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Evaluation of antioxidant capacity and bioactive compounds in *Capsicum annum L.* red peppers following drying in a polycarbonate greenhouse

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Abstract

The current study aims to provide insights into the drying of agro products, with a specific focus on *Capsicum annum L.* (red pepper). Among open sun drying (OSD), polyethylene bag drying (PBD), and polycarbonate sheet drying (PCSD), PCSD was efficient requiring around 24 hours with a maximum yield of 350 g of dried product per 1000 g of supplied fresh peppers. The PCSD dried chili also showed greater retention of antioxidant markers (capsaicin and dihydrocapsaicin) than OSD and PBD as evidenced by UV-VIS spectroscopy. Additionally, the PCSD dried chili demonstrated highest antioxidant potential via ABTS (2, 2'-Azinobis-3-Ethylbenzothiazoline-6-Sulfonic Acid). Interestingly, the presence of various aromatic compounds and other chemical groups, indicated the occurrence of capsaicin and dihydrocapsaicin in each drying method used. The study suggests that PCSD sheet drying is an efficient and cost-effective approach that can conserve the antioxidant potential of agro products such as red pepper.

Keywords: Phenolics, Open sun drying (OSD), polyethylene bag drying (PBD), polycarbonate sheet drying (PCSD), 2, 2-Diphenyl-1-picrylhydrazyl (DPPH); 2, 2'-Azinobis-3-Ethylbenzothiazoline-6-Sulfonic Acid (ABTS).

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Introduction

Peppers (*Capsicum annum* L.) of the genus Capsicum are considered to be fruits in different parts of the world and have been consumed in various forms, e.g. raw, dried, cooked, but also fermented. They have become highly valued for their sensory attributes (color, pungency, and flavor [1,2]. Paprika, oleoresin, and dried chilies are three of the most significant processed pepper products that are traded in the international market (both whole and in powder form). Capsicum is enjoyed as food worldwide but additionally, it is also used as a medicinal plant globally because of its stimulant, diaphoretic and rubefacient properties. It is also used to treat depression, cough, asthma, diabetes, and obesity. Peppers have been preferred due to their strong antioxidant and anti-inflammatory properties [3].

Chili peppers have been widely used as an important and rich source of vitamins (A, B, C & E) and antioxidants in the diets of developing nations [4]. Due to higher chilies demand, fresh fruits must be processed to avoid financial losses during storage and transit [5]. To avoid perishing and demand gaps, open sun drying (OSD) of peppers is frequently used, and this practice causes changes like altered texture and color during drying [6]. Most interestingly, the limiting factor is the impact on the physical characteristics and nutritional profile of chilies upon drying [7]. Sun-dried peppers showed reductions in vitamin C, crude protein (CP), phenolics (antioxidants), total soluble sol-

ids and water content [8]. However, greenhouse solar drying is efficient (72 hours) in terms of time duration, as well as in terms of physical and nutritional characteristics retention [9]. Pepper capsaicinoids have excellent antioxidant, and anti-hypertensive properties [10,11]. Capsaicinoids, being antioxidants, relax the vasculature in heart syndrome [12]. Surprisingly, capsaicinoids alter the digestibility of pepper and its fate in the gastrointestinal tract [13]. Therefore, the selection of a suitable drying method is necessary to avoid changes in antioxidants levels of pepper.

Recently, traditional as well as technology-based drying (active, passive solar-hybrid green tunnel or PE (polyethylene, polythene) sheet based-drying) have mainly focused on reducing the dehydration time, and to avoiding changes in physical and capsaicinoid levels [14,15]. Capsaicinoid levels have been considered an indicator of the quality of red pepper [16-18]. Therefore, the current study aimed to compare antioxidant capacities and capsaicinoids retention upon red pepper drying in OSD, polyethylene bag drying (PBD) and polycarbonate sheet (PCSD) tunnel drying, which avoids UV rays).

Materials and Methods

2.1. Materials

Fresh samples of red peppers (*Capsicum annum L.*) were obtained from the local market (Bahawalpur, Pakistan). The samples were weighed accurately before placement in drying assemblies. The PBD and PCSD samples were placed in tunnel as triplicate see Figure 1. However, OSD samples (triplicate) were placed openly on mat in sunlight

2.2. Direct solar drying

Solar drying (under the open atmosphere) was performed using the direct placement of chili samples on wooden bordered net cages of approximately 4*4 ft² in size. The samples were dried directly under the sun and then placed inside once the sunlight duration was over.

2.3. Polyethylene Bag Drying

The samples were placed on a 4*4 ft² wooden bordered iron strainer to maintain proper air exchange for efficient drying. The cage was covered with a PE sheet to direct UV exposure as well as a variable temperature. The polyethylene bag-based tunnel is shown in Figure 1.

2.4. Polycarbonate sheet drying (PCSD)

The polycarbonate sheet instead of a polyethylene bag/cover was used to achieve controlled UV exposure and a temperature control for efficient drying as shown in Figure 2. The polycarbonate sheet width was 0.4 cm. Similarly, polythene carbonate sheet-based tunnel has already been utilized by Deng et al. [19].

