PLANT SCIENCE TODAY
Vol 13(2): 1-6
https://doi.org/10.14719/pst.10686

eISSN 2348-1900

RESEARCH ARTICLE

Optimising storage protocols to preserve the nutraceutical value of *Ficus carica* L. (Moraceae)

Abdulrahaman Mahmoud Dogara*, Harmand A Hama & Dogan Ozdemir

Biology Education Department, Tishk International University, Erbil 44001, Iraq

*Correspondence email - abdulrahman.mahmud@tiu.edu.iq

Received: 16 July 2025; Accepted: 12 January 2025; Available online: Version 1.0: 17 March 2026; Version 2.0: 01 April 2026

Cite this article: Abdulrahaman MD, Harmand AH, Dogan O. Optimising storage protocols to preserve the nutraceutical value of *Ficus carica* L. (Moraceae). Plant Science Today. 2026; 13(2): 1-6. https://doi.org/10.14719/pst.10686

Abstract

Ficus carica L. (fig) is traditionally used to treat diverse diseases. However, despite its health benefits, fig fruit deteriorates quickly after harvesting due to its delicate nature. This study aimed to examine the influence of storage conditions on the biological efficacy of *F. carica*. The extracts of *F. carica* were subjected to analysis of total flavonoid content (TFC), total phenolic content (TPC), 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity, ferric reducing antioxidant power (FRAP), α-glucosidase inhibitory activity and disc diffusion assay. The room temperature drying (RTD) fig extracts, especially those of the purple variety (RTD-P), were more bioactive than their counterparts, with a maximum flavonoid content (77.1 mg QE/g) and excellent antioxidant potential (DPPH IC_{50} = 20.2 µg/mL, FRAP = 23.6 mmol Fe^{2+}/g). Moreover, the RTD extracts exhibited high potential to inhibit α-glucosidase (IC_{50} 46.2 µg/mL) and potent inhibition against *Escherichia coli* (17.8 mm), *Citrobacter freundii* (13.9 mm) and *Enterobacter aerogenes* (8.4 mm). The RTD results in the retention of more compounds, which contributes to its biological activities. Future studies should profile the chemical composition of each drying method to obtain a better understanding of the effects of the drying methods on the degradation of compounds.

Keywords: alpha-glucosidase; bioactive; enzymes; fig; food; plants

Abbreviations: DMSO: dimethyl sulfoxide; TFC: total flavonoid content; TPC: total phenolic content; DPPH: 2,2-diphenyl-1-picrylhydrazyl radical scavenging; FRAP: ferric reducing antioxidant power; RTD-P: room temperature drying (28°C) (Purple); RTD-G: room temperature drying (28°C) (Green); FD-P: freeze drying (-80°C) (Purple); FD-G: freeze drying (-80°C) (Green); SD-P: sun drying (35°C) (Purple); SD-G: sun drying (35°C) (Green); OD-P: oven drying at 60°C (Purple); OD-G: oven drying at 60°C (Green); FS-P: fresh sample (Purple); FS-G: fresh sample (Green).

Introduction

Ficus carica (Moraceae), commonly referred to as figs or "kermas" in Arabic, is a highly valued medicinal plant indigenous to the Mediterranean region (1). It was first cultivated over 3000 years ago in the southern Arabian Peninsula. It later spread throughout the Middle East and the Mediterranean region in general (2). It is considered one of the first plants cultivated by man (3). The majority of global fig production is attributed to Mediterranean countries, with Turkey, Egypt, Algeria and Morocco contributing more than 65 % of the total output; Turkey is the foremost producer of fresh figs (4). The consumption of *Ficus carica* L. fruit has increased the significance of this species within the *Ficus* genus and it represents a crucial component of the Mediterranean diet due to its medicinal and pharmacological properties, including antioxidant, antimutagenic, anticarcinogenic, anti-inflammatory and antibacterial activities, largely attributed to its bioactive compounds (1). The consumption of fig fruit is a prevalent approach for mitigating discomfort related to toothaches and migraines (4). Postpartum, women consumed a decoction of leaves to facilitate the tightening of uterine and vaginal muscles (5). It has been posited that consuming a decoction derived from the leaves may enhance blood circulation, possess aphrodisiac properties and potentially aid in the management of diabetes (6). Traditionally, the leaves are used as livestock feed, the plant latex serves as a coagulant in cheese production by indigenous communities and the wood is employed for making hoops, garlands and other ornamental items (7). Leaves, bark, tender shoots, fruits, seeds and latex are traditionally employed in the treatment of jaundice, diarrhea and nutritional anemia and as anti-inflammatory agents (6).

