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Nutritional Evaluation, Chemical Investigation of Phenolic Content and Antioxidant Activity of Ferocactus Glaucescens Ripe Fruits

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THE present investigation aimed to assess the nutritional properties of the ripe fruits of Ferocactus glaucescens (DC.) for the first time. Total polyphenols and flavonoids in the methanolic extract of the fruits were determined colorimetrically and the quantification of their components was carried out using HPLC-UV. Antioxidant activity of the extract was also evaluated using $DPPH^+$ method. Total phenolics and flavonoids estimated as gallic acid and quercetin equivalents (mg/g of the dried extract) were 8.39 ± 0.074 and 3.82 ± 0.019, respectively. HPLC analysis of the phenolic compounds enabled the identification and quantification of 31 phenolic compounds (12 flavonoids and 19 phenolic acids). Naringenin was the major identified flavonoid (23.4 ± 1.2 mg/100g). While, trans-cinnamic acid was the major identified phenolic acid (22.37 ± 0.9 mg/100g). Also, DPPH assay revealed marked antioxidant activity of the methanolic extract. In nutritional analysis, carbohydrates (18.8 g/100g), protein (1.2 g/100g), total lipid (1.3%) and crude fiber (10.1%) content were detected. Vitamin C (503.12 mg/100g) was higher when compared to other two vitamins evaluated. Eight minerals were also quantified. These results suggest that F. glaucescens fruit is a rich source of nutrients and antioxidant compounds such as phenolic compounds and highly recommended for consumption.

Keywords: F. glaucescens, HPLC, Flavonoids, Phenolics, Antioxidant, Vitamins, DPPH.

Introduction

In recent years the demand for high value-added or functional foods has increased dramatically [1]. Functional foods can improve health by providing additional antioxidants, vitamins and minerals [2]. Fruits are widely accepted as a good and important source of nutrients, so knowledge about their composition and their nutrient potentials is imperative [3]. High consumption of fruits and vegetables was reported to reduce the incidence of many pathologies associated with oxidative stress such as cancer and cardiovascular diseases due to their high content of antioxidant vitamins and polyphenolic compounds [4]. Cacti are succulent plants included in family Cactaceae. They are often used as ornamental plants, but many are also cultivated as crops. Fresh cactus fruits have excellent quality and flavor [5]. Traditionally, they are used as a valuable health supporting nutrient and they also have applications in pharmaceutical industries [6,7]. Recent studies have demonstrated that cactus pears could be excellent candidates for the development of healthy food due to the presence of several potentially active nutrients with multifunctional properties such as vitamin C, betalains and flavonoids [8-10]. Cactus fruit extracts displayed remarkable antioxidant and anticancer activities and can be used as dietary supplements in normal and high-risk populations for cancer [6]. Cactus pears have been traditionally

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consumed by Native Americans for centuries and these ethnic groups show lower cancer rates when compared to white Americans [11]. *Ferocactus* is a genus of barrel shaped cacti of the semiarid highlands of Mexico. Many Ferocactus species are used in the candy industry, medicine, as a source of food and as ornamental plants [12]. *F. hamatacanthus* has brown juicy fruits and used as lemons and limes, *F. wislizenii* fruits are edible and used to make cactus candy [5]. *F. histrix* fruits are rich in phenolic acids and flavonoids and considered as important source of antioxidants [13]. *F. histrix* fruits are consumed by local people in Mexico and sold in the markets [12]. However, Ferocactus glaucescens fruits are underutilized and no reports was found concerning their nutritional value or chemical composition. Thus, the objective of this study was to investigate the nutritional properties e.g. Total soluble solids (TSS), pH, as well as fiber, protein, vitamin, sugar, mineral and amino acid contents in the ripe fruits of *F. glaucescens* DC. for the first time. Also, the phenolic composition of the methanolic extract of the fruits was evaluated using spectrophotometric and HPLC-UV analysis. Furthermore, the antioxidant effect of the extract was determined using DPPH assay to reveal the antioxidant and health-promoting properties of these fruits and to increase the added value of this plant.

Materials and Methods

Plant material

Ferocactus glaucescens (DC.) ripe fruits (500 g) were collected during May (2019) from Helal cactus farm, Qalyubia governorate. Their Identities were verified morphologically by Botany specialist, Dr. Mohamed El-Gibali, former researcher of Botany, Department of Botany, National Research Centre (NRC). The fruits were washed and cleaned with distilled water to remove the surface residues and one part of fresh ripened fruits were stored at 4°C for the evaluation of total carbohydrate, total protein, vitamins, pH of the juice. The other portion of the ripened fruits was dried in a hot air oven for 24 hours at 45°C. Then the dried fruits were ground well in a mixer grinder and kept in an air-tight bottle and stored at 4˚C in a refrigerator for the evaluation of crude fiber, mineral profiling and amino acid composition. For determination of phenolic content and antioxidant activity 1 g of the fresh fruits with homogenized with 100 ml methanol, followed by filtration through Watmann No.1 filter paper and the solvent evaporated in vacuo at 50 °C to give 50 mg dried residue.