2.5. Moisture content and yield (weight) determination

The moisture content of samples was measured at various time intervals (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 24, 30, 36, and 48 hours). The moisture content on a dry basis (Xdb) of both fresh and dehydrated samples was determined gravimetrically by drying them in a vacuum dryer at 70 °C until a constant weight was achieved. This method was adopted from AOAC (1999). The moisture (water) content was calculated using the equation proposed by Rodríguez-Ramírez et al [20].

$$Xdb = (W_0 - W_f) / W_f$$

W_0 stands for the initial weight (mass) and W_f for the final weight (mass).

2.6. Capsaicinoids Extraction

The capsaicin and dihydrocapsaicin collectively called capsaicinoids were obtained by extracting pepper-dried powder (1 g) in acetonitrile (30 ml) at 65°C for 20 min under an inverted vortex mixer (Polymix PX-MFC 90D, Kinematica, Switzerland). The prepared extracts (capsaicinoids) were quantified at 280 nm using a T80, which is a double-beam UV-VIS spectrophotometer made by PG instruments Ltd. (UK) [21].

2.7. Microstructure via optical microscope

The microscopic structure of chili was investigated via an optical microscope. The samples were cross-sectioned via a sharp blade into thin slices that were mounted on slides for visualization under a microscope lens 10x – 40x for proper magnification.

2.8. Antioxidant Assays

2.8.1. Total flavonoid content

The quantity of total flavonoids present in both samples was assessed using the method described by Zhishen et al. [22]. In this method, a 75 mL portion (equivalent to 1.5 mL) of a 5% solution of sodium nitrite was added to the pepper samples (3 mg), followed by 150 L of a 10% solution of aluminum chloride after vortexing for 1 minute. The absorbance of the resulting mixture was measured at 510 nm using a T80 spectrophotometer, and 0.5 mL of 1 mol/L NaOH was added to the mixture prior to measurement. The results were reported in terms of grams (g) of catechin equivalent (CE), which was determined using catechin as a reference standard. Catechins [The term "catechin" refers to a single molecule (CAS no 7295-85-4), while "catechins" refers to a group or class of molecules that have similar chemical structures and properties. catechins are a type of flavonoid. Flavonoids are a large group of natural compounds found in plants that have diverse biological functions, including antioxidant, anti-inflammatory, and anticancer activities. Catechins belong to a subclass of flavonoids called flavanols, which are characterized by a flavan-3-ol structure.] are a type of phenolic compound that can be found in high amounts in various foods, such as tea, cocoa, and berries. These compounds, particularly epigallocatechin-3-gallate (EGCG), are known for their strong antioxidant properties[1].

The studies were run for storage times of 1, 7, and 15 days. All determinations were made in triplicate.

2.8.2. Total phenolics (TP) content

The total phenolic (TP) content was determined using the Folin-Ciocalteu reagent method with slight modifications [23]. To prepare the samples, 3 mg of pepper was mixed with 1 mL of 10% Folin-Ciocalteu reagent and vortexed. Then, 2 mL of a 20% sodium carbonate solution was added to the mixture, which was incubated at 30°C for 60 minutes. The absorbance of the resulting mixture was measured at 760 nm using a T80 spectrophotometer. To recalculate the values of total phenolics, a standard curve of gallic acid in ethanol was used. The results were expressed in micrograms (µg) of gallic acid equivalent (GAE) using the gallic acid standard curve. Each measurement was performed three times, and one, seven, and fifteen days of storage were assessed.

2.8.3. Reducing power

The method outlined by Qureshi and colleagues [24] was used to determine the reducing power (RP) of the pepper extracts from both samples. In this method, 3mg of the sample was mixed with 0.5 mL of potassium ferricyanide ($C_6N_6FeK_3$) and sodium phosphate buffer (0.2 mol/L, pH 6.6). The mixture was then incubated for 20 minutes at 50°C, followed by the addition of 0.5 mL of trichloroacetic acid and vortexing. After centrifuging the mixture at 3,000 g for 10 minutes at room temperature, the clear supernatant was obtained and mixed with 0.15 mL of ferric chloride (0.1 percent). The absorbance of the resulting mixture was measured at 700 nm using a spectrophotometer. The reducing power ability was calculated using a Trolox standard curve and reported as mole Trolox equivalent (mol TE). Trolox is a water-soluble form of vitamin E commonly used as a standard antioxidant for comparison purposes in laboratory studies.

The sample mixture's enhanced absorbance showed increased RP (reducing power). The studies were run for storage times of 1, 7, and 15 days. All determinations were made in triplicate.

