International Journal of Innovative Approaches in Agricultural Research
2018, Vol. 2 (4), 327-334
https://doi.org/10.29329/ijiaar.2018.174.6

Original article

Effect of Different Drying Techniques on Some Functional Properties of Dried Fig[1]

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Abstract

Fig as one of the major export products of Turkey, deteriorates very quickly due to its perishable nature. For this reason it is utilized as dried fruit. In traditional drying method of figs, it was observed that there are some problems caused by climate, especially due to rainfall during drying season,thus, quality losses occur. With this project fresh figs were dried at two different humidity levels in both the sun and the cabinet type dryer using different immersion solutions at 2015 to 2017. Additionally, ¼ cut fruits was dried in both methods without using solutions. According to the sensory analysis results, ¼ cut fruits take the highest score while the second was dried figs without using immersion solutions. The immersion solutions were effective in reducing the drying time of the figs but due to the adverse taste effect of alkali ethyl oleate solution, it was not preferred. In the ¼-cut fruits the total phenolic content and antioxidant activity identified as 343.30 (mgGA / 100 g DM) and 259.32 (μM trolox / 100 g DM), respectively, and this application gives better results compared to others. In this study where fresh figs are dried, aflatoxin analysis was performed on all products and it was not detected in any of the samples.

Keywords: Fig, Drying methods, Total phenolic content.

Received: 29 August 2018 * **Accepted**: 11 November 2018 * **DOI**: https://doi.org/10.29329/ijiaar.2018.174.6

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[1] A part of this study was presented at the International Agricultural, Biological and Life Science Conference, Edirne, Turkey, September 2-5, 2018.

INTRODUCTION

The average production of fresh figs in Turkey is almost 300 thousand tons per year which corresponds to 26-28% of the world production. At 2017, 305.689 tons of fresh fig production was carried out in Turkey. Worldwide dried fig production is 107.000 tons and 80.000-tons of this amount is provided by Turkey in 2016, which with the export of 82% of our total production 253 million $ in revenue. (Arpacı, 2017).

Nowadays, environmental pollution, stress and unhealthy food consumption results the occurrence of various diseases in human. Instead of healing these diseases, the consumption of functional foods as a precaution to prevent their occurrence is an increasing trend. Besides, the relationship between safe food and healthy life is understood more clearly following the increase in educational, knowledge and revenue levels of the consumers. Dried fruits contain higher polyphenols and antioxidants levels compared to those of the fresh ones. Drying procedures used in dried fruit leads to a decrease in polyphenol in terms of dry weight basis. Dried figs and dates have very high antioxidant capacity compared to C and E vitamins. Fig antioxidants can enrich lipoproteins in plasma and protect them from subsequent oxidation. Figs significantly increase the antioxidant capacity in plasma for 4 hours after consumption and overcome the oxidative stress caused by carbonated drinks with high fructose corn syrup (Vinson et al., 2005).

Fig as one of the major export products of our country deteriorates very quickly due to its perishable nature. For this reason it is utilized as dried fruit. Dried figs are harvested by picking the ripen and partially dried fruits on the ground which have fallen spontaneously after a natural ripening stage. Then the partially dried fruits with 30-50% moisture content are spread under the sun in wooden or plastic trays for drying process. Although solar drying is economical, it has adverse effects such as the fruit's exposure to pests and unwanted contaminants like soil and dust, the interruption and time extension of drying in rain and extreme wind conditions and also susceptible to fungal infections occurring due to the high sugar content. The aim of this study was to find the effects of dip solutions and different drying techniques to the functional product content of figs during the drying of fresh figs.

Material and Methods

Plant Material and Drying System

The standard dried figs variety "Sarilop" in Fig Research Institute collection garden was subject to this study. Electrical cabinet type dryer and drying trays with plastic and porous structure of 70 * 90cm size for conventional solar drying were used during the drying process.

Pre-treatment and Drying Conditions

Two different dip solutions were used to provide faster drying; one of which was a potash solution (water containing 5% K_2CO_3 and 0.5% olive oil) and the other solution was alkali ethyl oleate (water containing 5% K_2CO_3 and 2% ethyl oleate). In the cabinet type dryer and under the sun,some of the fruits were dried by dip in potash and alkali ethyl oleate solution while the control group and ¼-cut fruit were dried without using dip solution. Fruits to be dried as whole were placed in 2 kg amounts per tray, while the others were cut in ¼ longitudinal with knife and placed in trays. In the cabinet type dryer, drying temperature was gradually increased to 60 °C and drying air velocity was settled to 1 m/s whereas in sun drying system, the figs placed on the plastic trays and spread under the sun.