Chemicals and Reagents

Folin–Ciocalteu's reagent was obtained from LobaChemie (Mumbai, India), 2, 2-Diphenyl-1-picrylhydrazyl (DPPH), t-butylhydroquinone (TBH) and ascorbic acid were obtained from Sigma Chemical Co. (St. Louis, MO, USA). Solvents for HPLC analysis; acetonitrile and methanol were of HPLC grade, and were purchased from Sigma–Aldrich (Steinheim, Germany). o-Phosphoric acid used was of analytical grade from Sdfine Chemlimited (Mumbai, India) and formic acid was purchased from E-Merck (Darmstadt, Germany). Distilled water was further purified using a Milli-Q system (Millipore, MA, USA). Acetonitrile and acidulated water were filtered through a 0.45 pm membrane filter (Pall Gelman Laboratory, USA) and degassed in an ultrasonic bath prior to HPLC analysis. Phenolic acids and flavonoids used in HPLC analysis were purchased from sigma Co. (St. Louis, MO, USA). Other chemicals used in the study were of reagent grade and supplied through (El-Gomhouria Company, GOMAC).

Determination of pH

Estimation of pH was done by mixing 3 g of fresh fruits with 12 ml deionized water; the pH was then measured by pH meter-thermo device (Table 1).

Determination of the Total Soluble Solids (TSS)

Total soluble solids were determined by mixing 1 g of fresh fruit with 1 ml distilled water, then by using the refractometer (ATAGO® Pocket PAL-α-Japan). TSS was measured in °Brix following the procedure described by [14]. The results were recorded in table 1.

Determination of total lipid content

Total lipids (free and conjugated with proteins) were determined using a rapid soxhlet extraction system, Gerhardt Soxtherm System and adopting the method of (A.O.A.C., 2000) [15]. Tested sample was first digested with boiling HCl to liberate the conjugated lipids. The digestion solution was filtered and the fat remaining in the filter left to dry, extracted with petroleum ether and the solvent evaporated. The dried residue was weighed and total lipid content (%w/w) was calculated (Table 1).

Determination of sugars

Total hydrolysable carbohydrates were determined spectrophotometrically using Perkin Elmer Lambda 11 Spectrophotometer: (Perkin Elmer, Massachusetts, USA) and adopting the

method of Masuko et al., [16]. While, glucose, fructose and sucrose were determined using liquid chromatography with refractive index detection following the method mentioned before [17]. HPLC analyses of sugars were performed on HPLC/ Agilent 1100, equipped with G1311A quaternary pump, G1322A degasser, G1329A autosampler, G1330A chiller, G1316A column compartment, Chemostation Software and coupled with a G1382A refractive index detector. A Carbohydrate Analysis Column (150 mm length x 4.5 mm ID) packed with Zorbax (particle size, 5µm in diameter) was used. Column temperature was 25°C; isocratic elution was carried out using acetonitrile: water (75: 25) as mobile phase at a flow rate of 1 ml/min. The results were recorded in table 1.

Determination of vitamins:

Vitamin C was determined spectrophotometrically [18]. Vitamin A and E were determined by adopting the spectrophotometrical method described before [19]. The results were recorded in table 1.

Determination of mineral content

Sodium, calcium, iron, manganese, magnesium, copper, zinc and cobalt were determined using Inductively Coupled Plasma (ICPA-AES, Thermo Sci, model: ICAP6000 series) and Advanced Microwave Digestion System according to the procedure described before [20]. The results were recorded in table 2.

TABLE 1. Nutritional analysis of the ripe fruits of F. glaucescens DC.

Nutritional Compound	*Concentration
Total soluble solids (TSS)	13.5 °Brix
pH	4.7
Fiber content (g/100 g D.W.)	10.1
Total carbohydrates (g/100 g D.W.)	18.8
Total lipid (g/100g D.W.)	1.3
Protein content (g/100 g F.W.)	1.2
Glucose (g/100 g D.W.)	2.017
Fructose (g/100 g D.W.)	3.189
Sucrose (g/100 g D.W.)	0.358
Vitamin A (IU/100 g F.W.)	1083.3
Vitamin E (IU/100 g F.W.)	3565.07
Vitamin C (mg/100 g F.W.)	503.12

*Average concentration of three determinations, D.W.; dry weight, F.W., fresh weight.