2.8.4. 2,2-Diphenyl-1-picrylhydrazylradical scavenging activity (DPPH) assay

To determine the total antioxidant capacity of the pepper, the DPPH assay was used [25]. The pepper extracts (2 ml) were mixed with a 2 mL solution of DPPH (60 µmol/L in 100% ethanol) and vortexed for 1 minute. The mixture was then incubated in the dark at room temperature for 30 minutes, and the absorbance was measured at 517 nm using a T80 spectrophotometer. A control solution prepared with absolute ethanol was used for comparison. The DPPH radical scavenging activity was calculated using a Trolox standard curve and expressed as micrograms (µg) of Trolox equivalent (TE). The study examined storage times of 1, 7, and 15 days, and all measurements were performed in triplicate.

2.8.5. Trolox equivalent antioxidant capacity

To evaluate the Trolox equivalent antioxidant capacity (TEAC) of the materials, the procedure outlined by Qureshi and colleagues [24] was followed. Specifically, 1 mL of pepper extract from each sample was mixed with 4 mL of a reagent solution composed of 0.6 mol/L sulfuric acid, 28 mmol/L sodium phosphate, and 4 mmol/L ammonium molybdate. The mixture was then incubated for 95 minutes at 90°C, followed by measuring the absorbance at 695 nm using a spectrophotometer. The Trolox standard curve was used to compute the TEAC of µg TE. The studies were run for storage times of 1, 7, and 15 days. All determinations were made in triplicate.

2.9. Fourier-transform infrared (FTIR) spectroscopy

The functional groups of capsaicin and dihydrocapsaicin in red pepper that underwent OSD, PBD, and PCSD were determined through the IR spectra of the red pepper powder using Fourier transform infrared spectroscopy (FTIR) (Thermo Fisher Scientific Inc., Nicolet iS10, USA). The pepper powder was mixed with KBr and the resulting pellet was analyzed using FTIR between 500 and 4000 cm^{-1}, with 16 scans at a resolution of 2 cm^{-1}

Statistical analysis

The statistical software package SPSS 18.0 from Chicago, USA, was used to analyze the collected data. In order to present the findings in a comprehensive manner, a one-way analysis of variance (ANOVA) was conducted. The results of the data analysis are presented below.

Results

The PCSD and PBD assemblies have been shown in Figure 1. PCSD and PBD drying assemblies (A). Model of PCSD drying tunnel (B). The results indicate less drying time was required in case of PCSD treated samples. However, for PBD and OSD the time needed for drying was higher (48 hr) with more moisture retention as shown in Figure 2. The cross air flow for PCSD pepper achieved desired moisture level in lesser time. As seen in Figure 2, the moisture content reduced from 65% to 11% after 48 hr stay in cross air flow PCSD assembly as shown in Figure 2.

Interestingly, the PCSD assembly showed a more than 20 degree rise in ambient temperature that correlates with less moisture and drying time compared to OSD and PBD. The possible reason behind temperature rise in PCSD assembly was due to continuous hot air flow, and dehumidified environment that causes faster drying rate. The moisture reduction was rapid till 12 hrs (65 – 28%) in the case of PCSD assembly. However, in the case of OSD and PBD, the reduction in moisture percentage till 12 hr was around 36%. The moisture removal equilibrium in the case of OSD and PBD was achieved till 36 hrs as shown in Figure 1. On the other hand, PCSD showed moisture removal equilibrium at 24 hrs.

As the yield of Capsicum annum L. is concerned, the initial weight after drying was reduced to around 300 g in both OSD and PBD assemblies. However, a maximum yield of around 350g/1000g (dried product: initial product) was achieved with PCSD assembly. Interestingly, after grinding the red chili color was more intense in PCSD assembly dried samples as shown in Figure 3.