Physical Analysis

- Moisture Content (%): % moisture was measured with Dried Fruit Analysis (DFA) device in dried fig samples passed through the mincing machine. 80-100g of pureed sample was placed to the device and the maximum conductivity value that the device assessed was determined. This value were converted from the conversion table of the device to the % moisture content.
- Total Soluble Solid (%): Pureed samples were diluted 4 times and measured by refractometer.

Chemical Analysis

Two step extraction process was applied. In the first step dissolved hydrophilic antioxidant compounds(aqueous extracts) and in the second step lipophilic compounds(ethanolic extracts) were extracted. The sum of these two values represents the total amount of antioxidants. These extracts were used in both analyses.

The extraction by homogenization of a 20 g dry fig sample with 60 mL of cold water (4 °C) or a 100g fresh fig sample in a Waring blender for 2 min. 2g homogenate with 12 mL of additional cold water. The slurry obtained was then further homogenized in a disperser-homogenizer (IKA-T 18, Brasil) at 18,000 rpm for 2 min and centrifuged at 4600 x g at 4 ºC for 20 min. The fatty layer at the top of the supernatant was discarded and the supernatant and pellet were collected. The supernatant aqueous extracts were collected, filtered and kept in an ice water bath until it was assayed for antioxidant activity and phenolic content. Mean while the pellet was suspended in 12 mL ethanol (96%) and homogenized in the disperser–homogenizer at 18,000 rpm for 4 min. The extract was then clarified by centrifugation at 4600 x g at 4 °C for 15 min. This extract ethanolic extracts was kept in an ice-water bath until it was assayed for antioxidant activity and phenolic content (Demirbüker et al, 2005).

Total Phenolic Content

The total phenolic content of the fig extracts was spectrophotometrically measured according to the Folin-Ciocalteu procedure of Singleton and Rossi (1965) using Folin-Ciocalteu as reactive reagent and gallic acid as standard. The results were expressed as mg gallic acid equivalents/100 g fresh weight of fig. The total phenolic contents of figs were determined by finding the sum of phenolic contents for aqueous and ethanolic extracts.

Total Antioxidant Activity

The antioxidant activity of the fig extract was determined spectrophotometrically according to the method of Re et al. (1999) as trolox equivalents by monitoring ABTS free radical cation decolorization caused by test samples at 734 nm. The results were calculated as the area under the curve (AUC) and expressed as µmol Trolox/100 g fresh weight of fig fruits. The total antioxidant activity of figs was determined by finding the sum of AUC values for aqueous and ethanolic extracts.

Statistical Analysis

Data analysis was done with the analysis of variance. Significant differences among means were determined by the least significant difference (LSD) with a significance level of 0.05.

Results

Some Physical and Chemical Analysis and Drying Times of Fruits

The effects of drying methods and dip solutions on some physical / chemical properties of the dried fruit samples are investigated in Table 1.

Table 1. The affect of drying methods and pre-treatment applications on drying time and physical / chemical properties of fruits

Drying Methods	**Pre-treatment Applications**	***Drying Time (hour)***	***Moisture (%)***	***TSS (%)***
Sun Drying	Control	*168*	*22.9±0.7*	*65.9±1.2*
	Potash solution	*141*	*20.1±0.4*	*66.4±1.8*
	Alkali ethyl oleate solution	*138*	*24.6±0.3*	*64.4±0.01*
	¼ cut fruit	*90*	*14.4±0.2*	*72.1±0.2*
Cabinet Drying	Control	*43*	*24.1±0.7*	*62.3±0.2*
	Potash solution	*43*	*22.7±0.4*	*61.7±0.2*
	Alkali ethyl oleate solution	*36*	*25.6±0.7*	*67.2±0.01*
	¼ cut fruit	*24*	*13.7±0.7*	*77.6±0.01*

±: Standard deviation

Considering in terms of drying time, its seen that cabinet type dryer shortens drying time of fruits (Table 1). The pre-treatment applications (dip solutions) for whole fruits were also shorten drying times compared to the control group, especially alkali ethyl oleate solution is effective in both drying methods on reducing this time. ¼ cut fruits were dried faster in each drying method.

The moisture content of the whole dried fruit varies between 20% and 25% whereas it is reduced to 13-14% for a more crisp structure in ¼-cut fruit. According to TSS values, highest values 77.60 and 72.13 were determined in ¼-cut fruits dried in cabinet dryer and under the sun significantly.

Total Phenolic Content and Antioxidant Activity

The effects of different drying methods and pre-treatment applications on total phenolic content and antioxidant activity of products were investigated and the results are given in Table 2. Since the moisture contents of the samples are different, the bioactive component of the samples were given on dry weight (DW) basis. According to Table 2, the effects of drying methods and pre-treatment applications on total phenolic content and antioxidant activity was found significant in terms of statistics. The highest total phenolic content value 356.16 mgGA/100g DW are determined in ¼-cut fruits dried in cabinet dryer while lowest value 187.23 mgGA/100g DW are determined in figs which applied with alkali ethyl oleate solution and dried in cabinet dryer. In terms of total antioxidant activity, highest value 261 µmol trolox/100g DW are determined in ¼ cut figs dried in cabinet dryer whereas lowest value 165.99 µmol trolox /100g DW are determined in figs which applied with alkali ethyl oleate solution and dried under the sun.