TABLE 2. Major mineral composition of the ripe fruits of F. glaucescens DC.

Mineral contents	*Concentration (mg/100g D.W.)
Calcium	41.35
Magnesium	13. 85
Sodium	29.7
Iron	3.905
Zinc	0.307
Copper	0.14
Cobalt	0.135
Manganese	0.098

*Average concentration of three determinations, D.W.; dry weight.

Determination of protein and amino acid contents

Total proteins were measured as total nitrogen by adopting the method of (A.O.A.C., 2016) [14]. While, Amino acids were estimated according to the method of Durrum et al., [21]. Amounts of free amino acids were determined according to the method described before [21]. The methanolic extract (10 mg) was hydrolyzed in a sealed tube with 6 N HCl (10 ml, 110°C, 24 h). A definite volume (1 ml) of the acid hydrolysate was treated with successive amounts of distilled water and subjected to vacuum distillation at 80ºC to remove any residual HCl and water evaporated to dryness. The residue was dissolved in the loading buffer (2 ml, 6.2M, pH 2.2) followed by filtration (0.45µ membrane). Amounts of free amino acids were determined by using an Automatic Amino Acid Analyzer AAA 400 adopting the analytical conditions adopted were; flow rate, 0.2 ml/min; buffer pressure, 0-50 bar; reagent pressure, 0-150 bar; reactor temperature, 121°C. The results obtained were compared with those of standard solution of amino acids. Determination of free amino acids was confirmed by comparing the retention times and peak areas of amino acid standards with those of the components present in the sample. The results obtained were compared with those of standard solution of amino acids. Determination of free amino acids was confirmed by comparing the retention times and peak areas of amino acid standards with those of the components present in the sample. The results were recorded in table 3.

TABLE 3. Amino acid composition of the ripe fruits of F. glaucescens DC.

Protein and amino acid contents	*Conc. in Ripe fruits mg/g D.W.	
Essential Amino Acids	Histidine	0.09
	Isoleucine	0.10
	Leucine	0.18
	Lysine	0.16
	Phenylalanine	0. 46
	Threonine	0.48
	Valine	0.28
Non-Essential Amino Acids	Alanine	0.36
	Arginine	0.108
	Glutamic acid	0.34
	Glycine	0.65
	Proline	0.006
	Serine	0.45
	Tyrosine	0. 25

*Average concentration of three determinations, D.W.; dry weight

Determination of total phenolics and flavonoids contents

The determination of total antioxidant phenolics in the ripe fruits was determined by the Folin–Ciocalteu method and adopting the procedures described before [22]. Briefly, 5 mg of the methanolic extract of the fruits was dissolved in distilled water (5 ml) by sonication, to yield a solution with a final concentration of 1 mg/ml. An aliquot (1 ml) of each standard dilution was placed in a volumetric flask (10 ml) and mixed with diluted Folin– Ciocalteu reagent (0.5 ml). After 3 min, 20% sodium carbonate solution (1 ml) was added. The flask was filled with distilled water up to 10 ml. After 30 min, absorbance of blue color was measured at λ_{max} 725 nm using Unicam UV–visible Spectrometer against a blank prepared at the same time, using 1 ml of distilled water instead of gallic acid solution. Gallic acid was used to compute the standard curve (20, 40, 60, 80, 100 mg/ml). Determination was carried out in triplicates; results were the mean values ± standard deviations and expressed as mg gallic acid equivalents per gram dry extract (mg GAE/g). The Quantification of total flavonoids was determined using aluminium chloride reagents [23]. 1 mg of the methanolic extract was dissolved in methanol (1 ml) by sonication, then a test solution (1 ml) was mixed with 0.1 ml aluminium chloride (10%), 0.1 ml potassium acetate (1M) solution and 2.8 ml distilled water. The intensity of the developed yellow color was measured immediately at λ_{max} 420 nm using a UV spectrophotometer against a blank prepared at the same time, using 1 ml methanol. Quercetin was used as standard and the equivalents (w/w) were determined from a standard concentration curve (20, 40, 60, 80, 100 mg/ml), Determination was carried out in triplicates; results were the mean values ± standard deviations and expressed as mg quercetin equivalents (QE) per gram dry weight.