However, despite its health benefits, fig fruit deteriorates quickly after being picked, as its flesh is delicate, the skin is thin and respiration is high. Owing to these issues, the shelf-life of the fruit is quite short. Therefore, maintaining *F. carica* activity to maintain its health benefits is important. Attention to the preservation of bioactive compounds has increased, particularly regarding post-harvest handling methods. However, factors such as drying techniques, temperature and storage conditions may influence the nutritional composition and bioactive components, hence diminishing the antioxidant properties and resulting in decreased advantages for consumers (5). Indeed, drying is a technique employed by our ancestors to conserve and prolong the shelf-life of food products (5). Drying processes, including air, sun, oven, and freeze drying, have distinct advantages and disadvantages relative to one another (8). Numerous studies have shown the impact of drying on chemical and phytochemical alterations, which can

substantially influence nutritional value and antioxidant capabilities (9, 10). Furthermore, improper storage can lead to the degradation of sensitive compounds, reducing their bioactivity and nutritional value.

Materials and Methods

Sample collection and processing

Fig fruits of two color varieties (green and purple) were used in this study (Fig. 1). Fresh specimens were collected from a farm in Sulaymaniyah in November 2024 and transported to the Department of Biology, Tishk International University, Erbil, for taxonomic identification (Voucher numbers TIU 00527 and 00528).

Table 1. Drying conditions of *Ficus carica*

Sample codes	Fruits color	Drying method	Temperature
FS-P	Purple	Fresh (No drying)	Nil
FS-G	Green	Fresh (No drying)	Nil
FD-P	Purple	Freeze drying	80 °C
FD-G	Green	Freeze drying	80 °C
OD-P	Purple	Oven	60 °C
OD-G	Green	Oven	60 °C
SD-P	Purple	Sun	35 °C
SD-G	Green	Sun	35 °C
RT-P	Purple	Room temperature	28 °C
RT-P	Green	Room temperature	28 °C

The samples were classified based on Table 1 (11, 12).

Extraction and yield percentage

The fig extraction was performed with ethanol as the extraction solvent. The fig fruit samples (200 g) were pulverized in the solvent via a blender at a ratio of 1:50 (sample to solvent). The fig fruit was pulverized to create a powder, which was subsequently macerated at a 1:50 (sample:solvent) weight/volume ratio at ambient temperature. The combination was subjected to sonication (CL-334 Qsonica) for 10 min, followed by a 5 min resting period and then sonicated again for an additional 10 min. The procedure was executed thrice (11). The mixture was subsequently subjected to filtration via Whatman No. 1 filter paper and the resulting filtrate was concentrated to dryness via a rotary evaporator (Heidolph, Germany). The resulting crude extracts were stored at -20 °C prior to utilization. The percentage yield of the fig fruit for each extraction was determined using the standard formula (12).

Percentage yield = Mass of crude extract/initial mass of sample × 100

Phytochemical analysis of fig fruit

Qualitative phytochemical screening

Qualitative tests were performed to detect the presence of carbohydrates, glycosides, triterpenes, steroids, phenolic compounds, flavonoids, alkaloids and saponins using standard procedures. All analyses were performed in triplicate, with three technical replicates. Detailed procedures for each test are described below.

Carbohydrates

The presence of carbohydrates in the fig fruit extract was assessed using the Molisch test (13). Approximately 2 mL of the aqueous extract was mixed with two drops of Molisch reagent (1 % α-naphthol in ethanol). Subsequently, 2 mL of concentrated sulfuric acid was carefully added along the wall of the inclined test tube. The formation of a violet ring at the interface indicated a positive result, reflecting the dehydration of carbohydrates to furfural derivatives, which then condensed with α-naphthol.

Glycosides

The presence of cardiac glycosides in the extract was assessed using Legal's test (14). One millilitre of the extract was mixed with 1 mL of pyridine, followed by 1 mL of 5 % sodium nitroprusside solution. A small amount of 10 % sodium hydroxide solution was added to render the mixture alkaline. The appearance of a deep red color indicated the presence of glycosides with an unsaturated lactone ring.

Triterpenes and steroids

For the detection of triterpenes and steroids, the Liebermann–Burchard test was used (15, 16). The extract (2 mg) was dissolved in 1 mL of chloroform. One drop of sulfuric acid was then added, followed by the addition of 2 mL of acetic anhydride. The solution was incubated for 10 min at room temperature. A rapid change in color to red and blue, followed by the development of a dark green colour, indicated the presence of triterpenes, whereas a blue–green color signified the presence of steroids.

Phenolic compounds

The ferric chloride test was used to determine the presence of phenolic constituents (15, 16). Three or four drops of the 5 % (w/v) neutral ferric chloride solution were added to 1 mL of the extract. The formation of deep blue, green or black color was considered a positive indication of phenolic compounds, resulting from the formation of ferric–phenolate complexes.

