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The Efficacy of Two Drying Techniques on the Bioactive Composition and Antioxidant

Iyad A. M. Alzaeem [1*] ; Khadir E. K. Abdelhakam [2]

[1,] Institute for Research and Studies of the Islamic World, Department of Applied Sciences, Sudan
[2] Faculty of Agriculture, Omdurman Islamic University, Sudan
*Corresponding Author: i.zaeem@ucst.edu.ps

Abstract:

Antioxidant is a substrate that stops molecules inside a cell from oxidizing. During the biological oxidation reaction, free radicals created; Also, it have the ability to stop a chain reaction by removing the free radical intermediate. The aim of the study was conducted to estimate the impact of two drying methods on phytochemical constituents of the Prickly pear fruit (Opuntia ficus indica, L.). Methods: In this work, the effects of oven-drying and freeze-drying methods have been studied in Special Units Departments - National Research Center (Cairo) in august 2021 on the chemical composition, total phenolic (TP) content material, total flavonoids (TF) content material, total betalain content, betacyanin, and betaxanthin and antioxidant capacity of Prickly pear fruit pulp. Results: The oven-dried samples demonstrated a decrease in the bioactive content (TP & TF) and a lower antioxidant capacity (DPPH, FARAP & CUPRAP), in comparison to the fresh samples. The pleasant antioxidant capacity and the bioactive content (TP & TF) values were obtained through freeze-drying. The findings of the present study reported that the freeze-drying method is appropriate for drying prickly pear fruits fruit pulp. Subsequently, this work found that freeze-drying can enhance the general nice of the dried Prickly pear fruit pulp in terms of bioactive content material and antioxidant capability; and freeze-drying additionally had outcomes that were nearly similar to those of the fresh samples. Conclusion: These research findings can probably applied to agricultural commodities, supporting the year-spherical food delivery and decreasing components waste.

Keywords: Prickly Pear Fruits, Drying Techniques, Antioxidants, Food Technology.

I. Introduction

Fruit-eating has recently emerged as a near-term necessity due to its high nutrient content, and it is now regarded as a significant slice of the dietary system of humans (L. M. R. da Silva et al., 2014). About 30% of most tropical fruits are loosed during the post-harvest stage, and these losses are very excessive, resulting in their products being highly perishable. These fruits losses may be decreased if the fruits were processed into a range of products (de Sousa et al., 2010). In this regard, food scientists have been concentrating their efforts on improving contemporary processing methods that preserve the bioactivity and availability of particular elements, as well as the nutritional and sensory qualities of these fruits (El-Mostafa et al., 2014). Antioxidants are thought to have a key role in managing and mitigating oxidative damage in foods and biomolecules, hence extending shelf life and improving product quality while also protecting biological systems (Altaher et al., 2022). This can be accomplished by preventing or delaying the oxidation process caused by reactive oxygen species (ROS) (Duthie, Ma, Ross, & Collins, 1996). Prickly pear fruit (PPF) is rich in nutritive values including minerals, ascorbic acid, phenolic substances, amino acids, and antioxidants. Additionally, it has a high-quality rule on health due to the richness of high antioxidant activity and phenolic materials (Çakmak et al., 2020). Because of its antioxidant activity, phenol content, and ascorbic acid content, PPF has essential functional effects (Sumaya-Martínez et al., 2011). Antioxidants in PPF display anti-inflammation effects, anticancer, hypocholesterolemic, hypoglycemic, and hypolipidemic effects (Bensadón, Hervert-Hernández, Sáyago-Ayerdi, & Goñi, 2010). The antioxidant activity of this fruit was shown to be 2-fold higher than that of tomato, apple, pear, and grape. However, it was discovered to be comparable to orange, red grape raisin, and grapefruit (Livrea & Tesoriere, 2006). PPF is typically consumed fresh between July and October of each year. Food technologists have also developed ways to extend the shelf life of fruits due to rising market demand for health-promoting foods (Cefola, Renna, & Pace, 2014). However, its consumption may be low due to technical problems related to production (Cassano, Conidi, & Drioli, 2010). PPF is considered an amazing source for coloring non-acid foods. This may be referred to the fact that their betalains are in a particular stable in the range of pH 4 to 7, and the presence of both betacyanins and betaxanthins results in a wide color range (Esatbeyoglu, Wagner, Schini-Kerth, & Rimbach, 2015). Many researchers in recent years have said that bioactive elements in PPF are a source of nutrition, health promotions (Esatbeyoglu et al., 2015). PPF processing has been limited, because it is a low-acid fruit (pH > 4.5) with high soluble-solids content, making it sensitive to microbial decomposition and having a short shelf life (Sáenz & Sepúlveda, 2001). Fruit processing solutions that maintain microbiological and nutritional integrity during preservation are needed. However, depending on the type of drying method utilized, maintaining bioactivity can be difficult due to the significant losses of these substances. Therefore, the main objective of this research was to find the best drying process for preserving the bioactive content of prickly pear fruits. Although drying fruits have numerous advantages, it could bring about a reduction in antioxidant capacity, vitamin degradation, and undesirable modifications in coloration, flavor, and texture of the fresh product (Fijalkowska, Nowacka, Wiktor, Sledz, & Witrowa-Rajchert, 2016). Freeze-drying is one of the best drying methods based on water removal by sublimation and is used to obtain several industrial products (Santo, de Lima, Torres, de Oliveira, & Ponsano, 2013). It is also an excellent approach for drying materials containing heat-sensitive antioxidant substances, and it improves the foodstuffs by reducing microbial proliferation and inhibitive lipid oxidation. Freeze-dried products are thought to have the same qualities as fresh ones. Although numerous previous articles deal with the drying of fruits products, there are few that deal with the chemical properties of the trace content in PPF pulp. To our knowledge, no study has been published to far that evaluates the influence of freeze and oven drying on the quality and stability of PPF fruits grown in Palestine. The study's second goal was to see how freeze- and oven-drying processes affected the PPF fruit's chemical properties, phenolic and flavonoid components, and antioxidant capacity.