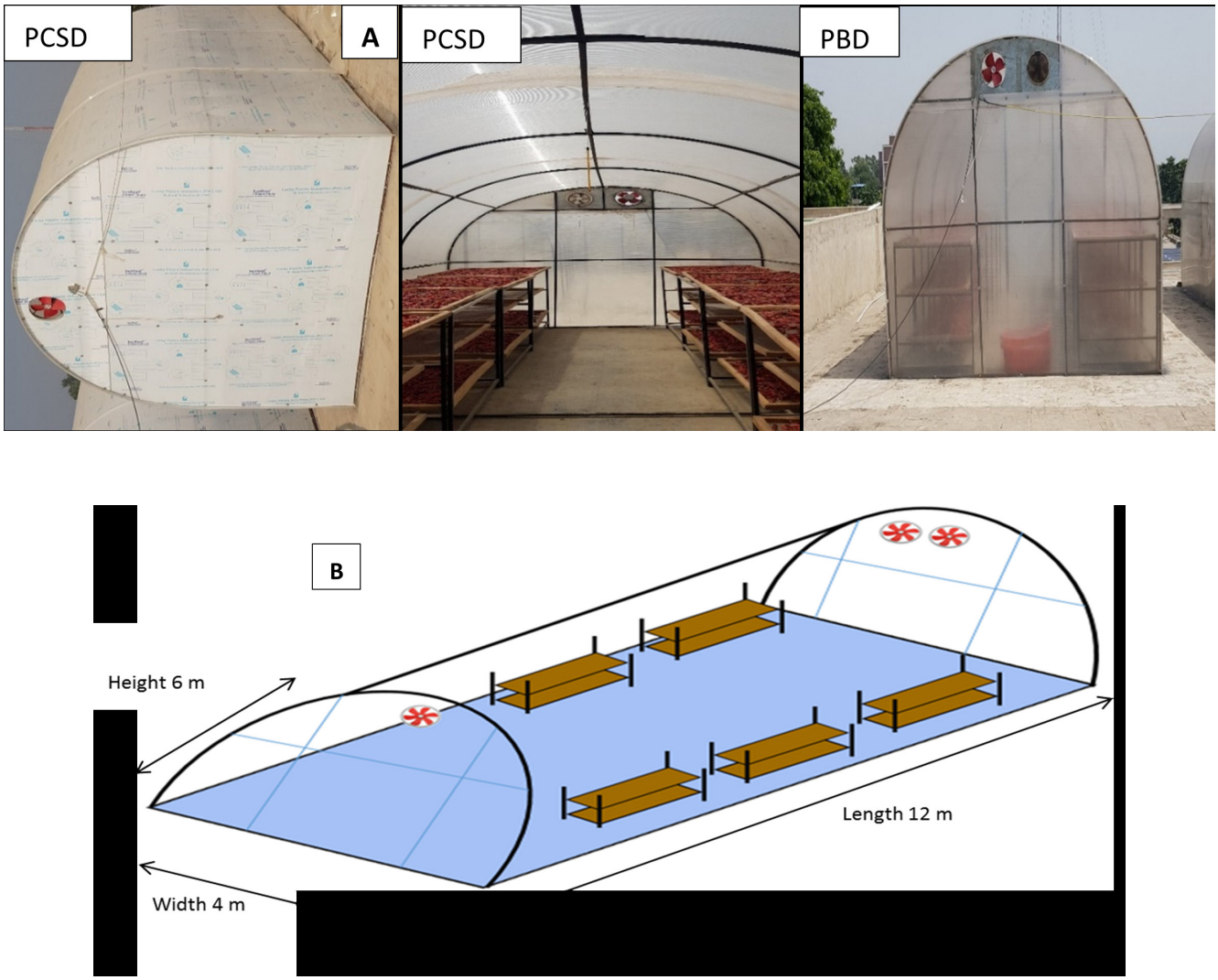


Figure 1. PCSD and PBD drying assemblies (A). Model of PCSD drying tunnel (B).

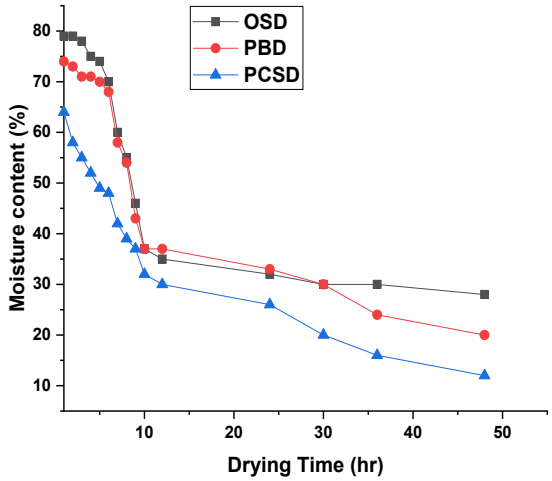


Figure 2. Capsicum annum L. yield after drying vs OSD, PBD, and PCSD.

