (5%), β-carotene (10%) and lycopene (10%) (Cano *et al.,* 2018). The functional compounds such as carotenoids, dietary fibres and phenolic compounds in persimmon are accountable for preventing oxidation different health benefits as anti-diabetic, antitumor and anti-hyperlipidemic effect (Yaqub *et al.,* 2016).

Because of the appealing distinctiveness, the fruits are in great demand and becoming popular among masses. Being a climacteric fruit, persimmon has medium to long period of storage (2-3 months). Its quality cannot be maintained at room temperature for longer period of time but can be stored up to 2-3 months at low temperature of 0°C and 85 to 90 per cent relative humidity (Candir *et al.,* 2009). The regular availability of fruits is difficult due to various reasons, such as the crop is grown only in a particular season in specific climatic regions, limited facilities for cold storage and mould growth caused by *Alternaria alternata* (Cho *et al.,* 2017). Moreover, when the fruit is fully ripe, its handling becomes difficult and get spoiled within a short period of time which leads to great post-harvest losses.

In order to prevent the losses and to make the fruit available throughout the year, it is essential to apply one or the other preservation method to conserve nutrients along with increase in shelf life and safeguard food (against insect and microbial growth). One of the commonly used and oldest methods is dehydration of fruits and vegetables for food preservation of food. The different methods of drying and dehydration are sun, solar, mechanical, freeze, oven and vacuum drying (Maisnam *et al.,* 2017).

Several studies have been reported on drying and dehydration of fruits and vegetables. Dhiman *et al.,* (2020) dried pumpkin cubes and slices by using various modes of drying such as sun, solar and cabinet (mechanical) driers. Sendeera *et al.,* (2020) dried persimmon cultivar Rojo Brilliante using convective drying method.

During drying and dehydration pretreatments before drying plays a major role in increasing material quality, drying rate and inhibiting bio-enzymes. It minimizes deterioration reactions during drying and storage (Araujo *et al.,* 2017). Minh *et al.,* (2018) blanched papaya (*Carica papaya*) in hot water at 95 ºC for 10 second for drying. Attri *et al.,* (2016) found high β-carotene and ascorbic acid content in papaya shreds when steam blanched (3 min) succeeded by immersion in KMS (0.20%).

The effect of 1 per cent potassium metasulphite for 5 min retained colour of mango slices during hot air drying (Nasiru *et al.,* 2019). Steam blanching (4 min) + KMS solution (1500 ppm/ 30 min dip) in water for pumpkin cubes had been highly suitable in retaining colour, texture, flavor and overall acceptability as per investigation of Dhiman *et al.,* (2020).

Taking into account the seasonal availability of persimmon and its perishable nature, it is necessary to preserve the crop to increase market efficiency for longer period of time during off season.

Since, very few reports have been published describing drying and dehydration processes and their effect on nutritional and functional quality. Research was carried out to investigate the changes caused on nutritional quality of different pre-treatments and drying modes on dried persimmon slices.

Materials and Methods

Method to prepare dried slices of persimmon

Persimmon (variety Fuyu) fruits have been purchased from the Regional Horticultural Research and Training Station, Seobagh, Kullu. The fruits were kept under ambient condition for ripening. The persimmon fruits were washed under running water. The fruits were peeled, cut into slices of uniform size i.e. approx 2 cm thickness using stainless steel knife.

The persimmon slices were subjected to various pre-treatments steam blanching (3 min), steam blanching (3 min) + KMS (500 ppm/ 20 min dip), steam blanching (3 min) + citric acid (0.5 %/ 20 min dip), steam blanching (3 min) + ascorbic acid (1 %/ 20 min dip) and steam blanching (3 min) + KMS (300 ppm) + citric acid (0.3 %/ 20 min dip). Without any pre-treatment is considered as control. After pretreatments the slices evaluated for various physico-chemical characteristics and sensory attributes in order to select the best treatment for further studies for dehydration by different methods. Prior to analysis the slices were dried in a mechanical cabinet dehydrator at 50 ± 2 ºC. The pre-treated persimmon slices as selected steam blanching for 3 min + 300 ppm KMS + 0.3 % citric acid dip for 20 min were used to standardize the method of drying. The slices were dried under three different modes i.e. mechanical cabinet dehydrator, solar tunnel dryer and solar glass dryer. But prior to mechanical cabinet dehydration, the drying temperature was standardized and the temperature of 60 ºC was selected for drying. The persimmon slices of selected pre-treatment dried by using different modes of drying were prepared then further packed within ALP (Aluminium Laminated Pouches) and High Density Polyethylene (HDPE) labeled pouches. The packed products were kept under ambient condition and for 3 different intervals (0, 3 and 6 months) it was stored. Further the packed products were evaluated for different chemical and sensory parameters. Throughout the experiments, being performed and managed under laboratory of Food Science and Technology Department, University of Horticulture and Forestry, Nauni, Solan, (HP), India.

Evaluation of different quality attributes

Persimmon slices had been investigated in order to get different quality attributes such as moisture content, total soluble solids (TSS), titratable acidity, ascorbic acid (Vitamin C), sugars, ash content, β-carotene, fibre content, total phenols and antioxidant activity. For the determination of total Folin-Ciocalteu reagent was used (Singleton and Rossi, 1999). Another attributes such as colour, texture, flavor and overall acceptability were analysed on the basis of hedonic scale ranged from 1 to 9 by a panel of 10 judges of pre-treated and dried slices (Ranganna, 2009).

Three replications were used for performing every experiment and results were analyzed with standard deviation. The statistical designs CRD (Completely Randomized Design) for chemical attributes and RBD (Randomized block design) for sensory was employed for the quantitative analysis of products during storage.

Results and Discussion

Chemical property of fuyu persimmon

Results (Plate 1 and Plate 2) pertaining to chemical properties of fuyu persimmon fruit are highlighted in Table 1 and Fig 1. The following data come out with that the average moisture content of 80.39 ± 2.00 per cent, TSS, acidity and pH was reported to be 17.06 ± 1.38 °B, 0.12 ± 0.01 per cent and 5.66 ± 0.20, respectively in persimmon fruit. The data recorded for total sugars (12.60 ± 2.14 %) and reducing sugars (5.83 ± 0.96 %). Further, the results revealed (12.40 ± 1.70) ascorbic acid and (1.54 ± 0.07) β-carotene content in mg/100 g. The fibre and ash content in present study was 1.02 ± 0.42 and 0.34 ± 0.03 per cent. Fuyu persimmon was found to possess 2.70 ± 1.2 mg/100 g of phenols and 70.33 ± 0.35 per cent of antioxidant activity.