II. Materials and Methods

The chemical and nutritional content of PPF fruit was analyzed. The analysis included moisture, ash contents, crude fiber, crude fats, nitrogen-free extract (NFE), and crude protein. In addition, evaluate the antioxidant capacity and bioactive contents.

II.1. Preparation of samples for the study:

For this study, the whole fresh 60 fruits with a maturation level were selected from freshly harvested fruits. To eliminate microorganisms, fruits were washed with distilled water, disinfected using 10% sodium hypochlorite solution, manually peeled; and the pulp of selected fruits was divided into two parts. Where the first one sliced into 1 and 1.5 cm thickness pieces and placed in aluminum trays (14 cm) that kept at −20°C for at least 24 hours until oven drying technique. The remaining portions chopped into 1 x 1 cm pieces, placed in 14 cm aluminum trays, frozen in liquid nitrogen, and kept at -80°C. Frozen nopal (200 g) was freeze-dried and stored at -20°C using a Labconco Free zone 4.5 freeze-dry system (Labconco, Kansas City, MO, USA) with a condenser temperature of -55°C and a vacuum pressure of 7 Par. The final freeze-dried pulp samples filled into polyethylene bags and glass containers and kept in a refrigerator at 4±1^{o}C until analysis. For the extraction procedure, the pulps pressed by hand. 5gram of squeezed pulps added to 50 ml of 50% methanol for each fruit sample and extracted for 24 hours at room temperature with magnetic stirring. The supernatant filtered through a cotton plug followed by 0.45 µm microbiological filters after centrifugation at 4500 g for 10 minutes. The extract then kept at 4 °C in a dark bottle for further study.

II.2. Chemicals and Reagents

All of the reagents and chemicals used in this work were analytical grade.