Table 2. The affect of drying methods and pre-treatment applications on total phenolic content and antioxidant activity of dried fruits

Drying Methods	**Pre-treatment Applications**	**Total Phenolic Content (mg GA / 100g DW)**	**Antioxidant Activity (µmol trolox/100g DW)**
Sun Drying	Control	272.86 cd	231.05 a
	Potash solution	289.40 bcd	259.56 a
	Alkali ethyl oleate solution	309.60 bc	165.99 b
	¼ cut fruit	330.43 ab	257.63 a
Cabinet Drying	Control	222.69 ef	238.92 a
	Potash solution	250.59 de	178.51 b
	Alkali ethyl oleate solution	187.23 f	187.75 b
	¼ cut fruit	356.16 a	261.00 a
Drying*Pretreatment	*P*	*0.0020*	*0.0141*
	Std Deviation	*15.344*	*11.871*

a-b: Values with different letters in the columns are significantly different ($p < 0.05$)

Discussion

Drying Time

The pre-treatment applications (dip solutions) for whole fruits were also shorten drying times compared to the control group, especially alkali ethyl oleate solution is effective in both drying methods on reducing this time. In a study carried out in Italy, they were applied pre-treatments to some fig types and dried in cabinet dryer to shorten the drying time of figs. (Piga et al., 2004). The drying time of control group figs is 54 hours, while 3% potassium metabisulphite application decreases the drying time of figs up to 33 hours (Piga et al.,2004). In a study where the effects of different dip solutions on drying time of grapes were investigated, alkali ethyl oleate and potassium carbonate (potash) solutions were applied. It is stated that dip solutions shorten the drying time compared to control group. The drying time of figs at 60 ° C was 20.5 hours with alkali ethyl oleate, 22 hours with potash solution and 48 hours in the control group significantly (Doymaz ve Pala, 2002). The use of dip solutions and cabinet type dryers shortened the drying time of figs and the results are consistent with the literature. In both drying methods, ¼ cut fruits has the shortest drying time.

Some Physical/Chemical Properties of the Product

The moisture content of the samples varied from 13.7 to 25.6% in dry products (Table 1). The moisture content of Sarılop variety fruits dried in the study was below the maximum moisture value of 26% stated in Turkish Standarts Institution 541 dried fig standard (TSE 541, 2006).

Total Phenolic Content and Antioxidant Activity Values

The effects of drying methods on total phenolic content was found significant in terms of statistics whereas the effects of sun drying and cabinet type dryers on antioxidant activity is not significant. Konak et al. (2017) reported that oven dryers and sun drying do not differ in terms of total phenolic content and antioxidant capacity in 3 different fig types. Slatnar et al (2011) stated that drying in cabin type dryers are more effective in protecting the total phenolic content and antioxidant capacity in dry figs compared to drying under the sun. The difference in literatures may occur due to factors such as sample types and sampling time.

Considering in terms of different pre-treatment applications, the total phenolic content and antioxidant activity of ¼ cut fruits takes the first place with 343.30-259.32 values respectively. After drying process, ¼ cut figs phenol content was higher compared to whole figs. This can be explained with drying time. ¼ cut figs dried faster than whole figs thus, thermal effects on phenols and deterioration of phenols was less than the whole figs in ¼ cut figs (Table 1). Vega-Galvez et al. (2012) carried out a study on apples and reported similar results on phenolic contents of apple slices which dried at 80 oC and 1,5 m/s air velocity due to less destruction of phenols. In a study, figs were dried in cabin type dryer both whole and slices at 2 different temperatures. The highest total phenolic content was reported in sliced dried fruits (Tan, 2017). The results are consistent with Vega-Galvez et al. (2012) and Tan (2017). While there are many literatures that alkaline ethyl oleate and potash applications shorten the drying time, no literature has been found in terms of phenolic content or antioxidant capacity.

Conclusions

In this study, the possibility of drying of fresh figs was investigated in cabinet type dryer and under controlled conditions. Dip solutions was effective in shortening the drying time of figs. It was determined that the total phenolic content and antioxidant activity of ¼ cut fruits were 343.30 (mgGA/100g DW) and 259.32 (µM trolox/100g DW) respectively and better preserved than the other applications.

Acknowledgement: The authors gratefully acknowledge the Ministry of Agriculture And Forestry General Directorate of Agricultural Research And Policies and all authors and referees for their contributions.

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