Quantitative determination of phenolic compounds by HPLC-UV

Quantitative determination of phenolic compounds was performed using HPLC apparatus, Agilent Series 1200 apparatus (Agilent, USA) composed of autosampling injector, solvent degasser, quaternary HP pump (series 1200), 1100 ChemStation software and ultraviolet (UV) detector (set at 280 nm for phenolic acids and 330 nm for flavonoids). The analysis was achieved on a zobrax ODS C18 column (particle size 5 µm, 250 mm × 4.6 mm Ø). Column temperature was maintained at 35◦C. Flavonoid separation was done adopting the method described earlier [24], using a mobile phase consisting of 50 mM H_3PO_4, pH 2.5 (solution A) and acetonitrile (solution B) acetic acid (40:60, v/v) in the following gradient: isocratic elution 95% A: 5% B, 0–5 min; linear gradient from 95% A: 5% B to 50% A: 50% B,5–55 min; isocratic elution 50% A: 50% B, 55–65 min; linear gradient from 50% A: 50% B to 95% A: 5% B, 65–67 min. The flow rate of the mobile phase was 0.7 ml/min. Phenolic acids separation was done adopting the method of Goupy et al., [25] with a solvent system consisting of A (aqueous acetic acid 2.5%), B (aqueous acetic acid 8%) and C (acetonitrile) in the following gradient: at 0 min, 5%B; at 20 min, 10% B; at 50 min, 30% B; at 55 min, 50% B at 60 min,100% B; at 100 min, 50% B and 50% C; at 110 min, 100% C until 120 min. The solvent flow rate was 1 ml/min. The injection volumes were 5 µL. Standard flavonoids and phenolic acids were prepared as10 mg/50 ml solutions in methanol and they were diluted to make concentrations (20–40 µg/ml) and injected into HPLC. Quantification of compounds was performed based on peak area computation (external standard method). The analysis was run in triplicates and HPLC chromatograms were demonstrated in Fig. 1-2 and the concentrations of the identified compounds were expressed as (mg ± SD/100 g dry weight) and listed in Table 4.

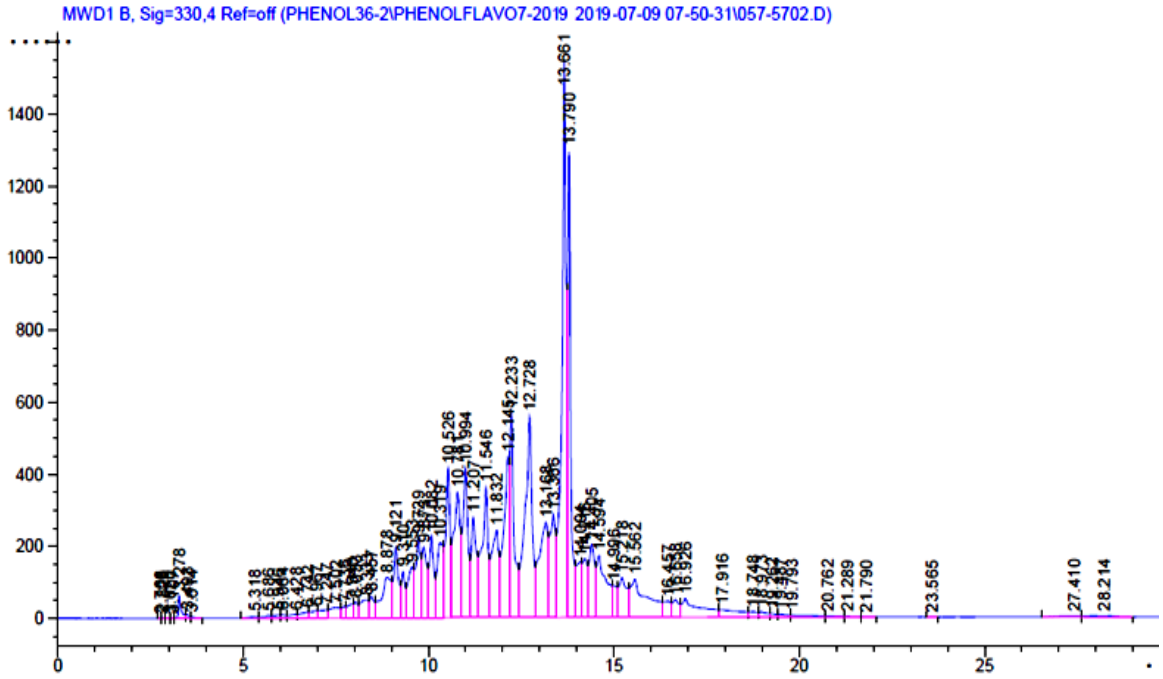

Fig.1. HPLC chromatogram showing identified flavonoids in the methanolic extract of the ripe fruits of F. glaucescens DC. measured at 330 nm.