Effect of pretreatments on ripe persimmon slices

The data (Table 2) showed that in T_1 (control) the value (11.03 %) was maximum for moisture content and in T_6 (steam blanching for 3 min + 300 ppm KMS + 0.3 % citric acid dip for 20 min) the value (10.53 %) was minimum. The highest value for TSS (37.80 ºB) of persimmon slices was noticed in T_3 and lowest (37.07 ºB) in T_1. The minimum moisture content in slices might be because of combined effect caused by blanching; sulphiting with acid in KMS pretreated slices which have reduced the moisture content by rupturing the cell membrane thus facilitates destruction of cells by heat as reported by Karki (2009). The reduced moisture content in KMS and citric acid treated persimmon was also recorded by Karakasova *et al.,* (2015). They noticed that 3% solution of potassium metabisulfite and 5 % solution citric acid for 5 min reduced moisture content in per cent from 81.26-16.92 and 81.26-15.86. The effect on the total and reducing sugars of dried persimmon slices indicated that the highest (30.95 %) value of total sugars was recorded in T_2 and lowest (30.05 %) in T_4, whereas, minimum (23.15 %) reducing sugars were found in T_4 (steam blanching 3 min + citric acid 0.5 % and dipped for 20 min) and maximum (23.34 %) in T_1 (control). The lower value for reducing sugars in T_4 was as a result of non-reducing sugars to reducing sugar inversion + protective effect of sulphites towards hydrolysis (Sra *et al.,* 2014). Dhiman *et al.,* (2020) found steam blanching (4 min) + KMS (1500 ppm) immersion of 30 min in pumpkin cubes and slices had maximum total and minimum reducing sugars among all the treatments. The persimmon slices of treatment T_4 exhibited higher value (0.99 %) of titratable acidity which was statistically at par with T_3 and T_6 having a value in per cent i.e.0.98.

The maximum content of ascorbic acid was present in T_5 (8.98 mg/100 g) i.e. steam blanched for 3 min + 1 % ascorbic acid dip for 20 min and minimum in T_2 (7.87 mg/100 g) i.e. steam blanching for 3 min. The β-carotene content data of dried persimmon slices was highlighted in Table 2 where the T_6 and T_1 represented the highest value (17.92 mg/100 g) and lowest value (11.56 mg/100 g). The ascorbic acid and β-carotene retention might be due to the antioxidant effect which prevents the loss of these contents against oxidative deterioration while processing as well as heat treatment (Majumdar, 2001). The findings are in similar trend to that of Mir *et al.,* (2009) and Dhiman *et al.,* (2020) in apricot and pumpkin slices. Mir *et al.,* (2009) observed that 6 per cent KMS for 30 min dip retained ascorbic acid and carotenoid content in apricot. Further, as presented in Table 2, the highest total phenols (14.09) in T_1 and same value of lowest total phenols (14.05) expressed in mg/100 g in T_3, T_5, and T_6. Table (2) showed that highest antioxidant activity was observed in T_1 followed by T_4. The higher retention of total phenols might be because of over estimation of phenols as per the formation of oxidized compounds (Singleton *et al.,* 1999). The antioxidant effect might be due to the free radical scavenger DPPH along with citric acid antioxidant action (Mbondo *et al.,* 2018). The findings of Dhiman *et al.,* (2020) revealed that steam blanching (4 min) + KMS (1500 ppm) and 30 min immersion was observed to be best treatment as per β-carotene, ascorbic acid and total phenols retention in pretreatment for drying of slices and cubes of pumpkin. The details of Table 4.12 data clearly stipulated that in dried persimmon slices ash content among different treatments the highest (1.07 %) in T_6 while lowest in T_1 (1.02 %). The data of ash is non-significant. Further, maximum fibre content of (1.42 %) was obtained by T_1 and minimum (1.21 %) in T_2. Jabbar *et al.,* (2014) reported that blanching of carrot at 100 ºC for 4 min however, in-activated peroxidase reduced phenols, ascorbic acid and antioxidant activity.

The data in Table 2 exhibited maximum mean score for sensory of 8.53, 7.50, 8.50 and 8.58 for colour, texture, flavour and overall acceptability was scored by T_6 then by T_4, T_3 and T_5 while the minimum score for the corresponding parameter was observed to be 7.57, 7.66, 7.45 and 6.53, respectively in T_1.

The data in Table 2 and 3 reflecting the chemical characteristics and sensory attributes reveal that though the treatment T_6 was not having higher value for all the chemical constituents but keeping in view the texture, appearance and acceptability, the treatment T_6 (3 min steam blanching + 300 ppm of KMS + 0.3 % of citric acid dip for 20 min**)** of slices chosen generally preferred for dehydration (by different modes).

Standardization of drying method of persimmon slices

The data presented in Table 4 indicated that three different time for drying of 5 kg persimmon slices was noted in three different drying modes i.e. in mechanical cabinet dehydrator (D_1) was 16.67 h, whereas, it was 56 h and 65.67 h for solar tunnel dryer (D_2) and solar glass dryer (D_3), respectively.

The drying curve for each drying method is given in Fig 2. The product recovery exhibited maximum value (19.60 %) in solar glass (D_3) while minimum value (13.38 %) was observed in mechanical cabinet dried slices (D_1).

Effect on quality characteristics during storage of dried persimmon slices

Results pertaining to the moisture content in dehydrated persimmon slices highlighted in Table 5 revealed that minimum (10.53 %) moisture was recorded in the slices dehydrated in mechanical cabinet dehydrator (D_1) and maximum (15.06 %) in solar glass dryer (D_3) at 0 day of storage. An increase in significantly in per cent moisture content of dried slices obtained while stored for 6 months. Further, the mean moisture was found to increase from 13.43 per cent to 14.31 per cent was recorded in slices. A significant interaction was noted of drying modes and storage interval. In mechanical cabinet dehydrator the moisture content was found to be low due to fast transfer of hot air to the food and efficient moisture is removed because of controlled temperature and relative humidity condition (Navalea *et al.,* 2015). The hygroscopic nature of the dried product during storage led to the moisture content increase (Sra *et al.,* 2014). These type of corresponding results also noted in carrot slices by Sra *et al.,* (2014) and Dhiman *et al.,* (2020) in dried pumpkin slices.

