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A REVIEW OF THE IMPACT OF FOOD PROCESSING DRYING ON ANTIOXIDANTS CONTENT OF FIGS

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ABSTRACT

Various techniques for processing fruits, including drying, dehydration, irrigation and canning, have the potential to affect the composition of their nutrients, particularly micronutrients and phytochemicals, as well as their antioxidant content. *Ficus Carica L.*, commonly known as the fig tree, grows extensively in the Mediterranean region. Prior research has indicated that this fruit serves as a plentiful reservoir of polyphenolic compounds. Drying is one of the practices popular for preserving figs and lengthening their shelf life; however, it can lead to the loss of nutrients, especially antioxidants and polyphenol compounds. This review focuses on the effect of drying on the antioxidant content of figs compared to fresh figs.

Key words: Figs, antioxidant content, polyphenolic compounds

INTRODUCTION

According to Sethi (2007), food processing is believed to have a long history and is connected to early human life. This processing ranges from basic dietary preparations like cooking or smoking food through sun drying and salt-based preservation. According to Heldman and Hartel (1997), food processing is the practice of turning uncooked plant or animal resources, such as cereals, vegetables, and meats, into food sources by putting them through a sequence of steps that result in products that are safe for consumption.

Fruit processing techniques, such as drying, dehydration, irrigation, and canning, have been shown to affect nutrient components, particularly micronutrients and other phytochemicals, and contaminate the antioxidants in these foods, according to Nayak et al. (2013). Pham-Huy et al. (2008) discussed the nutritional significance of antioxidants that are important for a healthy diet, such as vitamins E and C, beta-carotene, lycopene, omega-3 and omega-6 fatty acids, as well as other antioxidants, especially those found in natural sources. Race (2009) mentioned the high antioxidant content of several foods, including fruits, vegetables, seeds, and nuts.

This review aims to explore the effects of a type of food processing, namely drying, on the amount of antioxidants in fruits in general and figs in particular. Figs are a particularly rich source of antioxidants (Viuda-Martos et al., 2015). The evaluation acknowledges the value of antioxidants for a healthy lifestyle, particularly in reducing the risk of cancer and other diseases. The review is divided into four main sections: food processing, antioxidant content of dried fruit, figs, and antioxidants.

Food processing

Food processing seeks to increase nutritional content, preserve food, and extend food's shelf life. Enhancing a food's texture, colour, or other characteristics can be another goal (Heldman and Hartel, 1997). According to Smith and Hui (2004), the primary motivation behind the development of food processing, which dates back to prehistory, was to prevent food from rotting. Simple methods were employed, such as seasoning meat with salt, churning milk into yogurt or cheese, and pickling vegetables.

When pasteurization was developed during the Industrial Revolution, as mentioned by Heldman and Hartel (1997), it was a crucial factor in prolonging the shelf life of goods like milk and fruit juices. Because it increases the amount of time that food may be consumed, preservation is probably the most significant rationale for food processing. Foods that keep fresh for a longer amount of time make distribution and shipping easier for businesses and allow shops to sell food items for longer periods of time (Heldman and Harte, 1997; Halweil, 2002). According to Rickman et al. (2007), food preparation, such as freezing or canning, might assist certain items, such fruits and vegetables, keep some of their nutritional content after being harvested.

Antioxidants

According to German (1999), antioxidants are chemicals with the capacity to stop oxidation processes in various food types, particularly lipids and fats. According to their sources, antioxidants can be split into two main categories, as mentioned by Kumar (2011). Firstly, tocopherol, carotenoids, and certain polyphenols are examples of enzyme antioxidants that dissolve in fat while those that dissolve in water are polyphenols and ascorbic acid, respectively. The second category is synthetic antioxidants, which are thought to be superior than antioxidants derived from natural sources. Chemical compounds that are commonly used as synthetic antioxidants are those that the Food and Drug Administration (FDA) has deemed safe to add to food. Three such substances are tertiary butylated hydroxy quinone (TVHQ), butylated hydroxy toluene (BHT), and butylated hydroxy anisole (BHA).