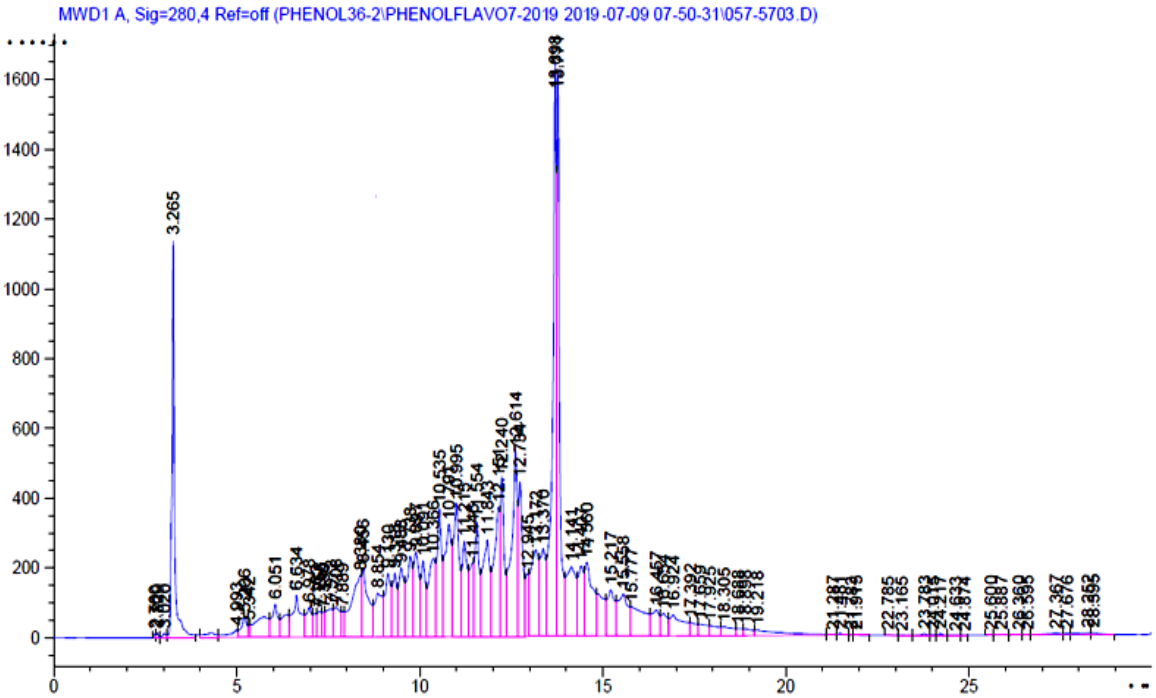

Fig.2. HPLC chromatogram showing identified phenolic acids in the methanolic extract of F. glaucescens ripe fruits measured at 280 nm.

TABLE 4. Quantifications of some phenolic compounds identified in the methanolic extract of F. glaucescens ripe fruits using HPLC-UV.

Compound	RT (min)	*Conc. mg± SD/100g	Reference
Identified Flavonoids			
Epicatechin	8.87	2.8±0.02	[26]
Catechin	9.12	3.9±0.05	[27]
Naringin	11.54	8.7±0.8	[27]
Quercitrin	12.14	13.3±0.5	[26]
Hesperidin	12.23	13.8±1.07	[27]
Rutin	13.16	3.3±0.2	[26]
Naringenin	13.66	23.4±1.2	[26]
Apigenin	13.79	16.7±0.78	[26]
Hesperitin	14.4	11.1±0.13	[27]
Quercetin	14.58	11.3±0.79	[27]
Kaempferol	15.56	11.6±0.22	[27]
Luteolin	16.45	1.2±0.6	[27]
Identified Phenolic acids			
p-Hydroxy benzoic acid	3.26	19±0.84	[28]
Benzoic acid	4.99	1.3±0.08	[29]
Vanillic acid	6.05	3.3±0.2	[28]
Pyrogallol	8.34	2.6±0.09	[26]
O-Coumaric acid	8.85	2.2±0.4	[26]
P-Coumaric acid	10.53	9±0.27	[27]
Gallic acid	10.79	9.5±0.14	[27]
Protocatechuic acid	10.99	14.4±0.15	[27]
Caffeic acid	11.55	9.4±0.4	[27]
Syringic acid	11.84	5.3±0.8	[30]
Chlorogenic acid	12.24	14.2±0.12	[28]
Ferulic acid	12.61	15.4±1.05	[26]
3,4,5 Trimethoxy cinnamic	12.73	12.2±0.74	[26]
Iso-ferulic acid	12.94	3.3±0.1	[26]
Cinnamic acid	13.59	22.37±0.9	[27]
4-Aminobenzoic acid	14.14	2.5±0.7	[26]
Rosmarinic acid	14.56	2.7±0.09	[29]
Ellagic acid	15.21	1.3±0.03	[27]
Catechol	15.55	2.5±0.02	[26]

*Average concentration of three HPLC determinations ± SD, RT; retention time in minutes.

