Ficus carica Fruits

Subjects: Agronomy

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figs leaf revalorization pulp added-value

1. Introduction

Ficus carica L. (fig) is a species of the very large number of the genus Ficus belonging to the Moraceae famil, characterized by milky latex in all parenchymatous tissue, unisexual flowers, anatropous ovules and aggregated drupes or achenes [1]. Figs are infruitescences—the true fruits of the fig are located inside the fig or siconio, which are called achenes [2]. The fleshy and sweet part of the fig corresponds to the flower receptacles that, after fertilization, become swollen and fleshy [3]. It is worth mentioning that it is one of the oldest species domesticated by humanity [4]. In the Middle East and the Mediterranean region, the fig has been included in the diet since ancient times and is considered a symbol of health [5]. It has been suggested that the cultivation of the fig originated in the East Mediterranean region, which was later expanded into the West Mediterranean area [6].

A high number of bioactive compounds have been found in the peel, flesh, leaves and whole fruits of figs, such as cyanidin, chlorogenic acid, rutin, luteolin and (+)-Catechin, among others [2][7][8]. Several authors have indicated that these compounds present potential health properties, such as antibacterial, hepatoprotective, antidiabetic, anti-inflammatory, antioxidant and anticancer activity [9][10][11]. Therefore, consumer demand for fig fruit and fig-based products has increased in the past decades [12]. It is essential to highlight that no health claim is yet authorized for “antioxidants”, “anthocyanins” or “fig” by the European Food Safety Agency (EFSA). There is just one authorized claim (for polyphenols): hydroxytirosol and derivatives in olive oil. On the other hand, the high concentration of calcium (133 mg/100 g) [1] in fig fruits allows to mention the nutritional claim “rich in calcium”, because its content is higher than 10% of the RDI (recommended dietary intake).

Fig products have been used in traditional medicine to treat many diseases, mainly in the dermatological field [13]. Abbasi et al. [14] studied the application of fig plant extracts and showed their effectiveness in relieving symptoms of atopic dermatitis, and can, hence, be used instead of cortisones. Moreover, another study reported the potential of fig plant extract to be used as a treatment of and prevention for skin warts and cervical cancer [15]. Ongoing research suggests anticancer effects of two components of fig leaf extract, bergapten and psoralen, which could be

a good source for developing drugs to suppress the growth of cancer cells [13]. Additionally, other studies concluded that figs are a concentrated source of benzaldehyde [16]. There are studies that also show the potential of fig extracts to produce medicines for cardiovascular diseases, by the content in components such as flavone, rutine and quercetin [17]. Additionally, fig fruits as well as leaves have a high nutritional value and their high content of dietary fiber is widely known [17]. Constipation is a very common health problem, and laxative foods such as figs and their derivatives could be considered effective for this problem [18]. Similar results were also reported in a previous study, in which fig leaf extracts were used to help combat eating and lifestyle disorders [19]. Additionally, Ajmal et al. [20] recognized the efficacy of fig leaf extracts for reducing blood glucose levels.

On the other hand, there is a need to reduce the fig's environmental impacts (zero waste) and fruit-based products present a high added value as functional ingredients. Among fruit-based products, peels, seeds, no-optimal fruits and leaves, among others, can be found. Focusing on fig by-products, the peel and leaf extracts could increase the nutritional and pharmaceutical properties of food products such as additives [4]. Therefore, there is a great need to generate comprehensive information about the bioactive compounds of fig fruits, their derivatives/by-products (peel, leaves and oil) and fig-based products. How the processing (drying and preparation of jams) and storage have affected the phenolic composition of fig products will also be an objective of this review.

2. Bioactive Compounds in Different Fig Parts

Table 1 shows the individual phenolic compounds found in different part of fig parts: whole fruit (n = 19), peel (n = 21), pulp (n = 22) and leaves (n = 40). Identified compounds belong to different chemical families, such as phenolic acids (caffeic acid, chlorogenic acid, ferulic acid, coumaric acid, syringic acid, quinol and gallic acid) and flavonoids (catechin, kaempferol, quercitin and myricetin). The chemical structure of the main compounds found in fig fruits and derivatives are shown in recent studies related to chemical composition [9][11]. It is important to highlight that the results in the literature are not always reported in a unified manner, which makes it difficult to compare research findings. Data are expressed as dried matter/weight (dw) and fresh matter/weight (fw). Depending on the part of the fruit, maturity index, variety and region, the type of compounds varies. Quercetin-3-O-rutioside was reported as the major individual phenolic compound in whole figs, followed by polymeric procyanidins, quercentin-3-glucoside, chlorogenic acid and cyanidin-3-0-rutinoside. As for the peel's bioactive compounds, cyanidin-3-rutinoside was the most abundant, followed by cyanidin-3,5-diglucoside, cyanidin-3-O-diglucoside, epitecatechin, catechin and quercetin-rutinoside. Epicatechin and cyanidin-3-rutinoside were the main compounds found in fig pulp, while caftaric acid, in the form of kaempferol 3-O-glucoside, was the main compound reported in fig leaves. On the other hand, Badgujar et al. [10] and Li et al. [9] reviewed the phytochemical composition of Ficus carica fruits and their derivatives. This study only indicated the profile of the bioactive compounds (isolation of phytosterols, anthocyanins, phenolic components and a few other classes of secondary metabolites), not the quantification. Most of these phytochemicals were found in latex, followed by leaves, fruit and root. Additionally, Li et al. [9] collected data of the phytochemical composition related to health properties, indicating that conventional and modern isolation and characterization techniques were used for the identification of about

126 chemical constituents, which were divided into eight categories: hydroxybenzoic acids, hydroxycinnamic acids, flavonoids, coumarins, furanocoumarins, volatile constituents, triterpenoids and miscellaneous [9].