Antioxidants' function is to reduce the harm that free radicals do to cells. An atom or collection of atoms having an excess of electrons is referred to as a free radical. Chronic illnesses like diabetes mellitus and chronic renal failure are made worse by free radicals (Koppenol, 2000; Young and Woodside, 2001). According to Greer and Woodward (2000; Pham-Huy et al., 2008), antioxidants have the power to protect cells from free radicals by balancing out the excess free electrons within them. This shields the cells from the toxic effects that could eventually cause cancer and chronic diseases like diabetes and cardiovascular diseases.

Fruit drying and antioxidant content

The effects of a particular food processing method, drying, on the antioxidant content of various fruits are covered in this section. The majority of research on processing fruits and vegetables has been on how different drying techniques affect phytochemical retention. Different drying techniques, including basic drying, vacuum microwave drying, freeze drying, air drying, and the combination of vacuum microwave drying and air drying, were compared by Kwok et al. in 2004. They came to the conclusion that these approaches preserved antioxidants while lowering the total phenolic levels of berries in contrast to berries in their fresh or frozen states. However, a second study (Leusink et al., 2010) discovered that freeze drying outperformed vacuum microwave drying in terms of preserving the antioxidants in berries.

Figs

The widely cultivated common fig tree (*Ficus Carica* L.) bears an edible fruit known as a syconium that is packed with tiny seeds. The fruit can range in colour from green to violet-black when completely developed, depending on the species. This is as a result of the peel's variable anthocyanin content (Li and Wang, 2020). Figs, common figs, and edible figs are all terms used to describe the fruits of the common fig tree. They have been grown for food for a very long time and are thought to be very dietary-healthy. As a result of human migration, the fig has been grown in tens of thousands of different kinds, the majority of which are unknown (Flaishman, Rodov, and Stover, 2008). The *Ficus Carica* L. genus contains more than 800 different species, most of which are cultivated in warm, arid regions like the Middle East and the Mediterranean (Ouchemoukh et al., 2012; Meziant et al., 2015; Harzallah et al., 2016).

Mission, Brown Turkey, Kadota, Bursa Siyahi, Sarilop, and Sarizeybek are the most significant fig cultivars (Crisosto, Bremer, Ferguson, and Crisosto, 2010; Yemis, Bakkalbas, and Artk, 2012). One million kilograms of figs were produced worldwide in 2011 (Viuda-Martos et al., 2015; Maghsoudlou, Kenari, and Amiri, 2017), with the Mediterranean region producing

76% of the total crop. Turkey contributed 20 to 30% of the global production followed by Egypt, Morocco, Iran, Algeria and Greece (Viuda-Martos et al., 2015; Maghsoudlou, Kenari, and Amiri, 2017). The peel of the fig, which can be eaten whole or peeled, is rich in polyphenols and adds to the fruit is nutritional worth (Pereira et al., 2017).

Figs are collected for fresh consumption when they are fully mature and have their finest organoleptic characteristics (Pereira et al., 2017). Fresh figs, however, are extremely prone to physical deterioration and post-harvest infections (Liu et al., 2020). Figs can also be dried or candied in order to extend their shelf life by lowering their water content (Yemis et al., 2012). Additionally, drying significantly reduces their bulk and weight, which lowers the cost of packing and shipment (Yemis et al., 2012). Additionally, figs are typically dried so that they can be sold widely outside of the fresh fig season. Figs are consumed all across the world as a result of drying. Like many other plant-based foods, figs are low in fat (0.30 g/100 g fresh and 0.9 g/100 g dried), high in fibre (9.8 g/100 g dry), and free of salt and cholesterol (Vinson, 1999). Both fresh and dried figs contain high levels of polyphenols, antioxidants, vitamins (thiamine, riboflavin, and vitamin K), minerals (iron, calcium, potassium, copper, manganese, and magnesium), and at least 17 amino acids (Vinson, 1999; Vinson et al., 2005; Solomon et al., 2006; Ouchemoukh et al., 2012; Viuda-Martos et al., 2015).