Evaluation of free radical-scavenging activities of the methanolic extract of the fruits using DPPH assay

The antioxidant activity of the methanolic extract of the ripe fruits was assessed by measuring their ability to scavenge DPPH (2, 2-diphenyl-1-picrylhydrazyl) free radicals according to the previously reported method [31]. Briefly, the methanolic extract was dissolved in 50% methanol at concentrations of 25, 50, 100, 200, 300, and 400 µg/ml, then were mixed with 1 ml of DPPH in methanol (0.02 g /1000 ml methanol) and 450 µl of 50 mM Tris-HCl buffer (pH 7.4). The solutions were incubated for 30 min in the dark at room temperature; the reduction of DPPH free radicals was measured by reading the absorbance at 517 nm against the blank. All experiments were performed in triplicates and the results were expressed as mean ± SD. L-ascorbic acid was used as a standard for antioxidant activity, Different concentrations of vit. C was prepared from the stock solution (0.1 g /100 ml methanol). The concentration (µg/ml) of the extract that was required to scavenge 50% of the radicals was calculated from the equation; Percentage inhibition (%) was calculated as follows: Percentage of scavenging activity (%) = [1-(absorbance of sample- Absorbance of control)] × 100

Results and Discussion

The nutritional analysis results of F. glaucescens ripe fruits were listed in Table 1. The amount of Total Soluble Solids (TSS) in the fruits was 13.5 °Brix. By comparing the result with reported values of other *Ferocactus* fruits [13], it was noticed that the TSS of F. glaucescens fruit was little higher than that of *F. histrix* (12.72 °Brix) indicating a higher percentage of sugars and other dissolved solids. For pH, Data in table 1 revealed that the fruits are slightly acidic. These results are in agreement with previous reports [13], which revealed that the total titrable acidity is decreased during the ripening process. A pH of 5.5 or higher is traditionally considered to be the critical for enamel dissolution [32]. The pH of *F. glaucescens* fruits (4.7) is low enough to induce erosion on enamel surface. Thereby, the integration of F. glaucescens fruits in human diet is safe and advantageous. The crude fiber content of the fruits was 10.1%, therefore, the fruits could be considered as an excellent source for dietary fibers. From table 1, it could be concluded that the ripe fruits were rich in glucose (2.017 g/100g), fructose (3.189 g/100g) and sucrose (0.358 g/100g). Also, the ripe fruits had more vitamins C (503.12 mg/100g) and E (3565.07 IU/100g) but less vitamin A (1083.3 IU/100g). Thereby, the fruits of *F. glaucescens* DC., could be considered as an excellent dietary source of vitamin A which is important for vision, expression of genes, growth and development as well as proper immune function. In addition, the fruits are rich source of vitamin C which plays an important role as a cofactor for many metabolic reactions and serves as antioxidant [33]. The results of mineral analysis of the fruits (table 2) showed that they are rich in calcium (41.35 mg/100 g), which is necessary for blood clotting, muscle movement, transmission of nerve signals and for formation of bones and teeth [34], also the fruits are rich in iron content (3.905 mg/100 g), which is an essential component of enzymes and haemoglobin in the body and also prevents anemia [33]. From table 1, it is evident that *F. glaucescens* fruits contain, in general, low fat and low protein contents (1.3 and 1.2 %, respectively). The fruits are rich in essential amino acids and non-essential amino acids (Table 3), that are essential for protein synthesis and metabolism. Therefore, the fruits could be considered as good source of essential nutrients and compounds that produce beneficial physiological effects.

Phenolic compounds such as, phenolic acids, flavonoids and anthocyanins have been associated with numerous bioactivities including antioxidant, anticarcinogenic and anti-inflammatory effects [35]. Many epidemiological studies suggested that the consumption of natural antioxidants such as fresh fruits providing protection against oxidative degradation from free radicals [36]. Therefore, the polyphenolic and flavonoid contents in the ripe fruits of *F. glaucescens* DC. were evaluated spectrophotometrically and by using HPLC-UV analysis. The methanolic extract of the ripe fruits were shown to be rich in flavonoids and phenolic compounds. The phenolic content in the fruits estimated as gallic acid equivalent was 8.39±0.074 mg/g (GAE). While, the flavonoidal content estimated as quercetin was found to be 3.82±0.019 mg/g (QE).

HPLC analysis of the phenolic compounds in the methanolic extract of the ripe fruits of *F. glaucescens* DC., has enabled the identification and quantification of 31 phenolic compounds (12 flavonoids and 19 phenolic acids). Their respective concentrations in the ripe fruit are

presented in table 4. Naringenin and apigenin were the major flavonoids identified 23.4±1.2 and 16.7±0.78 mg/100g, respectively of the dried powdered fruits. The percentage of total identified phenolic acids was 1.49% in the ripe fruit. trans-cinnamic and p-hydroxy benzoic acid were the major phenolic acids identified 22.37±0.9 and 19±0.84 mg/100g, respectively of the dried powdered fruits.