Item	Supplier
Copper (II) chloride dehydrate, Ammonium acetate, Sodium nitrate, Neocuproine, Sodium acetate trihydrate, Iron (III) Chloride, Sodium carbonate, Potassium Persulfate, Aluminum chloride, Gallic acid, Sodium hydroxide, Rutin stander	AppliChem- Germany
2,2-diphenyl-1-picrylhydrazyl (DPPH)	Biological Industries- Germany
6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (Trolox)	
Folin-Ciocalteu reagent	
FRAP reagent	
Methanol	Sigma Aldrich - USA
Hydrochloric	
De-ionized water	Prepared in the lab

II.3. Proximate analysis

Total protein (Method-950.48), moisture (Method-925.09), ash (Method-930.05) and fat (Method-983.23) were all measured using AOAC Official procedures (AOAC, 2005).

II.4. Determination of total phenolic contents (TPC)

To determine total phenolic content (TPC) the Folin-Ciocalteau method (Bendhifi Zarroug, Baraket, Zourgui, Souid, & Salhi Hannachi, 2015) was applied. In Brief, the methanolic extracts (100 µl) mixed with 900 µl of Folin-Ciocalteu reagent (diluted 1:10 with water). After 5 min, 7% sodium bicarbonate solution (0.75ml) was added to the mixture and vortexed for 30 s. The aforesaid solution was then maintained at room temperature for 90 minutes. The absorbance of the solution was read by spectrophotometer (Sica type) at 765 nm. As compared to a gallic acid calibration curve, the TPC was reported as gallic acid equivalents (GAE). All readings were expressed as the mean of three replications (mg of gallic acid equivalents/100 g of fresh weight) ± standard error (SE).

II.5. Determination of total flavonoid content (TFC)

The generation of complex flavonoid-aluminium complexes was used to determine the flavonoid concentration in the pulp methanolic extracts using spectrophotometry (Djeridane et al., 2006). 1 ml of pulp extract was mixed with 1 ml of 2 % aluminium chloride solution (w/v). After a 15-minute incubation period at room temperature, the absorbance of the reaction mixtures was quantified at 430 nm against a blank. The standard utilized to create the calibration curve was rutin. All measurements were repeated for three times and the results were represented as rutin equivalents (mg RE/100 g dry fresh weight).

II.6. Betalainscontents (TBC)

Determination of Betalains was done using the colorimetric method of Stintzing et al., (2005). In a nutshell, a 250 mg sample of pulp was mixed with 1 mL of distilled water and homogenized for 5 minutes in an ultrasonic bath. The extracts were then centrifuged at 13,000g for 5 minutes at 4 °C (Eppendorf AG Centrifuge 5417R), and the supernatant was diluted with water (1:1 v/v). Betaxanthins and betacyanins content were measured in milligrams of equivalent per 100g of prickly pear Deionised water. The betacyanins and betaxanthins were measured at 535 and 483 nm respectively and then calculated according to the Sumaya-Martínez equation (Sumaya-Martínez et al., 2011). Betaxanthins or betacyanins content (Mg/L) = DF x A x MW x 100 / (E x B).

II.7. Determination of DPPH (2, 2'-diphenyl-1- picrylhydrazyl) radical-scavenging activity (DPPH)

The DPPH capacity of PPF pulp was assessed using an adapted, diphenylpicrylhydrazyl free radical scavenging method and absorbance estimated at 515 nm, with concentrations represented as micromolar of Trolox equivalents (MTE; dry weight) (Thaipong, Boonprakob, Crosby, Cisneros-Zevallos, & Hawkins Byrne, 2006)**.**

II.8. Cupric Ion Antioxidant Reducing Capacity (CUPRAC)

The CUPRAC of PP fruit pulp extracts were assessed based on the Apak team method (Apak, Güçlü, Özyürek, & Karademir, 2004). Absorbance was measured at 450 nm and expressed as micromolar of Trolox equivalents (µMTE; dry weight) (Thaipong et al., 2006)**.**

II.9. Determination of Ferric reducing power Antioxidant Activity (FRAP)

The FRAP assay was carried out using the method described by (Benzie & Strain, 1999). Every 200 ml of the test tube extract received an aliquot of 3.0 mL of FRAP reagent. The mixture was stored at 37 °C in the dark. Absorbance was read at 593 nm after 30 minutes. Micromole Trolox Equivalent per gram fresh weight (mol TE/g FW) was used to calculate the recoded values.