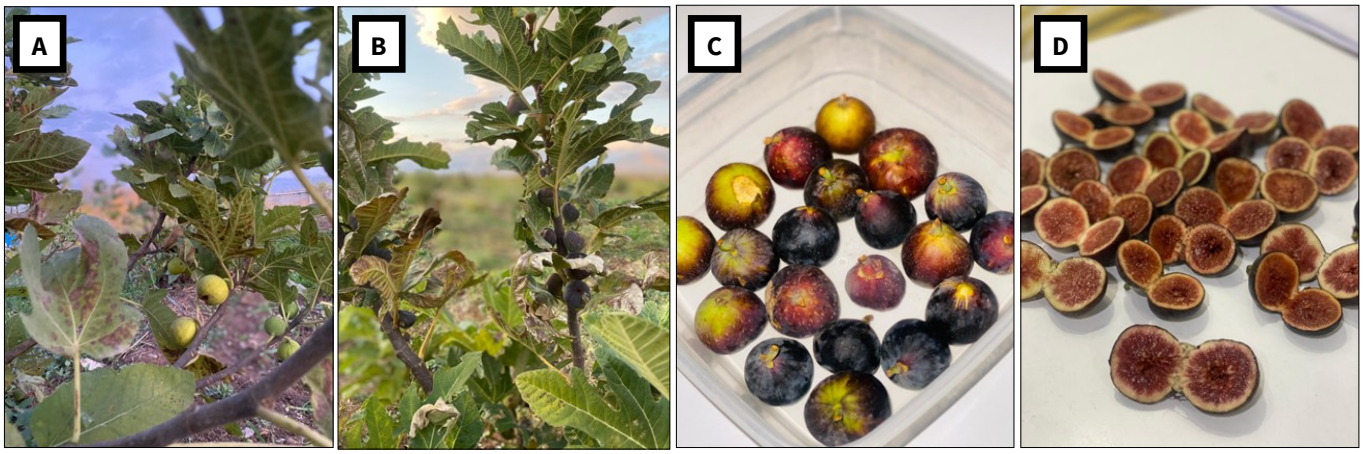

Fig. 1. *Ficus carica* L. (Moraceae). (A) wild green fig; (B) wild purple fig; (C) fig fruit; (D) processed fig fruit.

Flavonoid compounds

The alkaline reagent test was used to determine the presence of flavonoids (11, 12). To the extract, 2 mL of 2 M sodium hydroxide solution was added. The immediate appearance of a strong yellow colour that faded upon acidification with dilute hydrochloric acid was considered a positive indication of flavonoids, resulting from the opening of the pyrone ring under alkaline conditions.

Alkaloids

The Dragendorff test was used to establish the presence of alkaloids (15, 16). The extract was filtered and 1 % hydrochloric acid was added to acidify the extract. Two milliliters of potassium bismuth iodide reagent (Dragendorff's) were added to the filtrate. The formation of an orange to reddish-brown precipitate was recorded as a positive indication of alkaloids.

Saponins

Froth test was performed to identify saponins (15, 16). In a graduated cylinder, 0.5 g of the extract was thoroughly mixed with 10 mL of distilled water after being shaken for approximately 2 min. The presence of saponins was confirmed by the formation of a persistent froth that was greater than 1 cm in height and lasted for at least 10 min.

Quantitative and functional assays

Total phenolic and total flavonoid contents were quantified and antioxidant activity was evaluated using DPPH and FRAP assays. The functional potential of fig fruit extracts was assessed through α-glucosidase inhibitory and antibacterial activities. All analyses were performed in triplicate with three technical replicates. The procedures for each test are described below.

Total phenolic content (TPC)

Total phenolic content was determined using the Folin–Ciocalteu method and expressed as gallic acid equivalents (mg GAE/g). Approximately 1 mL of gallic acid standard solution at several concentrations was utilized and the absorbance was measured at 765 nm to generate a gallic acid standard curve. This mixture was subsequently combined with 10 µL of extracts and 100 µL of 10 % Folin-Ciocalteu reagent (v/v). Subsequently, 80 µL of Na_2Co_3 (7.5 %) was incorporated into the mixture and incubated at 45 °C for 40 min, after which the absorbance was re-evaluated (11). The total phenolic content was calculated using the following equation:

$$C = (c \times V)/m$$

where C represents the total phenolic content (mg/g), c denotes the concentration of gallic acid derived from the standard curve (mg/mL), V signifies the volume of extracts (mL) and m indicates the weight of the pure plant extract (g) (9).