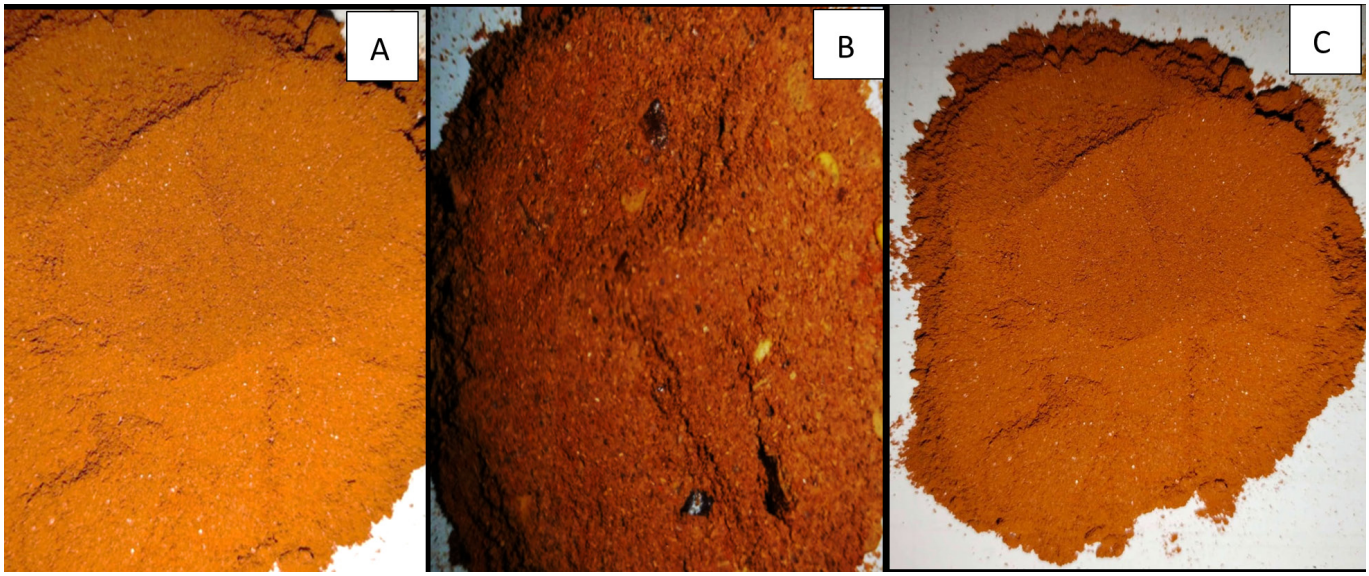


Figure 3. Shows pigment variation upon OSD (A), PBD (B), and PCSD (C) drying of red pepper.

Furthermore, the efficiency of OSD, PBD, and PCSD assemblies was evaluated on behalf of main compounds in red chili i.e, capsaicin, dihydrocapsaicin, and Nordihydrocapsaicin after drying. The three compounds were quantified using UV-VIS spectroscopy at 280 – 350 nm excitation wavelength. The presence of capsaicin, dihydrocapsaicin, and Nordihydrocapsaicin collectively termed capsaicinoids were detected at 280 nm in OSD, PBD and PCSD dried chilies have been presented in Figure 4. The level of capsaicinoids in non-dried green chili was around 0.10 (arbitrary units). In case of OSD red chili, the level was 0.06 on the first day, and on day 15 it remained at 0.055 nm as shown in Figure 4 (arbitrary units, in absorption). On the other hand, PBD red chili also showed similar capsaicinoid levels as appeared in OSD. The maximum capsaicinoids levels were present in PCSD-processed red chili as shown in Figure 4.

To elucidate the mechanism of chili drying via OSD, PBD and PCSD, microscopic examination of dried chilies has been presented in Figure 5. The microstructure shown by OSD (5A) and PBD (5B) dried chili was less porous as observed in cross-section. However, a more porous structure with large sized pores appeared in the PCSD chili cross-section (Figure 5C).

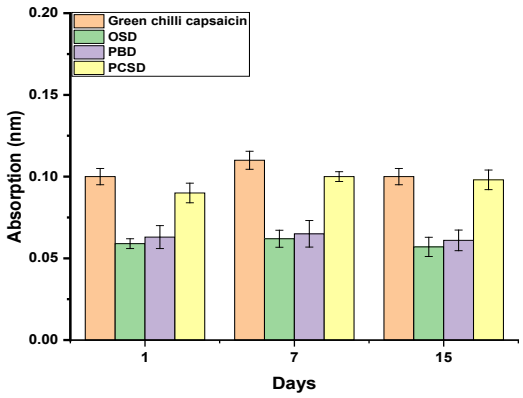


Figure 4. Levels of capsaicinoids in control, OSD, PBD, and PCSD dried red chili quantified at 280 nm via UV-VIS spectroscopy. A high absorption is correlated to a high concentration.

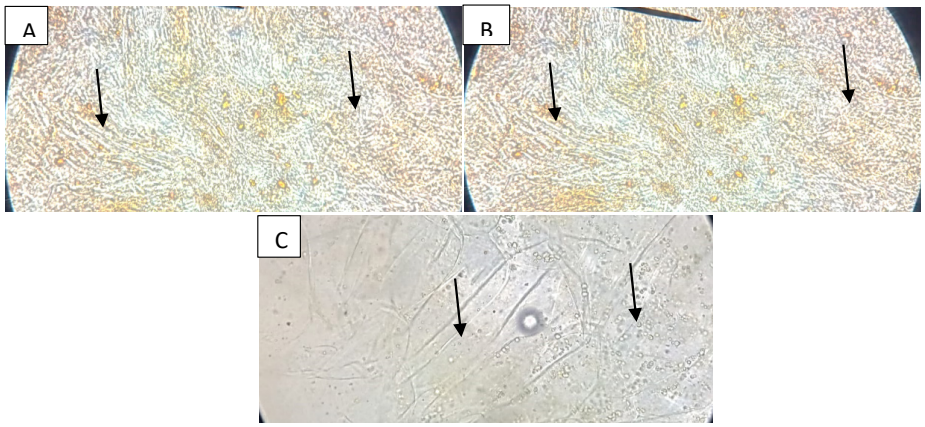


Figure 5. Porosity examination of Capsicum annum L. dried via open sun drying (OSD), Polyethylene bag drying (PBD) and Polycarbonate sheet drying (PCSD)