II.10. Statistical Analysis

The gathered data were analyzed using the Social Sciences Statistical Package (SPSS vr.16) (Version 16.0). Using the Analysis of Variance, the statistically significant difference between fresh and freeze-dried fruits according to antioxidant compounds and capacity was determined at p 0.05 and p 0.01.

III. Results and Discussion

III. 1. Chemical attributes of prickly pear fruit (PPF)

The chemical composition of the various OFI fruit parts indicated variation in content between fruit part types (skin, pulp, and seeds). The chemical composition parameters are listed in Table 1. Pulp and skin recorded a higher amount of water (90.32 and 88.57%, respectively) than the seeds (17.77%). These results were in the same trend as those obtained in previous studies **(**Saenz-Hernandez, 1995& Salim et al., 2009**).** On the other hand protein content in the seeds was higher than that of the pulp and the skin (3.75, 0.13 & 0.18%; respectively). Same observation was made for lipids, crude fiber, nitrogen-free extract, ash and total carbohydrates; where the seeds have a greater amount (2.89, 39.89, 30.76, 9.72 & 70.65% for these parameters; respectively) than the pulp (0.07, 0.12, 9.3, 0.06& 9.42%) or skin (0.13, 0.54, 9.88, 0.37 & 10.42%) for the same parameters, respectively. Results obtained by Salim et al., (2009) showed a high amount of water in the pulp (84.14%) and skin (90.33%) and PPF is a remarkable fruit and this may encourage its consumption. On the other hand, our results were inconsistent with those obtained by (Marwa, El-Masry, Gomaa, & Awad, 2020)**,** and they found that the fruits contained a high amount of ash and carbohydrates in peels than in seeds. However, they observed that the protein and the fat contents were considerably high in fruit seeds than in fruit pulp or skin.

Table 1: ***Chemical Composition of (OFI) fruit (%, w/w, fresh weight).***

Item	%, Chemical Composition		
	Pulp	Skin	Seed
Moisture content	90.32±3.14**	88.57±6.15**	17.77±3.12
Dry Matter %	9.68±1.02	11.10±2.10	82.23±10.50**
Organic Matter %	9.62±0.89	10.77±1.25	77.19±9.98**
Protein% (N × 6.25)	0.13±0.003	0.18±0.005	3.75±0.05*
Crude Fats %	0.07±0.001	0.13±0.001*	2.89±0.01*
Crude Fiber %	0.12±0.003	0.54±0.047*	39.89±3.15**
Nitrogen Free Extract %	9.30±0.84	9.88±1.02	30.76±5.44*
Ash %	0.06±0.002	0.37±0.005*	9.72±1.56**
Carbohydrates %	9.42±0.06	10.42±1.07	70.65±3.53**

Notes: All values are means of 3 replicates ± SE; * indicates statistically significant difference (*p < 0.05; **p < 0.01)

III. 2. Efficacy of dry method on Chemical attributes of (OFI) fruit pulp.

Other than the moisture content, ash, and crude fiber; there are no significant differences in the rest of the measurements shown in Table 2. Across the two methods of drying, the average value of moisture content removed from PPF pulp was between 87.7 ± 1.79 and 89.21 ± 0.13% (Table 2). This suggests that the freeze-dryer caused more moisture loss than oven drying. A previous study by (Nobel & De la Barrera, 2003) indicated that the moisture content of PPF pulp is needed for the plant's metabolism, and the lipid-based skin is thought to operate as a water-preserving barrier, limiting moisture loss. As reported in previous studies by (de Torres, Díaz-Maroto, Hermosín-Gutiérrez, & Pérez-Coello, 2010) and (Reyes et al., 2011), freeze-drying or oven drying at the degree of temperature lower than 50 °C and for short times, were have been recommended. They found that the Freeze-drying technique minimizes the effect on nutritional values of foodstuffs and ensures the retention of physicochemical properties. They also found that the use of freeze-drying for moisture removal was more effective compared to other drying methods.