Data in Table 5 highlight that the maximum (37.60 ºB) TSS was recorded in slices dried in mechanical cabinet dehydrator (D_1) followed by D_2 (35.18 ºB) and D_3 (34.49 ºB) at 0 day of storage. The mean TSS observed to be decreased (35.76 to 35.54 ºB) within 6 months of storage. United effect in reference to drying modes with storage on TSS was inferred to be non-significant. Due to controlled condition of temperature in mechanical cabinet dehydrator, the highest value of TSS was recorded in D_1. The decreasing trend in TSS in during storage may be attributed to the increasing moisture content of product. Similar decreasing trend in TSS has also been noted by Attri *et al.,* (2014) in papaya and apricot toffee and Dhiman *et al.,* (2020) in dried pumpkin slices.

The highest (30.09 %) total sugar in dried slices was observed in dehydrator (mechanical cabinet) whereas lowest (27.40 %) in solar glass drier at 0 day of storage is manifested from Table 5. Among various treatments, mean maximum value of 30.01 per cent was investigated in D_1 and in D_3 (minimum of 27.14 %). With the advancement the overall (mean) total sugars were decreased (28.93 to 28.64 %) in dried slices, respectively throughout an interval of 6 months. The significant values of united effect of drying modes with storage on total sugars were observed. The gradual decrease in total sugars during storage might have occurred due to as various bio-chemical reactions like non-enzymatic browning and formation of HMF. Therefore, there is maximum retention of slices dried in mechanical cabinet dehydrator (D_1). A similar trend of change in total sugars was also observed by Attri *et al.,* (2014) in papaya and apricot toffee and Dhiman *et al.,* (2020) in dried pumpkin slices during storage.

The data in Table 5 elucidate an increase in amount of reducing sugars significantly of dried persimmon slices during storage. The maximum (23.19 %) reducing sugars were observed in slices dried in mechanical cabinet dehydrator (D_1) and minimum (21.41 %) in solar glass dryer (D_3) at initial day. Further, the overall (mean) reducing sugar content was increased to 22.90 per cent from 22.37 per cent after 6 months of storage. During storage the sugars (non-reducing) inversion to reducing sugars along with other polysaccharides takes place which ultimately showed an increase in content of reducing sugars. In mechanical cabinet dehydrator the higher reducing sugars in was found in comparison with solar tunnel (D_2) and solar glass dryer (D_3) perhaps as a result of lower value of moisture content that led to more concentration. An increase in reducing sugars has been observed by Attri *et al.,* (2014) in papaya-apricot toffee and Dhiman *et al.*, (2017) in Instant Soup Mix of dehydrated pumpkin powder.

The data (Table 5) for titratable acidity of dried persimmon slices indicated a gradual significant decrease in values during storage. Maximum (0.98 %) titratable acidity was observed in slices dried in mechanical cabinet dehydrator (D_1) and minimum (0.85 %) in solar glass dryer (D_3) at 0 day of storage. The non-significant effect of both (drying modes and storage interval) on titratable acidity was observed. The higher acid content basically in cabinet drier (mechanical) is because of low moisture content that led to increased concentration of acids in end product. In addition, due to accelerated drying and depressed level of moisture leading to less participation of acids in browning reactions within mechanical cabinet dehydrator (D_1) in contrast to solar tunnel and solar glass dryer (D_2 and D_3). Similar decreasing trend was observed for dehydrated apple rings by Sharma *et al.*, (2006), for carrot slices by Sra *et al.,* (2014) and for dried pumpkin slices by Dhiman *et al.,* (2020). The ash content of slices showed less significant difference in values among different drying modes and packaging materials (Table 5). Maximum (1.07 %) ash content was observed in the slices dried in mechanical cabinet dehydrator (D_1) and minimum (1.05 %) in both solar glass and solar tunnel dryer at 0 day of storage. The united effect on ash of drying modes and different storage period exhibited to be significant. During storage decrease in ash content of persimmon slices might be due to moisture absorption by slices. The results obtained for ash content are near to those reported earlier by Pritika (2015) in dried pumpkin slices.

The scrutiny of data presented in Table 5 shows that the ascorbic acid content of slices of different drying modes significantly decreased during storage up to six months. At 0 day, the maximum (8.96 mg/100 g) ascorbic acid was found in slices of D_1 followed by D_2 (7.97 mg/100 g) and D_3 (7.35 mg/100 g). Moreover, the mean value of ascorbic acid content was recorded as to be decreased (8.09 to 4.32 mg/100 g) after storage of 6 months, respectively. Highest ascorbic acid retention in slices dried in mechanical cabinet dehydrator (D_1) might be due to less amount of loss since faster drying led to lesser exposure time of slices for oxidation. The higher retention can be correlated to reduce moisture content with regard in mechanical cabinet drying which might have led to more extent of ascorbic acid content. Nearly similar pattern of data in ascorbic acid content in mechanical cabinet and solar tunnel drier have been stated by Rahman *et al.*, (2010) in carrot slices. An assessment of data presented in Table 5 depicts a highly significant difference in β-carotene content of slices of different treatments with maximum (17.92 mg/100 g) value for D_3 and minimum (15.23 mg/100g) for D_1 at 0 day of storage. The maximum mean value was recorded in dried slices of D_1 (15.68) while minimum in D_3 (11.45) expressed in mg per 100 g among different modes of drying. Further, the content for β-carotene of slices the mean value was decreased from 16.45 (mg/100 g) to 12.51 (mg/100 g) was observed in ALP. A significant interaction of drying modes and storage interval was observed. The more retention regarding to *β*- carotene in slices dried in of mechanical cabinet dehydrator (D_1) may be on account of least intermittent drying cycle that prevented its exposure to these cycles and of controlled drying conditions.