Total flavonoid content (TFC)

Approximately 1 mL of serially diluted quercetin was introduced into individual wells of a 96-well plate and measured at 595 nm to create a standard curve. Subsequently, 25 µL of extracts and 10 µL of 5 % $NaNO_3$ were introduced, followed by a 6-min incubation of the mixture in the dark at ambient temperature. Subsequently, 15 µL of $AlCl_3$ was added and the mixture was incubated for 5 min at ambient temperature.

Subsequently, 50 µL of 1 M NaOH was added and the mixture was gently stirred for 1 min. The absorbance was measured at 595 nm via an ELISA reader (Thermo Fisher Scientific). The formula C = (c × V)/g was utilized, where C represents the total flavonoid content (mg/mL), c denotes the quercetin concentration derived from the standard curve (mg/mL), V indicates the volume of the extract (mL) and m signifies the weight of the extract (g) (11).

2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay

Within a 96-well microplate, aliquots of 50 µL from each test sample and serial dilutions of quercetin (positive control) at concentrations of 3.91, 7.81, 15.63, 31.25, 62.5, 125, 250 and 500 ppm were dispensed into separate wells prior to the addition of 100 µL of 59 mg/L DPPH. A 30 min incubation was conducted in the dark, followed by absorbance measurement at 517 nm via an ELISA reader (Thermo Fisher Scientific) (17). The percentage inhibition was determined via the following formula:

$$\text{Percentage inhibition} = [(AR - (H - AH))/AR] \times 100$$

where AR= Absorbance of the reagent blank, H= Absorbance of the sample and AH= Absorbance of the blank sample.

Ferric reducing antioxidant power (FRAP) assay

A functional FRAP solution was prepared by mixing 300 mM acetate buffer, 10 mM TPTZ (2,4,6-tri(2-pyridyl)-s-triazine) in 40 mM HCl and 20 mM $FeCl_3$ at a ratio of 10:1:1. The solution was subsequently heated in a water bath at 37 °C for 10 min before application. The fig fruit samples (ethanol) (100 µg/mL) were mixed with 285 µL of the working FRAP solution and incubated at ambient temperature in the absence of light for 30 min. The absorbance was measured at 539 nm using an ELISA reader (Thermo Fisher Scientific)(18).

Alpha-glucosidase inhibition assay

The α-glucosidase inhibitory activity was determined. Ten microlitres of extracts from the fig fruit samples at concentrations of 0, 1.56, 3.13, 6.25, 12.5, 25, 50 and 100 µg/mL were combined with 50 microlitres of 0.1 M phosphate buffer (pH 7.0). Subsequently, 25 microlitres of α-glucosidase in buffer (0.2 U/mL) were introduced into the well plate and incubated for ten minutes at 37 °C to commence the reaction. Twenty-five microlitres of 0.5 mM 4-nitrophenyl α-D-glucopyranoside (pNPG) substrate were introduced to finalize the reaction and the mixture was incubated for an additional 30 min at 37 °C. The reaction was halted by the addition of 100 µL of 0.2 M sodium carbonate solution. Acarbose served as the positive control. The absorbance was quantified at 410 nm via an ELISA reader (Thermo Fisher Scientific) (17). The percent inhibition was determined via the following formula:

$$\text{Percentage inhibition} = [(AR - (H - AH))/AR] \times 100$$

where AR represents the absorbance of the reagent blank, H represents the absorbance of the sample and AH represents the absorbance of the blank sample.

Antibacterial inhibition assay

The disc diffusion method for antibacterial susceptibility testing was conducted following conventional procedures to evaluate the antibacterial activity of the fig fruit extracts. A bacterial culture, calibrated to the 0.5 McFarland standard, was utilized to inoculate Mueller–Hinton agar plates uniformly with a sterile swab (15). The plates were dried for 15 min before being utilized for the sensitivity test. The discs impregnated with 100 mg/mL plant extracts were positioned on the surface of Mueller-Hinton agar. The normal antibiotic disc mixture consisted of 10 µg of ampicillin. The negative control utilized was 100 % dimethyl sulfoxide (DMSO). The plate

were thereafter incubated at 37 °C for 18–24 hr, contingent upon the bacterial species employed in the assay. Following incubation, the plates were assessed for the presence of inhibitory zones (19). The inhibitory zones were subsequently measured with calipers and documented. The tests were conducted three times to assure reliability.

Statistical analysis

The data were statistically analyzed using the statistical analysis system (SAS) software version 9.4 (University edition). Experiments were conducted in a completely randomized design (CRD) with three replications. One-way ANOVA was conducted and mean differences were evaluated using Duncan's multiple range test (DMRT) at a significance level of $p \leq 0.05$ (20).