Table 2: the efficacy of freeze-drying and oven drying on the chemical composition of PPF pulp (%, W/W).

Item	%, Chemical Composition		
	Fresh	Oven-dried	Freeze-dried
Moisture content	90.32±1.55	3.25±0.15**	1.11±0.01^{**++}
Dry Matter %	9.68±0.42	96.75±4.12**	98.89±3.44**
Organic Matter %	9.62±0.88	91.65±3.8**	94.53±5.12**
Protein % (N × 6.25)	0.13±0.002	1.38±0.11*	1.39±0.06*
Crude Fats %	0.07±0.005	0.72±0.009*	0.70±0.01*
Crude Fiber %	0.12±0.005	1.26±0.003*	3.72±0.26^{**++}
Ash %	0.06±0.001	0.59±0.003*	4.36±0.15^{**++}
Carbohydrates %	9.42±0.76	89.35±3.18**	92.44±5.03**

Notes: All values are means of 3 replicates ± SE; * indicates statistically significant difference (*p < 0.05; **p < 0.01) when compared to fresh PPF pulp; $^{+}$ indicates a statistical significant difference (+p < 0.05; ++p < 0.01) between oven dried and freeze dried samples.

III. 3. Antioxidant capacity and bioactive content

The methodology used to analyze the bioactive components allowed the two active forms to be quantified: TPC and TFC. Meanwhile, the antioxidant capacity study approach allowed for the assessment of three active forms: Free Radical Scavenging Activity (DPPH), Cupric Ion Antioxidant Reducing Capacity (CUPRAC), and Antioxidant Capacity by Ferric Reducing Antioxidant Power (FRAP). The antioxidant activity and bioactive components of analyzed samples are presented in Table 3.

III. 3.1. Efficacy of drying method on TPC) & (TFC) of PPF pulp.

Data presented in Table 3, clearly indicate a statistically significant difference ($p < 0.05$) in values of TPC and TFC of fresh and dried PPF pulp, belonging to the two drying methods. The freeze-drying method of PPF pulp exhibited about 77.56 ± 8.4 mg GAE/100gm fresh weight (FW) for TPC whereas the TFC was estimated to 26.81 ± 11.4 mg GAE/100gm FW for the same sample. As shown in Table 3, the TPC in the freeze-drying method was significantly higher (77.56± 8.4 mg GAE/100gm) GAE/100gm) than those reported by Medina et al., (2007)**,** who found that TPC was

45.2 ± 7.4 mg GAE/100gm. The impact of the drying method on the TPC of fruits has been investigated. The drying process was reported to induce a drop in TPC by certain researchers (MERAL, 2017; Zanoelo, Cardozo-Filho, & Cardozo-Junior, 2006), meanwhile, the study conducted by Carranza-Concha et al., (2012) indicated that the drying process increased TPC and this increase may be due that heat treatment converts some phenolic compounds and some are released to medium. In this respect, it can be said that the drying method does not have the same effect on the TPC of different products (Miletić et al., 2013). The previous study by (Ivanov Ivan; et al., 2014) has shown that the content of phenols in fruit extracts affects the activity of antioxidants. The significant-close link between total phenols and antioxidant power have been reported in some studies (Katalinic, Milos, Kulisic, & Jukic, 2006; E. M. Silva, Souza, Rogez, Rees, & Larondelle, 2007) and this correlation between TPC and antioxidant activity has been explained by Rice et al., 1996 study who mentioned that phenolic compounds have significant free radical scavenging properties because of their reactivity as hydrogen or electron-donating agents and metal ion chelating characteristics (Rice-Evans, Miller, & Paganga, 1996). Concerning the effect of different drying methods on the TFC of PPF pulp, the results in Table 3 clearly show that the drying method had a significant effect on the TFC, as the recorded values were 39.88µg/g CE FW & 18.05 µg/g CE FW; for the oven and freeze-drying method, respectively. The results of (Kamiloglu et al., 2016) indicate that some phenolic and flavonoid components may be destroyed or reduced by heat treatment, and the flavonoids content of fruits and vegetables may be changed by different preservation procedures such as drying. Data presented in Table 3 indicate that our study may support this hypothesis. In a study by Hahm et al., (2014), they found that TFC in PPF was 1.91±0.29 mg QE/g DM. TFC may decrease as a result of some interactions in the structure of fresh vegetables and fruits that are subjected to preservation techniques such as freezing or drying (Kamiloglu et al., 2016). Generally, TPC and TFC levels in fresh and frozen PPF pulp were higher than those in oven-dried fruits in this research. These findings may support the hypothesis that freezing is the optimal strategy for preserving PPF.