Different properties (chemical) of Fuyu persimmon fruit

Table.1 Chemical characteristics of Fuyu persimmon fruit

Characteristics	Without peel (Mean ± SD)
Moisture (%)	80.39 ± 2.00
TSS (ºB)	17.06 ± 1.38
Titratable acidity (%)	0.12 ± 0.01
Ph	5.66 ± 0.20
Total sugars (%)	12.6 ± 2.14
Reducing sugars (%)	5.83 ± 0.96
Ascorbic acid (mg/100 g)	12.40 ± 1.70
β-carotene (mg/100 g)	1.54 ± 0.07
Fiber (%)	1.02 ± 0.42
Ash (%)	0.34 ± 0.03
Total phenols (mg/100 g)	2.70 ± 1.27
Antioxidant activity (%)	70.33 ± 0.35

Table.2 Different pre-treatment effects on chemical characteristics of dried persimmon slices

Characteristics	Treatment						
	T_1	T_2	T_3	T_4	T_5	T_6	$CD_{0.05}$
Moisture (%)	11.03	10.95	10.81	10.85	10.83	10.53	0.02
TSS (°B)	37.07	37.16	37.80	37.36	37.43	37.60	0.18
Total sugars (%)	30.82	30.95	30.08	30.05	30.06	30.09	0.01
Reducing sugars (%)	23.34	23.24	23.18	23.15	23.19	23.19	0.04
Titratable acidity (% citric acid)	0.94	0.96	0.98	0.99	0.97	0.98	0.02
Ascorbic acid (mg/100 g)	8.82	7.87	8.81	8.92	8.98	8.96	0.06
β-carotene (mg/ 100 g)	11.56	13.45	17.85	17.76	17.46	17.92	0.02
Phenols (mg/100 g)	14.09	14.07	14.05	14.07	14.05	14.05	0.02
Antioxidant activity (%)	63.47	63.45	63.15	63.46	63.17	63.19	0.01
Ash (%)	1.02	1.05	1.06	1.04	1.06	1.07	NS
Fiber (%)	1.42	1.21	1.37	1.29	1.33	1.25	0.03

T_1	=	Control (without blanching)
T_2	=	Steam blanching (3 min)
T_3	=	Steam blanching (3 min) + KMS (500 ppm) immersion for 20 min
T_4	=	Steam blanching for (3 min)+ citric acid (0.50 %) immersion for 20 min
T_5	=	Steam blanching (3 min) + ascorbic acid (1.00 %) immersion for 20 min
T_6	=	Steam blanching (3 min) + KMS (300 ppm) + citric acid (0.30 %) immersion for 20 min

Table.3 Sensory scores* of pretreated persimmon slices

Treatment	Colour	Texture	Flavour	Overall Acceptability
T_1 (Without blanching)	7.57	7.66	7.45	6.53
T_2 (Steam blanching (3 min))	7.96	7.84	7.65	7.25
T_3 (Steam blanching (3 min) + KMS (500 ppm) immersed for 20 min)	8.45	7.98	8.53	8.45
T_4 (Steam blanching (3 min)+ citric acid (0.50 %) immersed for 20 min)	8.49	7.46	8.47	8.48
T_5 (Steam blanching (3 min) + ascorbic acid (1.00 %) immersed for 20 min)	8.42	7.47	8.45	8.35
T_6 (Steam blanching (3 min) + KMS (300 ppm) + citric acid (0.30 %) immersed for 20 min)	8.53	7.50	8.50	8.58
$CD_{0.05}$	0.02	0.03	0.03	0.03

* 9 point hedonic scale

Table.4 Different drying modes effect on different characteristics as drying time, dehydration ratio, product recovery and shrinkage of persimmon slices

Characteristics \ Drying modes (D)	D_1	D_2	D_3	$CD_{0.05}$
Drying time (hrs)	16.67	56.00	65.67	3.87
Product recovery (%)	13.38	16.43	19.60	1.87
Dehydration ratio	9.06	6.11	5.10	0.99
Shrinkage (%)	66.54	73.49	75.36	0.08

D_1 = Mechanical cabinet dehydrator
D_2 = Solar tunnel dryer
D_3 = Solar glass dryer

Fig.1 Chemical characteristics of pre-treated dried persimmon slices

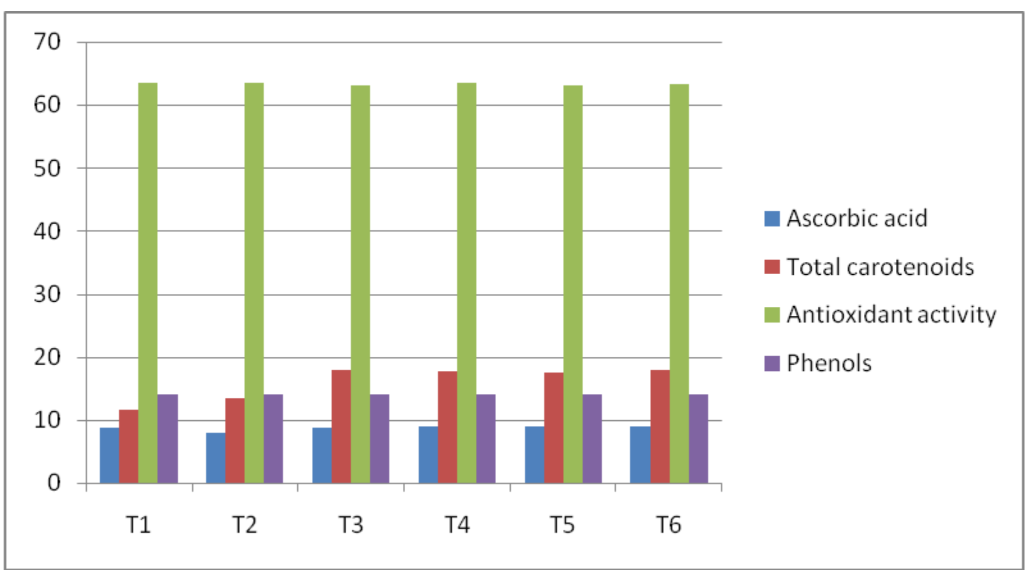


Table.5 Different drying modes effects on chemical characteristics during storage of dried slices