Results and Discussion

Percentage yield of extraction

The yield percentage demonstrated substantial variation based on the drying method employed (Table 2). Drying at room temperature produced the highest yields (58.9 % purple, 57.9 % green), whereas FD produced the lowest yields (39.4 % purple, 40.8 % green). The extract yield fluctuated with respect to three extraction parameters: temperature, time and drying method. Drying methods are a primary determinant of extraction yield (8). The low extraction yield of the fresh fig samples was due to their relatively high water content. Fresh fruits, unlike dried samples, have too much moisture and do not allow much of their compounds to be extracted. The intact structure of cells in fresh figs could prevent solvents from reaching some important substances inside the cells. The process of drying can damage cell walls, which may allow the release of some compounds and therefore make them easier to extract (16). The findings contrast with those of another study in which the yield from fresh calyx with a relatively low water content was reported (8).

Table 2 Extraction percentages

Sl.no.	Samples	Yields (%)
1	Room temperature Purple- RTD-P	58.9[a]
2	Room temperature Green- RTD-G	57.9[a]
3	Freezing drying Purple- FD-P	39.4[e]
4	Freezing drying Green- FD-G	40.8[e]
5	Sun drying Purple- SD-P	56.8[b]
6	Sun drying Green- SD-G	52.6[c]
7	Oven drying Purple- OD-P	47.2[d]
8	Oven drying Green- OD-G	48.1[d]
9	Fresh sample Purple- FS-P	27.8[f]
10	Fresh sample Green- FS-G	30.3[f]

Note: Values sharing the same letter are not significantly different at $p \leq 0.05$.

Qualitative phytochemical analysis of fig fruit

The qualitative phytochemical analysis (Table 3) indicated that all fig-drying methods (room temperature, freeze-drying, sun drying and oven drying) conserved the same bioactive compounds (phenols, flavonoids and alkaloids) in both fig varieties. The phytochemical composition of fresh and dried samples was similar, indicating that drying did not result in the loss of the assessed compounds. This aligns with the use of polar solvents which are effective in extracting secondary metabolite components from plant material. The phytochemical contents of plants are contingent upon environmental factors (17).

Total flavonoids, phenolic contents, antioxidants, α-glucosidase and antibacterial inhibition

Compared with the fresh figs, the room-temperature-dried figs were well preserved and contained flavonoids (67.8–77.1 mg QE/g) and phenolics (74.6–89.1 mg GAE/g) (Table 4). The antioxidant efficacy of phenolic substances is associated primarily with their redox potential, which is achieved via the neutralization of free radicals, stabilization of reactive oxygen species and breakdown of peroxides. Among the drying methods, room-temperature drying had the highest DPPH radical scavenging activity (IC_{50} values of 20.2-31.6 µg/mL). Similarly, in terms of the ability to convert Fe^{3+} to Fe^{2+}, the samples dried at room temperature presented the most significant result (23.6 mmol/g). Notably, the IC_{50} value for α-glucosidase inhibition of the fresh sample was similar to that of the room-temperature dried extracts (46.2–47.0 µg/mL) and close to that of the fresh samples (40.1–40.2 µg/mL). The overall antioxidant capacity is preserved by this softer drying technique, which leads to increased DPPH scavenging activity, the conversion of Fe^{3+} to Fe^{2+} and alpha-glucosidase inhibition. The antibacterial efficacy of all the plant extracts against the five bacterial strains evaluated was determined by the presence or absence of inhibition zones. An effective method of preserving phytochemicals, antioxidants and enzyme inhibition was found at RTD, revealing that room temperature can minimize the degradation of the compounds responsible for these activities. However, the drying strategy depends

Table 3. Qualitative phytochemical analysis of fig fruit

Sl. no.	Samples									
	RTD-P	RTD-G	FD-P	FD-G	SD-P	SD-G	OD-P	OD-G	FS-P	FS-G
Carbohydrates	+v	+v	+v	+v	+v	+v	+v	+v	+v	+v
Glycosides	+v	+v	+v	+v	+v	+v	+v	+v	+v	+v
Triterpenes	+v	+v	+v	+v	+v	+v	+v	+v	+v	+v
Steroids	+v	+v	+v	+v	+v	+v	+v	+v	+v	+v
Phenolic compounds	+v	+v	+v	+v	+v	+v	+v	+v	+v	+v
Flavonoids	+v	+v	+v	+v	+v	+v	+v	+v	+v	+v
Alkaloids	+v	+v	+v	+v	+v	+v	+v	+v	+v	+v
Saponins	+v	+v	+v	+v	+v	+v	+v	+v	+v	+v

RTD-P: Room temperature drying (28 °C) (Purple); RTD-G: Room temperature drying (28 °C) (Green); FD-P: Freezing drying (-80 °C) (Purple); FD-G: Freezing drying (-80 °C) (Green); SD-P: Sun drying 35 °C (Purple); SD-G: Sun drying 35 °C (Green); OD-P: Oven drying 60 °C (Purple); OD-G: Oven drying 60 °C (Green); FS-P: Fresh sample (Purple); FS-G: Fresh sample (Green); +v: Present.