Table (3): Effect of drying methods (Freeze-dried oven-dried), on TPC & TFC of OFI fruit pulp.

Parameters	**Fresh Sample (Control)**	**Drying method**	
		Freeze-dried	Oven-dried
TPC	103.05± 7.11	77.56± 8.4^{*+}	26.81± 11.4**
TFC	56.32± 3.48	39.88± 5.1^{*+}	18.05± 1.7*

Notes: All values are means of 3 replicates ± SE; * indicates statistical significant difference (*p < 0.05; **p < 0.01) when compared to fresh PPF pulp; $^{+}$ indicates statistical significant difference (+p < 0.05; ++p < 0.01) between oven dried and freeze dried samples; TPC: Total Phenolic Content (mg/100g GAE, FW); TFC: Total Flavonoid Content (mg/100g RE, FW).

III. 3.2. Efficacy of drying method on betalains content (BC) of PPF pulp.

When considering the investigated bioactive contents (Total betalains content, and Betacyanin and Betaxanthin; Table 4) significant differences ($p < 0.05$) were observed between means, in comparisons between the two methods of drying. The freeze-drying method of PPF fruit pulp recorded about (1.07, 3.19 & 4.26 mg /100gm FW; for BE, IE, TBC: respectively) whereas for the oven-dried method these values were: 0.07, 1.27 & 1.35 mg /100gm FW; for BE, IE, TBC: respectively. However, when these values were compared to that of the fresh PPF pulp, out-of oven-dried method, no significant differences ($p > 0.05$) in values were found for the freeze-dried method. This means that the larger betalains loss was observed using oven-drying than freeze-dryer. Betalains include both compounds betacyanins and betaxanthins. Of the numerous natural sources

of betalain, red beet and prickly pear are the only foods containing this class of compounds (Kanner, Harel, & Granit, 2001).

Table (4): The efficacy of drying methods (Freeze-dried oven dried), on total betalain content of PPF pulp.

Parameters	Fresh Sample (Control)	Drying method	
		Freeze dried	Oven dried
BE content	1.11± 0.02	1.07± 0.09	0.07± 0.01*+
IE content	3.24± 0.06	3.19±0.15	1.27± 0.28*+
TBC content	4.89± 0.03	4.26± 0.18	1.35± 0.29*+

Notes: All values are means of 3 replicates ± SE; * indicates statistical significant difference (*p < 0.05) when compared to fresh PPF pulp; + indicates a statistical significant difference (+p < 0.05 < 0.01) between oven dried and freeze dried samples; BE: Total Betacyanins Content (mgBE/100 g); IE: Total Betaxanthin Content (mgIE/100 g); TBC: Total Betalains Content (mg/100 g)..

III. 3.3. Efficacy of drying method on antioxidant capacity of PPF pulp.

III.3.3.1. The DPPH Radical Scavenging Activity.

Data represented in Table 5 indicate there were significant (p < 0.05) differences in free radical scavenging activity between fresh, freeze-dried, and oven-dried PPF pulp. The DPPH scavenging activity for freeze-dried samples was significantly (p < 0.05) higher (249.80± 20.6) than that of the oven-dried sample (75.21± 7.2). The scavenging activity of PPF fruit extract on DPPH radicals were demonstrated also by Fernández-López et al., (2010).