Parameters	Persimmon slices					
	Modes of drying	**0 months**	**3 months**	**6 months**	**Mean**	**$CD_{0.05}$**
Moisture		**0**	**3**	**6**		
	D_1	10.53	10.86	10.99	**10.79**	D= 0.01
	D_2	14.70	15.31	15.50	**15.17**	S=0.01
	D_3	15.06	16.21	16.43	**15.90**	S×D=0.02
	Mean	**13.43**	**14.13**	**14.31**	**13.96**	
TSS (˚B)		**0**	**3**	**6**		
	D_1	37.60	37.53	37.49	**37.54**	D= 0.04
	D_2	35.18	35.07	34.98	**35.07**	S=0.04
	D_3	34.49	34.32	34.15	**34.32**	S×D= 0.06
	Mean	**35.76**	**35.64**	**35.54**	**35.64**	
Total sugars (%)		**0**	**3**	**6**		
	D_1	30.09	29.99	29.96	**30.01**	D= 0.12
	D_2	29.30	29.09	29.00	**29.13**	S=0.11
	D_3	27.40	27.08	26.94	**27.14**	S×D= 0.19
	Mean	**28.93**	**28.72**	**28.64**	**28.76**	
Reducing sugars (%)		**0**	**3**	**6**		
	D_1	23.19	23.39	23.41	**23.33**	D= 0.16
	D_2	22.50	22.90	22.98	**22.79**	S=0.16
	D_3	21.41	22.20	22.31	**21.97**	S×D= 0.27
	Mean	**22.37**	**22.83**	**22.90**	**22.70**	
Titratable acidity (%)		**0**	**3**	**6**		
	D_1	0.98	0.95	0.93	**0.95**	D= 0.02
	D_2	0.91	0.86	0.83	**0.87**	S=0.08
	D_3	0.85	0.78	0.74	**0.79**	S×D= 0.03
	Mean	**0.92**	**0.86**	**0.83**	**0.87**	
Ash (%)		**0**	**3**	**6**		
	D_1	1.07	0.99	0.95	**1.01**	D= 0.02
	D_2	1.05	0.93	0.87	**0.95**	S=0.02
	D_3	1.05	0.89	0.81	**0.92**	S×D= 0.03
	Mean	**1.06**	**0.94**	**0.88**	**0.96**	
Ascorbic acid (%)		**0**	**3**	**6**		
	D_1	8.96	6.68	4.66	**6.78**	D= 0.02
	D_2	7.97	5.87	4.45	**6.10**	S=0.01
	D_3	7.35	5.35	3.85	**5.52**	S×D= 0.02
	Mean	**8.09**	**3.91**	**4.32**	**6.13**	
β-carotene (mg/100 g)		**0**	**3**	**6**		
	D_1	17.92	15.64	13.47	**15.68**	D= 0.02

	D_2	16.21	14.82	12.61	**14.55**	S=0.01
	D_3	15.23	13.76	11.45	**13.48**	S×D= 0.03
	Mean	**16.45**	**14.74**	**12.51**	**14.57**	
Fiber (%)		**0**	**3**	**6**		
	D_1	1.25	1.07	1.04	**1.05**	D= 0.01
	D_2	1.13	0.89	0.83	**0.90**	S=0.01
	D_3	1.06	0.76	0.67	**0.87**	S×D= 0.03
	Mean	**1.15**	**0.92**	**0.85**	**0.94**	
Antioxidant activity (%)		**0**	**3**	**6**		
	D_1	63.19	61.77	59.59	**61.52**	D= 0.02
	D_2	62.49	62.97	58.75	**61.40**	S=0.01
	D_3	61.69	59.99	57.78	**59.82**	S×D= 0.02
	Mean	**62.46**	**61.58**	**58.71**	**60.91**	
Total phenols (mg/100 g)		**0**	**3**	**6**		
	D_1	14.05	12.41	10.30	**12.26**	D= 0.01
	D_2	13.35	11.30	9.19	**11.28**	S=0.01
	D_3	12.71	11.01	8.99	**10.90**	S×D= 0.02
	Mean	**13.37**	**11.57**	**9.49**	**11.48**	
Rehydration ratio		**0**	**3**	**6**		
	D_1	6.46	6.26	6.22	**6.32**	D= 0.02
	D_2	6.05	5.78	5.71	**5.84**	S=0.02
	D_3	5.77	5.42	5.31	**5.50**	S×D= 0.03
	Mean	**6.09**	**5.82**	**5.75**	**5.89**	

D_1 = Mechanical cabinet dehydrator, D_2 = Solar tunnel dryer, D_3 = Solar glass dryer, S= Storage period and D= Drying modes and C=Critical Difference

Fig.2 Drying curve of different drying modes

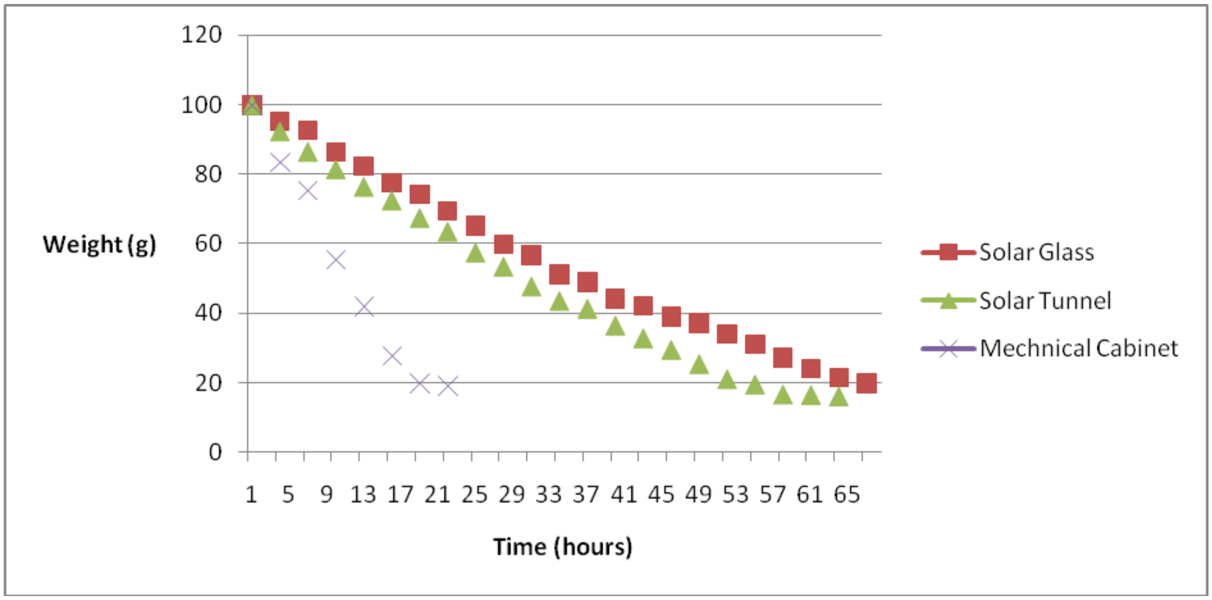


Table.6 Different drying modes effects on sensory scores* during storage of dried slices