The antioxidant capacity of dried chilies processed via different drying methods OSD, PBD, and PCSD has been evaluated using the following assays: 2,2'-Azinobis-3-Ethylbenzothiazoline-6-Sulfonic Acid (ABTS), 2,2-Diphenyl-1-picrylhydrazyl (DPPH), reducing power, total flavonoids, and total phenolics as shown in Table 1. The antioxidant capacity of OSD dried chili was lower in all assays as shown in Table 1. The antioxidant capacity of chili obtained via ABTS was 350.01±0.261 mg/g that further reduced to 331.10±0.20 mg/g after 15 days of storage. ABTS showed a maximum antioxidant capacity of PCSD (1091.33±1.24 mg/g) and PBD chili samples (550.73±0.524 mg/g). The increased ABTS values reflected high pigmented and hydrophilic antioxidants compared to other assays. A similar increasing trend of antioxidant capacity was observed in all PCSD chili samples analyzed by DPPH (520±0.40 mg/g), Reducing power (170±0.11 mg/g), total flavonoids (579±0.12 mg/g), and total phenolics (373.25±1.21 mg/g).

Fourier transform infrared spectroscopy (FTIR) was done to evaluate the chemical composition of red chili after OSD, PBD, and PCSD drying. FTIR is useful to judge the presence and confirmation of chemical compounds. The method of drying normally affects the composition of red chilies and this FTIR approach will be helpful to select the suitable drying technique on behalf of the presence of several functional groups. The FTIR spectra of OSD, PBD, and PCSD red chili sample has been shown in Figure. 6.

OSD red chili have been presented in Figure 6B. The peaks 3535, 3261, and 3222 wave numbers (cm-1) showed the O-H stretch indicating aromatic compounds, and 2900 cm^{-1} represents the O-H stretch due to carboxylic acid. The peaks at 2307 and 2152 cm^{-1} indicated the presence of C=O ester bonds, while 1957 and 1675 cm^{-1} confirmed the presence of N-H bond as amines. Additionally, the presence of alkanes (C-H) and C-N aliphatic amines were shown at 1500.62 and 1350.75 cm^{-1}, respectively. These functional groups collectively confirmed the presence of capsaicin and dihydrocapsaicin in the PBD dried sample. The only difference in OSD and PBD dried peppers was the slightly lower peak intensities of C=O. In comparison, the functional groups indicating the presence of capsaicin and dihydrocapsaicin were present in OSD and PBD dried chilies, but their peak intensities were higher in PCSD dried chilies, as shown in Figure 6C. Similar results were reported by Nitin et al. (2019) who found changes in the chemical composition of red chili upon solar hybrid greenhouse active and passive drying. They confirmed the presence of O-H stretch, O-H carboxylic acid, N-H amines, C=O esters, and C-N aliphatic amines, which are indicative of capsaicin and dihydrocapsaicin.

Discussion

Water removal of agricultural produce is a demanding process to keep the final goods available to consumers throughout the year. Drying kinetics for any dried product is of immense importance to justify the yield of final dry mass. Recently, Pochont et al. [26] reported chili drying in a hybrid green-house dryer, and the drying time required was around 24 hrs compared to OSD. These results were in accordance to the findings of current study. In our case, OSD moisture removal equilibrium was achieved earlier compared to PBD and PCSD. The possible reason behind this difference is the direct exposure of sunlight that caused quick release of moisture. This is the reason that PBD and PCSD had higher yield after drying due to slower moisture removal equilibrium.

Interestingly, microstructure also favored the mechanism of quick drying in PCSD tunnel. It has been a well-established fact that the cellular orientation of agro products correlates to drying time and antioxidant potential [27]. The porosity reported in our study was well correlated to the findings of Deng et al. [19] who reported a more porous and great number of pores in cellular morphology of chili upon hybrid green solar drying.

The total flavonoid content of chili was more in PCSD than in OSD and PBD as presented by Table 1. The total flavonoid contents decreased with a storage period of 1, 7, and 15 days. Total flavonoids of chili in PCSD were higher on day 1 (579±0.12 mg/g) that reduced to (515±0.11 mg/g) catechin

Table 1. Effect of drying OSD, PBD and PCSD on total antioxidant potential, total phenolics, Reducing power, DPPH antioxidant capacity, and total phenolics of *Capsicum annum L.* Values have been presented as mean ± standard deviation (SD).