Table (5): Effect of drying methods (Freeze-dried& oven-dried), on antioxidant activity of OFI fruit pulp.

Parameters	Fresh Sample (Control)	Drying method	
		Freeze-dried	Oven-dried
DPPH	318.00± 11.7	249.80± 20.6	75.21± 7.2*+
CUPRAC	1005.80± 36.1	973.52± 87.1	553.15± 16.6*+
FARAP	510.12± 13.5	413.47± 17.1	200.57± 10.1*+

Notes: All values are means of 3 replicates ± SE; * indicates statistically significant difference (*p < 0.05) when compared to fresh PPF pulp; + indicates statistically significant difference (+p < 0.05 < 0.01) between oven-dried and freeze-dried samples; DPPH: Free Radical Scavenging Activity (μMTE); CUPRAC: Cupric Ion Antioxidant Reducing Capacity (μMTE); FRAP: Antioxidant Capacity by Ferric Reducing Antioxidant Power (μMTE).

III.3.3.2. Cupric Ion Antioxidant Reducing Capacity (CUPRAC).

The CUPRAC analysis of the three various tested OFI fruit pulp indicated variation in values between types: fresh, freeze-dried, and oven-dried (Table 5). The mean values of CUPRAC were 1005, 973& 553μM_{TE} for fresh, freeze-dried & oven-dried samples; respectively. Here were no significant differences (p > 0.05) in values between fresh and freeze-dried samples. Meanwhile, the values were significant differences (p < 0.05) in comparison between the two different drying methods (973.52± 87.1 &553.15± 16.6; for freeze-drying and oven-drying; respectively). Reducers work by breaking the free radical chain by donating a hydrogen atom, converting free radicals to more stable molecules and so reducing oxidative damage (Subhashini, Thangathirupathi, & Lavanya, 2011; Yıldırım et al., 2000).

III.3.3.3. FARAP assay.

The FRAP assay determines a compound's overall reducing capacity by determining its ability to decrease the Fe3+/tri pyridyl triazine complex to its blue-colored ferrous state. Table 5 depicts the reducing power of PPF pulp. Our results showed that the fresh PPF pulp exhibited the higher FRAP value of 510.12± 13.5µmol TE/g FW compared to the two drying techniques used in this study (Table 5). Also, the values of the freeze-dried PPF pulp exhibited higher FRAP values (413.47± 17.1µmol TE/g FW) compared to that of the oven-dried samples (200.57± 10.1 µmol TE/g FW) and there was a significant ($p < 0.05$) difference between means. There was no significant change in FRAP rates between the fresh and freeze-dried Samples ($p > 0.05$). The obtained results from Table 5 indicate that the two drying methods used in this study had the same effect of both DPPH assay and FRAP assay.

The FRAP method was developed to be better suited for evaluating the antioxidant activity of water and lipid-soluble components in a study done by (Duh, Du, & Yen, 1999)

The products with higher levels of specific antioxidant or bioactive content were assumed to have a better chance of preserving nutritional or bioactive value. The drying method that produced products with the greatest amount of certain bioactive or antioxidant activity was thought to be a better method, which could explain why the contents of PPF pulp processed by oven drying rather than freeze-drying were lower in this study. Heat, on the other hand, may release more unwanted content by breaking down more complex compounds or boosting availability through cellular structure damage (Kamiloglu & Capanoglu, 2013)

Conclusion

In this study, we have examined the efficacy of two drying methods on the chemical composition, bioactive contents (TP, TFC, TBC, BE, and IE) and antioxidant capacity (DPPH, FARAP & CUPRAC) of PPF pulp. Freeze drying had the best results for the antioxidant capacity values and bioactive contents as the values were the closest to the values of the fresh sample. Overall, this study indicated that freeze-drying can improve the overall quality of the dried PPF pulp samples in terms of bioactive content and antioxidant capacity; and freeze-drying also had results that were close to that of the fresh samples. Finally, in considering the results that are available on this study at present, we recommend freeze-drying method for drying PPF pulp.

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Disclosure statement

The authors reported no potential conflict of interest.

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