Parameter	Persimmon slices					
	Modes of drying	**0 months**	**3 months**	**6 months**	**Mean**	**$CD_{0.05}$**
Colour		**0**	**3**	**6**		
	D_1	8.79	7.98	7.67	**8.15**	D= 0.03
	D_2	8.03	7.52	7.04	**7.53**	S=0.03
	D_3	8.00	7.45	6.95	**7.47**	S×D=0.05
	Mean	**8.27**	**7.65**	**7.22**	**7.72**	
Texture		**0**	**3**	**6**		
	D_1	7.50	7.27	7.15	**7.30**	D= 0.01
	D_2	6.95	6.89	6.44	**6.76**	S=0.02
	D_3	6.76	6.56	6.13	**6.48**	S×D= 0.03
	Mean	**7.07**	**6.91**	**6.57**	**6.85**	
Flavour		**0**	**3**	**6**		
	D_1	8.50	7.94	7.39	**7.94**	D= 0.02
	D_2	7.85	7.45	7.13	**7.48**	S=0.02
	D_3	7.56	7.36	7.01	**7.31**	S×D= 0.03
	Mean	**7.97**	**7.58**	**7.18**	**7.58**	
Overall acceptability		**0**	**3**	**6**		
	D_1	8.59	7.86	7.65	**8.03**	D= 0.02
	D_2	7.71	7.32	7.04	**7.36**	S=0.02
	D_3	7.56	7.24	6.97	**7.26**	S×D= 0.03
	Mean	**7.95**	**7.48**	**7.22**	**7.55**	

D_1 = Mechanical cabinet dehydrator, D_2 = Solar tunnel dryer, D_3 = Solar glass dryer, S= Storage period and D= Drying modes and CD=Critical Difference

Plate.1 Slices dried by different drying modes before storage (0 month)

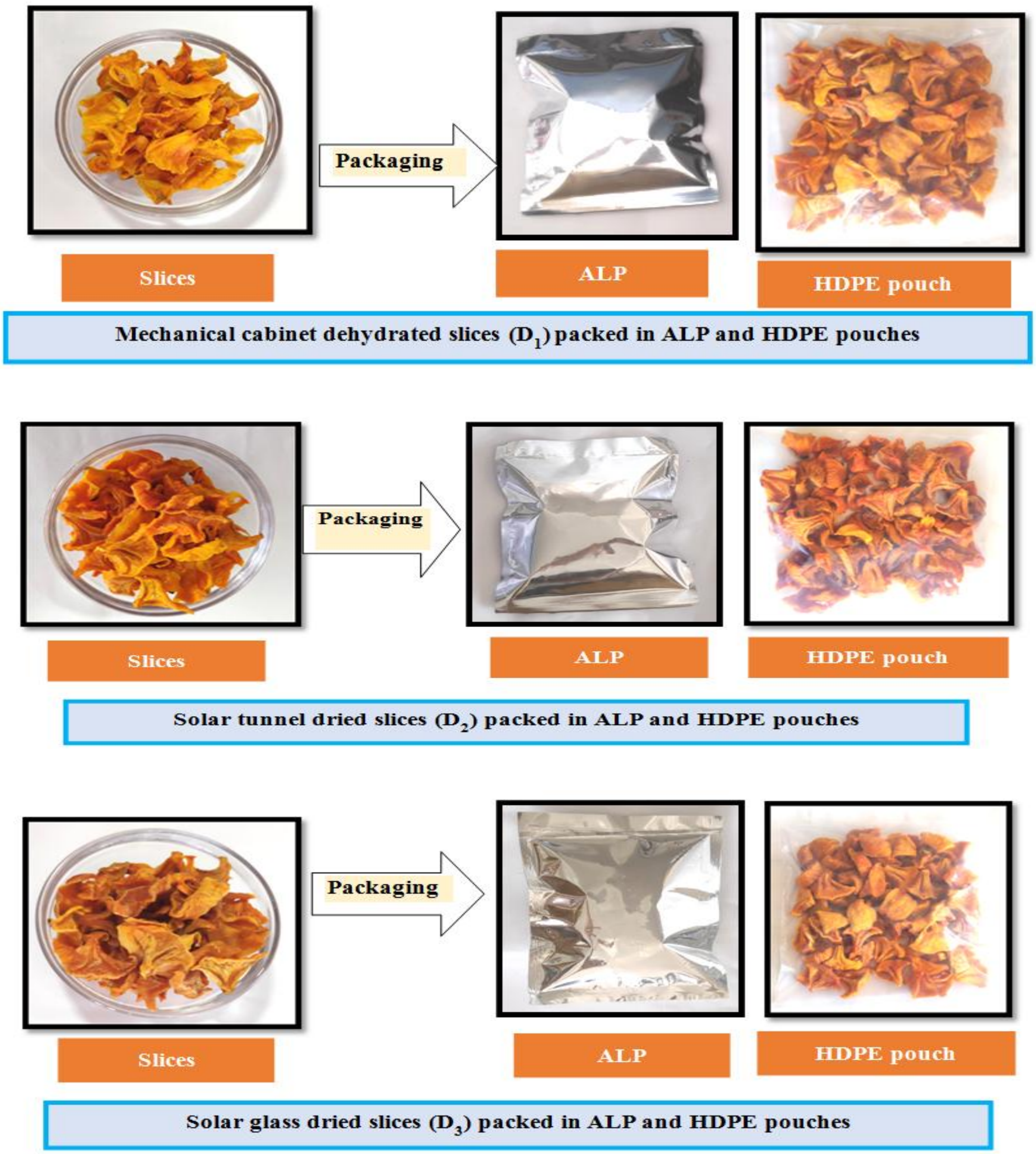
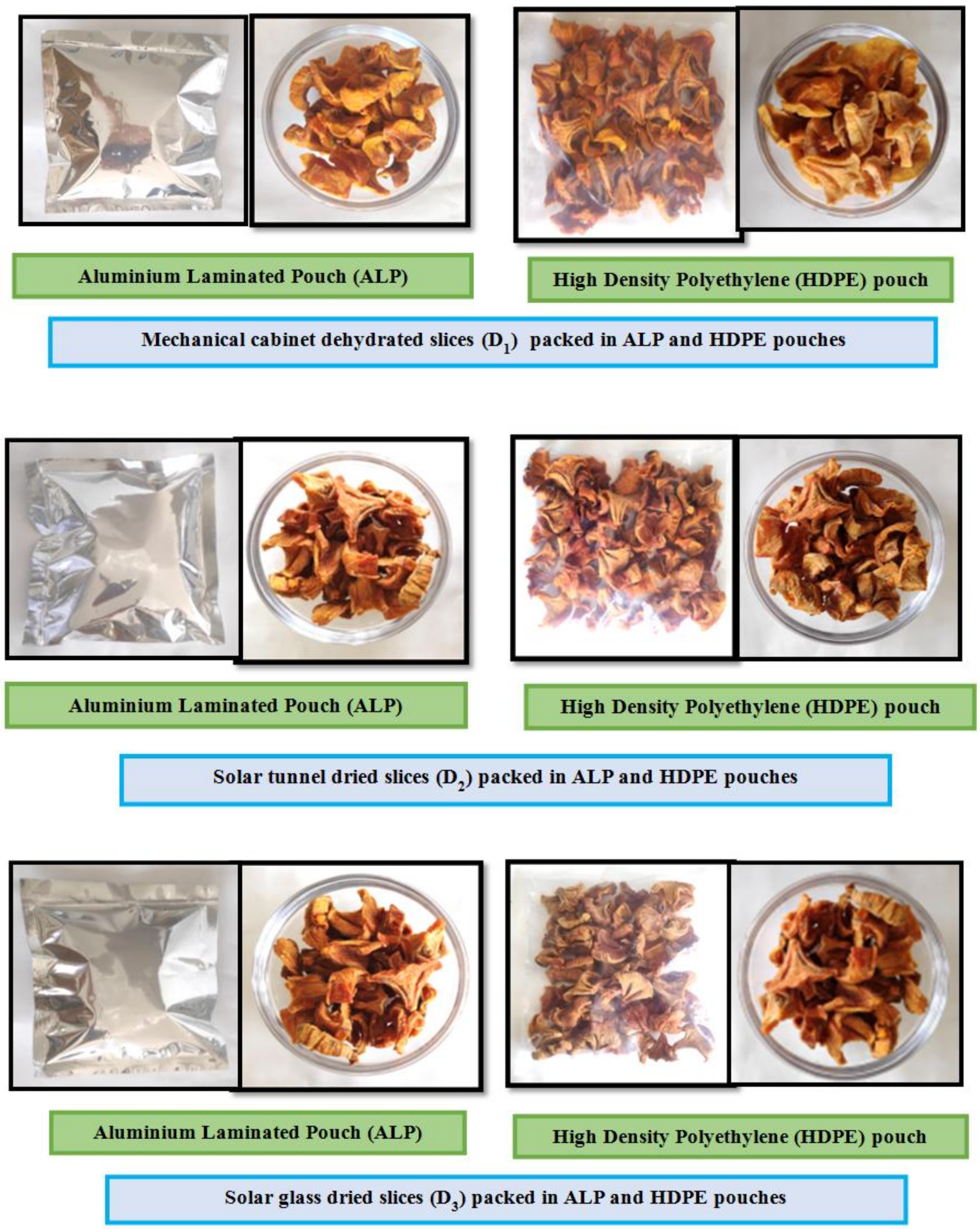