DPPH free radicals can be used to evaluate the antioxidant activity in a relatively short time [37]. Thus, the methanolic extract of the fruits was evaluated by DPPH radical scavenging assay. The extract of the fruits significantly inhibited the activity of DPPH radicals in a dose-dependent manner and its activity was comparable to that of ascorbic acid, which was used as a control antioxidant. The concentration required to achieve a 50% reduction in DPPH radicals (IC_{50}) was 120.24 ± 0.66 compared to vit. C (IC_{50} = 90.37 ± 0.23 µg/ml). The highest antioxidant capacity of the fruits was in agreement with their highest content of phenolic acids and flavonoids (Table 4).

Conclusion

The present study shows that the underutilized *F. glaucescens* fruits had appreciable amounts of antioxidant compounds such as ascorbic acid, phenolics and flavonoids which provide a good antioxidant capacity. Also, the ripe fruits could be a potential source of dietary fiber, protein, vitamins and minerals and can be used in balanced diets and functional foods. Finally, this evaluation of the nutraceutical properties of F. glaucescens fruits, provides a chemical based evidence for their nutritive and health benefits and suggests an increase in the plant propagation. This, not only for edible purposes but for its promising economical and pharmaceutical benefits as well.

References

1. Yuan Y., Capps O., and Nayga R.M., Assessing the demand for a functional food product: Is there cannibalization in the orange juice category?. *Agri. and Resource Econ. Rev.* **38**(2): p. 153-165 (2009).
2. Arvanitoyannis I.S. and Van Houwelingen-Koukaliaroglou M., Functional foods: a survey of health claims, pros and cons, and current legislation. *Crit. Rev. Food Sci. & Nutr.* **45**(5): p. 385-404 (2005).
3. Sudhakaran A. and Nair G.A., Nutritional Evaluation of Fruits of Gynochthodes umbellata (L.) Razafim. & B. Bremer–An Underutilized Edible Fruit Plant. *Phcog J.* **8**(1) (2016).
4. Tesoriere L., Butera D., Pintaudi M., Allegra M., and Livrea M.A., Supplementation with cactus pear (Opuntia ficus-indica) fruit decreases oxidative stress in healthy humans: a comparative study with Vit C. *Am J Clin Nutr.* **80** (2004).
5. Shetty A.A., Rana M., and Preetham S., Cactus: a medicinal food. *J. of food sci. and tech.* **49**(5): p. 530-536 (2012).
6. Piga A., Cactus pear: a fruit of nutraceutical and functional importance. *J. Prof Assn. Cactus Dev.* **6**: p. 9-22 (2004).
7. Stintzing F.C., Schieber A., and Carle R., Phytochemical and nutritional significance of cactus pear. *Eur Food Res Tech*. **212**(4): p. 396-407 (2001).
8. Stintzing F.C., Herbach K.M., Mosshammer M.R., Carle R., Yi W., Sellappan S., Akoh C.C., Bunch R., and Felker P., Color, betalain pattern, and antioxidant properties of cactus pear (Opuntia spp.) clones. *J. of Agri.and Food Chem.* **53**(2): p. 442-451 (2005).
9. Butera D., Tesoriere L., Di Gaudio F., Bongiorno A., Allegra M., Pintaudi A.M., Kohen R., and Livrea M.A., Antioxidant activities of Sicilian prickly pear (Opuntia ficus indica) fruit extracts and reducing properties of its betalains: betanin and indicaxanthin. *J. of Agri and Food Chem*. **50**(23): p. 6895-6901 (2002).
10. Abdel-Razek A.G., Shehata M.G., Badr A., Gromadzka K., and Stępień L., The Effect of Chemical Composition of Wild Opuntia Ficus Indica Byproducts on its Nutritional Quality, Antioxidant and Antifungal Efficacy. *Egyptian Journal of Chemistry,* (2019).
11. Harlev E., Nevo E., Solowey E., and Bishayee A., Cancer Preventive and Curative Attributes of Plants of the Cactaceae Family: A Review. *Planta Med.* **79**(9): p. 713-722 (2013).
12. del Castillo R.F. and Trujillo S., Ethnobotany of Ferocactus histrix and Echinocactus platyacanthus (Cactaceae) in the semiarid central Mexico: past, present and future. *Econ. Bot.* **45**(4): p. 495-502 (1991).