Table 4. Total flavonoids, phenolic contents and antioxidant and alpha glucosidase activities

Conditions	TFC (mg QE/g)	TPC (mgGAE/g)	DPPH IC_{50} (µg/mL)	FRAP Fe2+/ (mmol/g)	Alpha glucosidase IC_{50} (µg/mL)
RTD-P	77.1±0.4^{a}	89.1±0.7^{c}	31.6±0.6^{d}	22.9±0.3^{b}	46.2±0.1^{d}
RTD-G	67.8±3.1^{b}	74.6±1.7	20.3±1.1^{f}	23.6±0.4^{a,b}	47.0±0.5^{c}
FD-P	65.3±0.5^{b}	104.0±5.8^{a}	54.1±1.2^{a}	15.7±0.6^{e}	ND
FD-G	65.3±0.5^{b}	112.4±1.2^{b}	49.9±0.2^{b}	16.4±0.2^{e}	ND
SD-P	60.1±0.3^{c}	65.9±1.0^{d}	38.5±2.8^{c}	18.2±0.1^{d}	ND
SD-G	56.2±0.6^{d}	60.7±4.0^{e}	37.3±0.3^{c}	18.3±0.2^{d}	ND
OD-P	46.8±0.1^{e}	68.3±3.6^{d}	32.5±0.1^{d}	20.7±0.4^{c}	68.6±0.3^{b}
OD-G	56.2±2.8^{d}	90.9±0.5^{c}	33.3±2.4^{d}	20.9±0.5^{c}	70.1±0.8^{a}
FS-P	78.3±2.8^{a}	90.9±0.3^{c}	28.5±2.4^{e}	24.3±0.8^{a}	40.1±0.8^{e}
FS-G	79.0±0.1^{a}	91.6±0.2^{c}	28.1±0.2^{e}	24.9±0.3^{a}	40.2±0.2^{e}
STD			28.8 ±0.6^{e}	25.6 ±0.2^{a}	45.6 ±0.7^{e,f}

Note: RTD-P: Room temperature drying (28 °C) (Purple); RTD-G: Room temperature drying (28 °C) (Purple); FD-P: Freezing drying (-80 °C) (Purple); FD-G: Freezing drying (-80 °C) (Green); SD-P: Sun drying 35 °C (Purple); SD-G: Sun drying 35 °C (Green); OD-P: Oven drying 60 °C (Purple); OD-G: Oven drying 60 °C (Green); FS-P: Fresh sample (Purple); FS-G: Fresh sample (Green). Values horizontally with the same letter are not significantly different at the $p \leq 0.05$ level.

on the type of plant and the compound of interest. This is clearly demonstrated when contrasting our results with the previous study on *Capparis spinosa* L. (21), which reported the highest phenolic content at 900 W microwave treatment. Thermal treatment can induce nutritional and organoleptic deterioration, as well as alterations in the concentrations of carotenoids, ascorbic acid and phenolic compounds, resulting in decreased antioxidant capacity and other impacts on biologically active chemicals (12, 22).

The antibacterial findings indicate that RTD-P and RTD-G showed the most potent inhibitory activity against *E. coli* (17.8 mm), *C. freundii* (13.9 mm) and *E. aerogenes* (8.4 mm) compared with the standard (13.8 mm against *E. coli*). Weak or no antibacterial activity was observed for the other drying methods (Table 5). The high performance of the RTD samples can be directly explained by the conservation of heat-sensitive antibacterial phytochemicals (7). The timing and standard postharvest processing methods affect product quality. Moreover, postharvest management influences the storage duration and marketability of crops (23). High temperatures influence the overall characteristics of the bioactive chemicals present in plants (12). This outcome substantiates the idea that drying temperature influences the retention of volatile chemicals.