Samples	Days	ABTS Total antioxidant potential (mg/g) ascorbic acid equivalent	DPPH (mg/g) equivalent of ascorbic acid	Reducing Power (mg equivalent of ascorbic acid/g)	Total Flavonoids (mg/g) equivalent to Quercetin	Total Phenolics (mg/g) of folin equivalent
OSD	1	350.01±0.261 [a]	407±0.01 [a]	135.67±0.001[a]	471±0.12 [a]	254.75±0.11 [a]
OSD	7	340.11±0.417 [a]	392±0.32 [a]	120.1±0.01 [a]	465±0.21 [a]	220±0.10 [b]
OSD	15	331.10±0.20 [b]	380±0.11 [b]	108±0.12[b]	445±0.20 [a]	202.1±0.21 [c]
PBD	1	550.73±0.524 [a]	462±0.2 [a]	157.33±0.12 [a]	490±0.01 [a]	303.5±0.21 [a]
PBD	7	490±0.01 [a]	303.5±0.21 [a]	145±0.001 [a]	479±0.12 [a]	270.1±0.42 [b]
PBD	7	534.33±3.29 [a]	449±0.22 [a]	145±0.001 [a]	479±0.12 [a]	270.1±0.42 [b]
PBD	15	500±0.81 [b]	415±0.23 [b]	122±0.11 [b]	460±0.15 [b]	225.01±0.01 [c]
PCSD	1	1091.33±1.24 [a]	520±0.40 [a]	170±0.11 [a]	579±0.12 [a]	373.25±1.21 [a]
PCSD	7	1042.66±2.05 [b]	501±0.12 [a]	162±0.01 [a]	560±0.01 [a]	240.2±0.22 [b]
PCSD	15	969.6±1.24 [c]	490±0.22 [b]	96.2±0.21 [b]	515±0.11 [b]	213.1±0.1 [c]

Data has been presented as Mean±S.D.

When the total phenolic content of a sample is measured using the Folin-Ciocalteu assay, the result is expressed in terms of "Folin equivalent", which is the amount of phenolic compounds in the sample that can react with the Folin-Ciocalteu reagent to form blue-colored complexes. The result is usually reported in milligrams (mg) of gallic acid equivalent (GAE) or catechin equivalent (CE) per gram (g) of sample, which are reference standards commonly used for comparison purposes in phenolic content analyses.

equivalent/g) after 15 days. A variation of all the antioxidant assays with storage period were shown in Table 1. There is a great tendency for smokers and drinkers to have more flavonoids enriched food in daily consumption that could help in longevity. The results were in accordance with Zahoor et al. [28,29] who observed similar flavonoid contents in chilies.

Total phenolic content of PCSD was higher on day 1 (373.25±1.21 mg folin equivalent/g) that reached to 43% lower value (213.1±0.1 mg folin equivalent/g) on day 15. In case of OSD, total phenolics on day 1 (254.75±0.11 mg folin equivalent/g) were 21% higher than on day 15 (202.1±0.21 mg folin equivalent/g) as provided by Table 1. Of all three OSD, PBD, and PCSD samples, the antioxidant capacity was reduced over storage time. Similarly, the reduced antioxidant potential is linked to oxidative degradation of polyphenols to reactive ortho-quinone and autocatalytic products of phenolics, and the hydrolysis of conjugate structures are the possible reasons behind this reduced antioxidant capacities. Similar reduced levels of total phenolic content during storage have been reported earlier [30,31].

The reducing power of PCSD was higher on the 1st day (170±0.11 mg) which was reduced to 96.2±0.21 mg after 15 days during storage. However, in OSD chili powder the reducing power level was 135.67±0.001 mg as given in Table 1. Reducing power levels of PCSD were higher compared to