3. Bioactive Content of Fig-Based Products and Their Antioxidant Activity

In general, fig fruits have mainly been consumed fresh and dried, but they have also traditionally been preserved and processed into jams [16]. Nowadays, consumer trends have changed and there is an increase in the range of other products based on figs [4].

As for dried figs, Slatnar et al. [21] showed results of total phenolics after a drying treatment. The drying process affected the degradation of phenolic compounds, the content of phenolic compounds being higher in fresh figs, followed by oven-dried figs and sun-dried figs. For example, Vallejo et al. [5] showed that around 15% of the total phenolics were lost in the drying processes in figs “Cuello Dama”. Not only is the quality important, but safety is essential to be maintained. Mycotoxins have been found in quantities above the recommended limit in commercial samples of dry figs [22]. Therefore, a controlled drying process helps to reach a safety level. Alternatives to traditional sun drying is necessary for improving the protection of public health [23].

Recent studies suggested that by-products/co-products obtained from peel and fig pulp showed potential properties to be used as ingredient in food products/additives . **Table 3** shows the reported research about different raw fig by-product materials (different plant parts, peel, leaves and whole figs) and the extraction method used to obtain the desired ingredients/additives and their uses. For instance, peel extract could be used as a colorant due to its potential source of anthocyanin. Consequently, fig peel extract has great potential to be used as a natural food dye, where in addition to its ability to add natural purple colors, it also presents interesting antioxidant and antimicrobial activities. **Table 1** also shows the extraction and uses of pectin from fig peel and pulp [24].

Table 1. Different potential uses of underutilized fruits and extracts of fig by-products.

Plant Part	Extract	Method	Uses	References
Peel	Lyophilized powdered	Extracted with 100 mL of acidified solvent 100% etanol	Natural purple colorants	[25]
	Lyophilized powdered	Heat-assisted extraction Microwave-assisted extraction Ultrasound-assisted extraction	Bioactive anthocyanin pigments	[26]
	Pectin	Hot-water extraction Ultrasound-assisted extraction Microwave-assisted extraction	The strong antioxidant and emulsification capacities	[27]
Leaves	Aqueous extract	Finely ground leaf powder suspended in 96 mL deionized water filtered by	Prolong the shelf life of pasteurized milk	[28]

Plant Part	Extract	Method	Uses	References
		sterilized membrane filter, concentrated by using a rotary evaporator at 50 °C and followed by drying in an oven at 50 °C		
	Powdered	Ethanol and chloroform were used as extracting solvents	Milk-clotting activity, which is most likely due to an enzyme component	[29]
	Fresh Leaf	Fig leaf extract, 96% ethanol. Using the maceration method	Antibacterial activity of fig leaf extracts	[30]
	Powdered	10 g of the finely divided leaf particles was dissolved in 200 mL of deionized water in a 500 mL flat bottom flask	Synthesis of eco-friendly and sustainable nanoparticles	[31]
	Fresh leaves and stems of the wild fig	Simple and chemical-free method (crushed and centrifuged).	Clotting ability in goat's fresh cheese production	[32]
	Powdered	Surfactant (PEG8000)-based microwave-assisted extraction method	Source of bioactive compounds	[33]
	Powdered	0.1 g of sample and 10 mL aqueous 50% acetone, centrifuged using Eppendorf centrifuge and filtered with a 0.22 µm PTFE syringe filter.	Source of bioactive compounds	[34]
Whole figs	Syrup	100 g of low-quality dried fig fruits were soaked in 500 mL distilled water, mixed and then centrifuged to remove solids.	Pullulan gum production from low-quality fig syrup using Aureobasidium pullulans	[35]
	Powdered	Samples (1 g) were mixed with ethanol (50 mL) and left macerating for 24 h; then, solutions were centrifuged (6800× *g*/20 min) and extraction was repeated three times.	Source of bioactive compounds	[36]
	Dry fig and stevia extract	Microwave-assisted extraction of stevia	Sugar replacement in ice cream	[37]

Regarding leaf extracts, El Dessouky Abdel-Aziz et al. [28] suggested that they can be used to extend the shelf life of pasteurized milk from 5 to 16 days without altering organoleptic properties. Moreover, other authors have reported that leaf extracts or fig powder can be a potential product for manufacturing functional foods [38] (**Table 1**). Fermentation is also known to promote the concentration of bioactive compounds of fruits and vegetables [24].

4. Conclusions

Although there has been an increase in research focused on the bioactive compounds of fig fruits and their by-products, more scientific evidence (combined with a unified way of publishing data on bioactive compound content) is needed to establish the potential health properties. Future investigations should be focused on in vitro and in vivo studies to reveal their beneficial properties. There is scientific research about the potential use of underutilized fig fruit and figs by-products and its bioactive compounds as nutritional, functional and techno-functional properties. The use and valorization of the waste material (leaves, peel and pulp) produced during fig processing should be further investigated, since this could offer financial benefits to farmers and solve environmental issues by ensuring the sustainable management of these materials and, furthermore, bringing benefits to consumers' health and well-being. In addition, an economic estimation of the bioactive compounds of fig by-products could be essential to gain more knowledge and obtain added value. Although fig-based products and their uses were reported, such as smoothies, fig powders, colorants, fermented drinks and biscuits, among others, in the future, other products should be researched, for instance: fig coffee, dried figs using novel technologies and fermented milks based on fig by-products.

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