Table 5. Antibacterial inhibition of fig fruit

Conditions	*E. coli* 100 mg/mL	*C. freundii* 100 mg/mL	*E. Aerogenes* 100 mg/mL
RTD-P	17.8 ±0.7^{a,b}	13.9 ±0.6^{a}	8.4 ±0.8^{a}
RTD-G	18.9 ±0.9^{a}	14.3 ±0.3^{a}	5.9 ±0.3^{b}
FD-P	8.2 ±0.1^{e}	ND	ND
FD-G	6.7 ±0.5^{g}	ND	ND
SD-P	11.9 ±0.1^{e}	ND	3.8±0.3^{c}
SD-G	13.5±0.3^{d}	ND	5.4 ±0.1^{b}
OD-P	8.9 ±0.9^{f}	ND	ND
OD-G	8.3 ±0.3^{f}	ND	ND
FS-P	15.6 ±0.1^{c}	7.8 ±0.4^{b}	ND
FS-G	14.3±0.4^{d}	6.9 ±0.8^{c}	ND
STD	13.8 ±0.2^{d}	ND	ND

Note: RTD-P: Room temperature drying (28 °C) (Purple); RTD-G: Room temperature drying (28 °C) (Green); FD-P: Freezing drying (-80 °C) (Purple); FD-G: Freezing drying (-80 °C) (Green); SD-P: Sun drying 35 °C (Purple); SD-G: Sun drying 35 °C (Green); OD-P: Oven drying 60 °C (Purple); OD-G: Oven drying 60 °C (Green); FS-P: Fresh sample (Purple); FS-G: Fresh sample (Green). Values horizontally with the same letter are not significantly different at the $p \leq 0.05$ level.

The loss of these active compounds in samples dried in the oven may be an indicator of thermal degradation, which is a well-recorded phenomenon in which high temperatures disrupt the molecular structure. Similarly, the low activity of the freeze-dried samples, although they retain most of the nutrients present, implies that the antibacterial compounds, that are particular to figs, could be prone to degradation associated with the formation of ice crystals or oxidative stress, which could be experienced throughout the lyophilization process. The best way to preserve figs is to dry them at room temperature, as they preserve the majority of important phytochemicals and biological properties and cause the least amount of degradation. Drying figs without freezing at normal temperature provides the best alternative for long-term storage, which is still nutritious.

Conclusion

Drying figs at room temperature is the most effective method for preserving their properties, as it eliminates the risk of thermal degradation of heat-sensitive compounds and prevents cell damage associated with freezing and ice formation. This method maintains the product shelf life for a longer time period without harming beneficial chemicals (phytochemicals) through high-temperature drying methods (oven or sun) or freezing. Overall, this method preserves the protective matrix and natural synergistic interactions of bioactive compounds, resulting in antioxidant and antidiabetic activities comparable to those of fresh figs. Future studies should focus on profiling the chemical composition associated with each drying method to better understand the effects of drying processes on compound degradation.

Authors' contributions

AMD, HAH and DO carried out the experiments and contributed to drafting the manuscript. All authors have read and approved the final version of the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