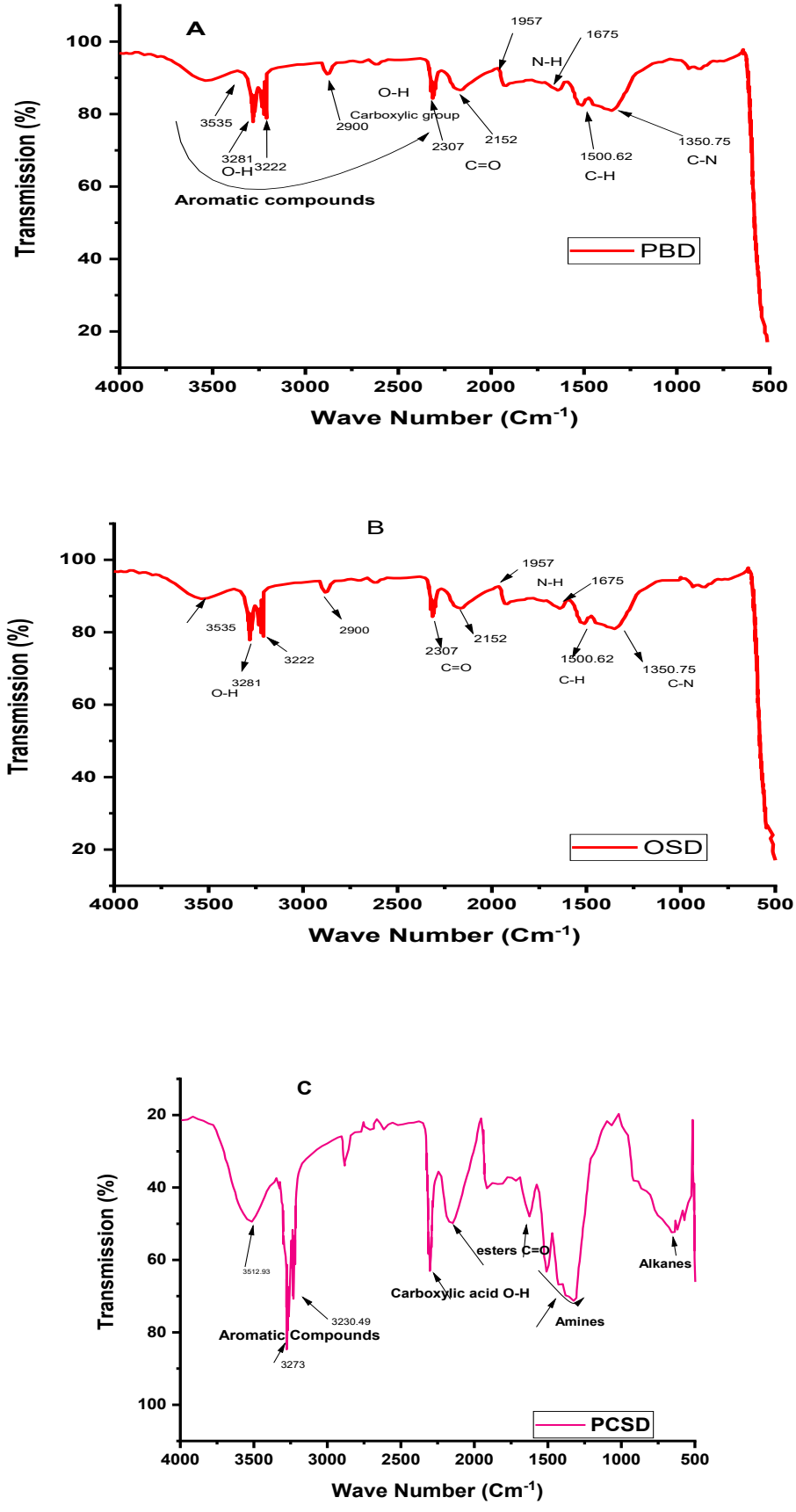


Figure 6. FTIR spectroscopy of Capsicum annum L. upon drying with PBD (A), OSD (B) and PCSD (C)

OSD and PBD. Reducing power as representative of antioxidant capacity also showed decreasing trend during the storage of chilies. [32-35]. ABTS and DPPH assay confirmed the antioxidant activity of PCSD was doubled (1091.33±1.24 mg/g ascorbic acid equivalent mg/g) than other antioxidant indicators (Table 1). The better antioxidant capacity assayed by ABTS has also been reported in for fruits, vegetables and fruits [37]. The PCSD showed excellent antioxidant potential in all chili samples compared to other dried chilies. DPPH and ABTS levels were in similar trend as reported earlier [25,36].

Peppers drying results in variation of capsaicinoids that caused burning sensation upon interaction with mucous membrane [19]. The main compounds of red peppers capsaicin and dihydrocapsaicin responsible for burning sensation are alkanes, C=O, N-H, C=C, aromatic, and vanillyl groups. The above mentioned compounds showed sharp peaks in PCSD dried chilies compared to OSD and PBD dried chilies. This suggests more antioxidant compounds retention upon PCSD drying of red peppers. On the other hand, the quantification of capsaicinoids in PCSD dried pepper was highest compared to OSD and PBD. Finally, the functional groups alkanes, C=O, N-H, C=C, aromatic, and vanillyl responsible for capsaicin and dihydrocapsaicin were characterized via FTIR. In our case, OSD showed the presence of all above mentioned functional compounds but the peaks were not sharp. However, in the case of PCSD dried chili powder all capsaicin and dihydrocapsaicin linked functional groups showed sharp peaks in FTIR spectra. Similar, findings of sharp peaks in active solar hybrid green dried red chilies have been reported.

Conclusion

The drying of agro products is demanding currently. The drying of red pepper in a PCSD tunnel having active air exhaust resulted in drying time of 24 h having 350g/1000g yield (where the yield is defined as g of finished, dried product per 1000g of supplied fresh, water-bearing biomass). However, in case of OSD and PBD, the drying time and yield were less which suggests the superior performance of PCSD assembly. More interestingly, PCSD drying conserved quality attributes of red chili powder like capsaicinoids responsible for pungency. Moreover, PCSD retained higher levels of capsaicin and dihydrocapsaicin functional groups compared to OSD and PBD dried red chili powder. A recent study has proved PCSD is a suitable method to achieve a better yield, efficient drying, and retention of antioxidant potential of chilies as powder.

Author Contributions

Asad Rehman: Conception of idea and experiment planning, Afshan Shafi: Execution of experiments, Usman Majeed: Data acquisition, Hamid Majeed and Tahir Mahmood Qureshi: Literature search and proof reading; Irfan Baboo, Muhammad Shabaz and Zahid Manzoor: Literature gathering and write up of manuscript; Muhammad Mazhar Munir and Iqra Saif, Rizwana Sultan, Maximilian Lackner: Data interpretation and experiment execution, Daniel Kallinger, Ali Değirmencioğlu, Maximilian Lackner; Overall formatting and technical proof reading of manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

Data Availability

Data will be available on demand.

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