Plate.2 Slices dried by different drying modes after 6 months of storage



The findings of Dhiman *et al.*, (2020) in dried pumpkin slices confirmed the above results of β-carotene. Further, decrease in β- carotene might be due to anti-oxidative degradation during storage. This similar trend in β- carotene content was observed by Rahman *et al.*, (2010) that basically associated with carrot slices, Attri *et al.*, (2014) with papaya, Dhiman *et al.*, (2017) with Instant Soup Mix of pumpkin powder and Dhiman *et al.*, (2020) in dried pumpkin slices. Data (Table 5) for fibre content of slices of different treatments reflected that the maximum (1.25 %) fibre content was exhibited in slices dehydrated in mechanical cabinet dehydrator (D_1) and minimum (1.06 %) in solar glass dryer (D_3) at 0 day of storage. The mean maximum value of fibre content in slices was found in D_1 (1.05) and minimum in D_3 (0.67). Further, the mean value exhibited decreased trend (1.15 to 0.85) in per cent during storage period of 6 months. The drying modes with storage interval showed significant effect unitedly. The lower moisture content in slices dried in mechanical cabinet dehydrator (D1) led to higher value of fiber content in it against solar tunnel (D_2) and solar glass dryer (D_3).

The storage effect on dried persimmon slices antioxidant activity is presented in Table 5. The results reflected a decreasing trend in antioxidant activity during storage of 6 months where the mean value decreased from 62.46 to 58.71. The storage conditions revealed a mean value of 60.91 per cent. The different drying modes and storage interval united effect on antioxidant activity was found to be significant. Six months of storage period effect DPPH antioxidant activity of dehydrated slices decreased significantly may be because of non-enzymatic browning reactions and deterioration of some chemical parameter such as ascorbic acid, total phenols and flavonoids. Similar trend of antioxidant activity was observed by Park *et al.*, (2006) in dried persimmon.

Table 5 indicated the significant differences in total phenols for dried persimmon slices of different treatments with maximum content for D_1 (14.05 mg/100 g) accompanied by D_2 (13.35 mg/100 g) and D_3 (12.71 mg/100 g) at storage initial period (0 day). Advanced studies showed that the average (mean) total phenols decreased from 13.37 to 9.49 mg per 100 g with 6 months storage period. The effect of drying modes and storage interval collectively on total phenols was also found to be significant.