Phenolic acids, flavonoids, and carotenoids are the primary phytochemicals present in both fresh and dried figs. Additionally, hydroxybenzoic acids and hydroxycinnamic acids, two subtypes of phenolic acids, are also present. The basic structure of hydroxybenzoic acids is identical to that of benzoic acids, but each benzene ring has one or more hydroxyl groups. The C6-C3 structure, which is present in hydroxycinnamic acids, consists of a three-carbon chain joined to an aromatic ring (Robbins, 2003; Shahidi and Ambigaipalan, 2015). Alkaloids, flavonoids, coumarins, saponins, and terpenes have also been found to be present in the aqueous extract of the mature dried fruit of Ficus Carica L. (Gilani et al., 2008). According to research on the phytochemistry of figs (Ross et al., 2002; Gilani et al., 2008; Jeong, Kim, and Cha, 2009), figs are an abundant source of flavonoids, polyphenols, and a wide range of other chemicals, including arabinose, b-amyrin, b-carotenoids, glycosides, and b-sitosterols.

Flavonoids (flavan-3-oles, anthocyanins, and other flavanol glycosides) and phenolic acids (hydroxycinnamic and hydroxybenzoic acids) make up the majority of polyphenols (Hssaini et al., 2021). According to Karantzi et al. (2002), the primary anthocyanins found in fig peels are cyanidin-3-o-glucoside, cyanidin-3-o-ruteneside, cyanidin-3, 5-diglucoside, and pelargonidin-3-o-glucoside. These anthocyanins make up the main class of water-soluble pigments that give figs their distinctive colour. The Spanish fig cultivar contains a lot of anthocyanins, about 100 mg/100 g, according to Vallejo et al. (2012). The idea of consuming the entire ripe fruit rather than just the flesh is supported by the presence of polyphenols in the peel. Following automated examination (using UV-visible spectroscopy, high-performance liquid chromatography (HPLC), and mass spectrometry (MS)), sample preparation—which includes pre-treatments and polyphenol extraction is followed by characterization and quantification (Vallejo et al., 2012).

According to Kamiloglu and Capanoglu (2015), air drying, and sun drying are the two most popular methods for drying figs. These methods can lower the product's moisture content to a range of 20–26%, prolonging its shelf life by up to a year. As opposed to their fresh counterparts, it has been found that traditional techniques of drying figs have a negative impact on their physical, sensory, nutritional, and microbiological features (Kamiloglu and Capanoglu, 2015; Omolola et al., 2017). Compared to sun drying, air drying is characterized by faster drying times. The use of high temperatures in this method causes greater losses in the composition of natural antioxidant molecules (Kamiloglu et al., 2015). The phytochemical components present in both fresh and dried figs, as well as their precise amounts of phenolic compounds and carotenoids, have generated inconsistent results in the scientific literature to date (Arvaniti et al., 2019).

According to several studies (Slatnar et al., 2011; Nakilcioglu and Hisil 2013; Konak et al., 2017), dried figs contain higher quantities of these chemicals than fresh figs do. Previous studies (Yemis et al., 2012; Kamiloglu and Capanoglu, 2015; Bachir Bey et al., 2016) have shown that the drying techniques utilized result in a loss of phytochemicals. Recent studies by Slatnar et al. (2011), Yemis et al. (2012), Kamiloglu and Capanoglu (2015), and Bachir Bey et al. (2016) investigated the effects of oven drying and sun drying on the primary antioxidant compounds present in figs, and these results were compared with those obtained from fresh figs. When Yemis et al. (2012) looked at how traditional drying methods affected the chemical makeup of specific carotenoids in Turkish yellow fig cultivars, the findings showed that sun drying caused the carotenoids to decrease. After drying in direct sunshine for seven days, almost 80% of the carotenoids started to degrade.