References

1. Dogara AM, Hama HA, Ozdemir D. Taxonomy, traditional uses and biological activity of *Ficus carica* L. (Moraceae): a review. Plant Sci Today. 2024;11(2):385–400. https://doi.org/10.14719/pst.3085
2. Hajam TA, Saleem H. Phytochemistry, biological activities, industrial and traditional uses of fig (*Ficus carica*): a review. Chem Biol Interact. 2022;368:110237. https://doi.org/10.1016/j.cbi.2022.110237
3. Mawa S, Husain K, Jantan I. *Ficus carica* L. (Moraceae): phytochemistry, traditional uses and biological activities. Evid Based Complement Alternat Med. 2013;2013:974256. https://doi.org/10.1155/2013/974256
4. Shahrajabian MH, Sun W, Cheng Q. A review of chemical constituents, traditional and modern pharmacology of fig (*Ficus carica* L.), a super fruit with medical astonishing characteristics. Pol J Agron. 2021;44:22–9. https://doi.org/10.26114/pja.iung.452.2021.452.04
5. Irudayaraj SS, Christudas S, Antony S, Duraipandiyan V, Naif Abdullah AD, Ignacimuthu S. Protective effects of *Ficus carica* leaves on glucose and lipids levels, carbohydrate metabolism enzymes and β-cells in type 2 diabetic rats. Pharm Biol. 2017;55(1):1074–81. https://doi.org/10.1080/13880209.2017.1279671
6. Lansky EP, Paavilainen HM, Pawlus AD, Newman RA. *Ficus* spp. (fig): ethnobotany and potential as anticancer and anti-inflammatory agents. J Ethnopharmacol. 2008;119(2):195–213. https://doi.org/10.1016/j.jep.2008.06.025
7. Badgujar SB, Patel VV, Bandivdekar AH, Mahajan TR. Traditional uses, phytochemistry and pharmacology of *Ficus carica*: a review. Pharm Biol. 2014;52(11):1487–503. https://doi.org/10.3109/13880209.2014.892515
8. Kolla MC, Laya A, Bayang JP, Koubala BB. Effect of different drying methods and storage conditions on physical, nutritional, bioactive compounds and antioxidant properties of doum (*Hyphaene thebaica*) fruits. Heliyon. 2021;7(4):e06678. https://doi.org/10.1016/j.heliyon.2021.e06678
9. Lema AA, Nor HM, Khandaker MM, Nudin NFH, Dogara AM. The effects of various drying techniques on physicochemical and nutritional qualities of roselle (*Hibiscus sabdariffa* L.) calyx. Plant Sci Today. 2022;9(4):926–33. https://doi.org/10.14719/pst.1796
10. Dev SRS, Raghavan VGS. Advancements in drying techniques for food, fiber and fuel. Dry Technol. 2012;30(11–12):1147–59. http://doi.org/10.1080/07373937.2012.692747
11. Hashim NA, Mahmod NH, Lema AA, Ho LH, Khandaker MM. Effects of extraction solvents and drying techniques on antioxidant content and radical scavenging activity of roselle (*Hibiscus sabdariffa*) calyx. Sarhad J Agric. 2024;40(Special issue 1):110–21. https://dx.doi.org/10.17582/journal.sja/2024/40/s1.110.121
12. Agidew MG. Phytochemical analysis of some selected traditional medicinal plants in Ethiopia. Bull Natl Res Cent. 2022;46(1):1-22. https://doi.org/10.1186/s42269-022-00770-8
13. Harborne JB. Phytochemical methods: a guide to modern techniques of plant analysis. 3rd ed. Dordrecht (NL): Springer Science + Business Media; 1998.
14. Evans WC, Evans D, editors. Trease and Evans' Pharmacognosy. 16th ed. Edinburgh/London: Elsevier Health Sciences/Saunders Ltd.; 2009.
15. Iqbal E, Salim KA, Lim LBL. Phytochemical screening, total phenolics and antioxidant activities of bark and leaf extracts of *Goniothalamus velutinus* (Airy Shaw) from Brunei Darussalam. J King Saud Univ Sci. 2015;27(3):224–32. https://doi.org/10.1016/j.jksus.2015.02.003
16. Lema AA, Dogara AM, Al-Zahrani AA, Bomoi AM, Alessi AM. An investigation of *Ficus platyphylla* Delile: antioxidant and antimicrobial activity, chemical composition, and molecular docking study. ChemistrySelect. 2025;10(15):e202404856. https://doi.org/10.1002/slct.202404856
17. Dogara AM, Ibrahim MT, Mahmud AA, Danladi MD, Lema AA, Usman M, et al. Biological activity, chemical composition and molecular docking of *Eugenia punicifolia* (Kunth) DC. J Umm Al-Qura Univ Appl Sci. 2024;11:294–307. https://doi.org/10.1007/s43994-024-00160-y
18. Dogara AM, Ibrahim MT, Mahmud AA, Danladi MD, Lema AA, Muhammad U, et al. Antioxidant, Alpha glucosidase inhibition, Chemical composition, and Molecular docking of *Thesium viride* AW Hill. Arab J Med Aromat Plants. 2024;10(1):1–19. https://doi.org/10.48347/IMIST.PRSM/ajmap-v10i1.45992
19. Aadil KR, Barapatre A, Sahu S, Jha H, Tiwary BN. Free radical scavenging activity and reducing power of *Acacia nilotica* wood lignin. Int J Biol Macromol. 2014;67:220–7. https://doi.org/10.1016/j.ijbiomac.2014.03.040
20. Abdulrahman MD, Hasan Nudin NF, Khandaker MM, Ali AM, Mat N. *In vitro* biological investigations on *Syzygium polyanthum* cultivars. Int J Agric Biol. 2019;22:1399–406. https://doi.org/10.17957/IJAB/15.1214
21. Babaei Rad S, Mumivand H, Mollaei S, Khadivi A. Effect of drying methods on phenolic compounds and antioxidant activity of *Capparis spinosa* L. fruits. BMC Plant Biol. 2025;25:133. https://doi.org/10.1186/s12870-025-06110-y
22. Gonzalez-Palomares S, Estarrón-Espinosa M, Gómez-Leyva JF, Andrade-González I. Effect of the temperature on the spray drying of roselle extracts (*Hibiscus sabdariffa* L.). Plant Foods Hum Nutr. 2009;64(1):62–7. https://doi.org/10.1007/s11130-008-0103-y
23. Lema AA, Mahmod NH, Khandaker MM, Hasan Nudin NF, Dogara AM. The role of anthocyanins in activating antioxidant enzymes during postharvest degradation of (*Hibiscus sabdariffa* L.) roselle calyx. Plant Omics. 2022;15(1):25–36.

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

Copyright: © The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited (https://creativecommons.org/licenses/by/4.0/)

Publisher information: Plant Science Today is published by HORIZON e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.