The data revealed that slices dried in mechanical cabinet dehydrator (D_1) contained higher amount of total phenols in comparison with solar tunnel (D_2) and solar glass drying (D_3) which as per the involvement of phenols to lesser extent in enzymatic reactions due to fast drying. Nearly indistinguishable results for total phenols content was observed by Pritika (2015) in pumpkin cubes dried by different (mechanical cabinet and solar drier) drying modes. The decreasing trend of total phenols were also noticed in persimmon by Park *et al.*, (2006), dried carrot slices by Kapoor and Aggarwal (2015) and Dhiman *et al.*, (2020) in dried pumpkin slices during storage.

A critical look at the data for rehydration ratio (Table 5) reflects that the slices dried in mechanical cabinet dehydrator (D_1) showed maximum (6.46) rehydration ratio while minimum (5.77) was recorded in solar tunnel dryer (D_3). Among different drying modes, mean maximum value of 6.32 was recorded in D_1 and minimum (5.50) in D_3. The collective effect on rehydration ratio of drying modes and storage interval was found to be significant.

The diminished value for rehydration ratio during storage might be as a result of changes in different macromolecule such as carbohydrates (cellulose, pectin and hemicelluloses) and protein content (Sra *et al.*, 2014). Other researchers herewith showed the similar findings in different products as carrot slices by Rahman *et al.*, (2010) in carrot slices, in dried carrot slices by Sra *et al.*, (2014) and dried pumpkin slices Dhiman *et al.*, (2020).

Sensory Evaluation

Data in Table 6 depicted the significant effect on the scores of colour in different drying modes. The mechanically dried slices D_1 recorded the maximum (8.79) score followed by D_2 (8.03) and D_3 (8.00) at 0 day (initial period) of storage. Besides different modes of drying average (mean) maximum (8.15) score was noticed in dried slices of D_1 and minimum in D_3 (7.47). However, the decrease in colour scores being significant throughout the storage but the non-significant value was found in overall effect of both (drying modes and storage interval). The faster drying rate in mechanical cabinet dehydrator (D_1) restricted the browning reaction that led to higher colour score in D_1. Therefore the judges awarded maximum score to D_1 compared to D_2 and D_3 (solar tunnel and solar glass dryer). Similar trend of results for colour scores has also been reported by Madan *et al.,* (2008) in dried tomato halves and Dhiman *et al.,* (2020) in dried pumpkin slices.

A significant decrease in texture scores of persimmon slices of different treatments presented in Table 6. The slices of D_1 (mechanical cabinet dehydrator) exhibited the maximum (7.50) mean score for texture while minimum (6.76) was awarded to D_3 (solar glass dryer) at initial (0) storage day. In different drying modes the average (mean) maximum (7.30) and minimum (6.48) scores for texture was related to D_1 and D_3. The data indicated a decrease in mean score of texture from 7.07 to 6.57 during 6 months of storage. The low moisture content of the persimmon slices dried in mechanical cabinet dehydrator might have resulted in better scores for texture in D_1 (mechanical cabinet dehydrator) compared to D_2 (solar tunnel dryer) and D_3 (solar glass dryer). Similar trend of results of texture scores has been reported by Doymaz (2006) for dried figs and Sra *et al.,* (2014) in dried carrot slices. Upon storage the pectic substances degradation and moisture permeability of packaging material resulted in decrease in texture scores (Sharma *et al.,* 2004). Similar decreasing trend in texture during storage was reported by Sra *et al.,* (2014) and Dhiman *et al.,* (2020) in dried carrot and pumpkin slices.

The data in Table 6 presenting flavor score represented the significant difference among the slices of various drying modes, but overall interaction of drying modes and storage was found to be significant. At 0 day of storage, the highest (8.50) score for flavour had been noted in D_1 (mechanical cabinet dehydrator) while lowest score (7.56) in solar glass drier (D_2). Among different drying modes mean maximum and minimum scores for flavour was found in D_1 (7.94) and D_3 (7.31).

An average decrease in score from 7.97 to 7.18 was recorded while stored up to 6 months. In mechanical cabinet dried slices the highest score for flavor in the product perhaps due to retention chemical constituents such as sugars and acid. Due to oxidation of compounds the decrease in flavour score was observed. In other dried products (tomato halves and slices of pumkin) Madan *et al.,* (2008) and Dhiman *et al.,* (2020) reported similar decreasing in scores of flavour.

The data in Table 6 clearly showed that the mean maximum (8.59) scores for overall acceptability was awarded to the slices dried in mechanical cabinet dehydrator (D_1) and minimum (7.56) in solar glass dryer (D_3) at 0 day. There was significant decrease in overall acceptability scores during 6 months of storage and the decrease was found to be from 7.95 to 7.22. The overall acceptability scores of dried slices were better in D_1 (mechanical cabinet dehydrator) contrasted with solar tunnel and solar glass dryer. A decreasing trend in scores with the advancement of storage might be due to enzymatic and non-enzymatic oxidation process which might have affected the quality of product (Sagar and Kumar, 2009) in dried mango slices. Similar decreasing trend in overall acceptability was noticed by Dhiman *et al.,* (2020) in dried pumpkin slices.

It can be visualized from the results presented in Tables 3 for standardization of technique for drying of persimmon, Tables 4 for chemical characteristics and Table 5 for sensory attributes during storage and after thorough discussion under each headings/parameters that the persimmon fruit is suitable for preparation of dried slices. The product had least changes in different quality (chemical and sensory) attributes during storage (up to 6 months) thereby it can be safely stored up to a period of 6 months. The retention of quality characteristics was observed to be greater in slices dried using mechanical cabinet dryer followed by solar tunnel dried and solar glass dried slices.

Authors Contribution

Samiksha Bisht: Write manuscript, data collection and evaluation and result generate

Dr Anju K Dhiman: Project objectives, guidance, project funding and review and corrections

Mrs. Surekha Attri (SG): Project objectives, guidance, review

Dr Deepika Kathuria: Guidance, Review and Corrections

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Data Availability

Data may be made available on request.

Conflict of Interest

All authors have no conflict of interest.

Abbreviations

FAO (Food and Agriculture Organisation), FAOSTAT (Food and Agriculture Organisation Statistics), MMT (Million Metric Tonnes), i.e. (that is), KMS (Potassium metabisulphite), ALP (Aluminium Laminated Pouch), HDPE (High Density Polyethylene), TSS(Total Soluble Solids), mL (millilitre), cm (centimeter), *et al.*, (co-workers), ºC (Degree Celsius), ºB (Degree Brix), g (gram), h (hour), mg (milligram), mm (millimeter).

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