According to Kamiloglu et al. (2015), among the chemicals examined, β-cryptoxanthin was found to be the most stable component, and the oxidisability of carotenoids was blamed for the decline in their concentration during the drying processes. The impact of sun drying on 22 phenolic components in three different cultivars of dark figs cultivated in Algeria was examined by Bachir Bey et al. in 2016. According to their findings, when dried in the sun for seven days at an average temperature of 27.8 °C, the quantities of phenolic components, notably phenolic acids and flavonoids, reduced by 29% and 86%, respectively.

In order to assess the effects of the drying procedure on the synthesis of Total Phenolic (TP), Total Flavonoid (TF), Total Anthocyanin (TA), and particular phenolic compounds in two varieties of Turkish figs, Kamiloglu and Capanoglu (2015) utilized sun drying.

After eight days of sun drying at an average temperature of 31 to 34 °C, reductions in antioxidant components were noted. Contrarily, Konak et al. (2017) investigated how different drying methods, such as oven and sun drying, affected the phenolic makeup of Turkish figs of both dark and light hues. While oven drying took place in a controlled environment for 12 hours at 60°C and $0.5 ms^{-1}$ air speed, sun drying took around three days to complete. The overall phenolic content of either dark or light-coloured figs was found to be unaffected by drying, however dark-coloured figs' antioxidant capacity was found to be reduced by 20–30%. This is most likely caused by anthocyanins, the colorants present in dark-coloured figs, which are heat sensitive.

In order to measure the amount of phenolic compounds in figs cultivated in Slovenia both before and after sun-drying and oven-drying, Slatnar et al. (2011) conducted a study. While sun drying required seven days, oven drying was done in a 24-hour period at a temperature of between 62 and 64 °C. Their findings suggested that both drying procedures resulted in a significant increase in the natural antioxidant chemicals under investigation. According to a review by Arvaniti et al. (2019), a comparison of oven-drying and sun-drying demonstrated that oven-drying produced a higher concentration of phenolic chemicals. Chlorogenic acid, catechin, epicatechin, kaempferol-3-O-glucoside, luteolin-8-C-glucoside, and total phenolic content were all significantly increased by oven drying.

Conclusion:

In conclusion, antioxidants are an important element in maintaining health, especially in protecting from diseases that may be caused by free radicals, including cancer. It is important to consume natural antioxidants, such as those found in fruits and vegetables; however, some forms of food processing may affect antioxidant content, especially processes involving heat, such as drying, even though they may be necessary prolong a product's shelf life and make it available despite its seasonal nature.

Figs are popular in Middle Eastern countries and contain many nutrients, from macronutrients to micronutrients and antioxidant components. Drying may influence the antioxidant content, but dried figs are still a source of nutrients and phenolic compounds, and they have a high fiber content. Nevertheless, there is a need for more studies on figs to determine their nutritional value and any relationship between daily consumption and health, and such studies should include different fig products, such as fig syrup, bakery products containing figs, traditional foods, and even new fig products. More studies are also needed on the effects of other food processing methods, such as freezing, on antioxidant content.

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الملخص العربي

مراجعة لتأثير معالجة الأغذية (التجفيف) على محتوى مضادات الأكسدة في التين

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معالجة الفواكه بطرق مختلفة كالتجفيف والتعليب يمكن أن يؤثر على القيمة الغذائية للفواكه المعالجة خاصة العناصر الغذائية الدقيقة ومضادات الأكسدة.

التين *Ficus Carica* L يزرع بشكل واسع في منطقة البحر الأبيض المتوسط. يعد التين من الفواكه ذات القيمة الغذائية العالية بما يحتويه من العناصر الغذائية الدقيقة وبعض المركبات وخصوصا البولي فينول. التجفيف من الطرق الشائعة في حفظ الأطعمة لفترة أطول. لكن هذه العملية قد تؤثر على القيمة الغذائية بانخفاض محتوى الفاكهة المجففة من مضادات الأكسدة. وتهدف هذه المراجعة الى دراسة تأثير التجفيف على القيمة الغذائية خصوصا محتوى التين من مضادات الأكسدة والبولي فينول بالمقارنة مع التين الطازج.

الكلمات المفتاحية: التين، مضادات الأكسدة، مركبات البولي فينول.