13. Álvarez-Sánchez J., Mercado-Silva E.M., Vázquez-Barrios M.E., Bárcenas R.T., and Rivera-Pastrana D.M. *Effect of ripening stage at harvest on phytochemical composition of "huamiche" (Ferocactus histrix) fruit. in ASHS 2015 Annual Conference.* 2015.

14. Latimer G.W.J., International A., and Cunniff P., *Official Methods of Analysis of AOAC International.* AOAC International (2016).

15. Horwitz W. and Chemists A.o.O.A., *Official methods of analysis of the AOAC.* Association of Official Analytical Chemists (2000).

16. Masuko T., Minami A., Iwasaki N., Majima T., Nishimura S.-I., and Lee Y.C., Carbohydrate analysis by a phenol–sulfuric acid method in microplate format. *Anal. Biochem.* **339**(1): p. 69-72 (2005).

17. Varandas S., Teixeira M.J., Marques J.C., Aguiar A., Alves A., and Bastos M.M.S.M., Glucose and fructose levels on grape skin: interference in Lobesia botrana behaviour. *Analytica Chimica Acta.* **513**(1): p. 351-355 (2004).

18. Iqbal H., Lajber K., Khan M., Khan F., and Sultan A., UV spectrophotometric analysis profile of ascorbic acid in medicinal plants of Pakistan. *World Appl Sci J.* **9**(7): p. 800-803 (2010).

19. Hawk P.B., Oser B.L., and Summerson W.H., *Practical Physiological Chemistry.* Blakiston Company (1937).

20. Kira C.S., Maio F.D., Maihara V.A., and Maihara V.A., Comparison of partial digestion procedures for determination of Ca, Cr, Cu, Fe, K, Mg, Mn, Na, P, and Zn in milk by inductively coupled plasma-optical emission spectrometry. *Journal of AOAC International.* **87**(1): p. 151-156 (2004).

21. Durrum E.L., Block R.J., and Zweig G., *A manual of paper chromatography and paper electrophoresis.* Academic Press (1958).

22. Shweta S., Ritesh T., Khadabadi S.S., and Deokate U.A., In vitro antioxidant activity and total phenolic, flavonoid contents of the crude extracts of Pterospermum acerifolium Willd leaves (Sterculiaceae). *J Chem Pharm Res.* **2**(3): p. 417-423 (2010).

23. Kiranmai M., Kumar C., and Ibrahim M., Comparison of total flavanoid content of Azadirachta indica root bark extracts prepared by different methods of extraction. *Res J Pharm Biol Chem Sci.* **2**(3): p. 254-261 (2011).

24. Mattila P., Astola J., and Kumpulainen J., Determination of flavonoids in plant material by HPLC with diode-array and electro-array detections. *J. of Agri.and Food Chem.* **48**(12): p. 5834-5841 (2000).

25. Goupy P., Hugues M., Boivin P., and Amiot M.J., Antioxidant composition and activity of barley (Hordeum vulgare) and malt extracts and of isolated phenolic compounds. *J. of the Sci. of Food and Agri.* **79**(12): p. 1625-1634 (1999).

26. EL MESALLAMY A.D.E.D., Ahmed F.A., and El-Bassossy T., Chemical Investigation of Flavonoid, Phenolic Acids and Vitamins Compositions of Forsskaolea viridis Aerial Parts. *Egyptian Journal of Chemistry.* **62**(10): p. 1815-1822 (2019).

27. Ibrahim R.M., El-Halawany A.M., Saleh D.O., El Naggar E.M.B., El-Shabrawy A.E.-R.O., and El-Hawary S.S., HPLC-DAD-MS/MS profiling of phenolics from Securigera securidaca flowers and its anti-hyperglycemic and anti-hyperlipidemic activities. *Rev Bras de Farmacog.* **25**(2): p. 134-141 (2015).

28. Ammar N.M., EL-HAWARY S., Mohamed D.A., Afifi M.S., Ghanem D.M., and Awad G., Phytochemical and biological studies of Tribulus terrestris L. growing in Egypt. *Inter J. Pharmacology.* **14**(2): p. 248-259 (2018).

29. Erian N., Hamed H., El-Khateeb A., and Farid M., Phytochemical, HPLC Analysis and Antibacterial Activity of Crude Methanolic and Aqueous Extracts for Some Medicinal Plants Flowers. *Arab Journal of Science and Research Publishing.* **17**(3207): p. 1-11 (2016).

30. Mohamed S.A., Sokkar N.M., El-Gindi O., Zeinab Y., and Alfishawy I.M., Phytoconstituents investigation, anti-diabetic and anti-dyslipidemic activities of Cotoneaster horizontalis Decne cultivated in Egypt. *Life Sci J.* **9**: p. 394-403 (2012).

31. Lee J.-C., Kim H.-R., Kim J., and Jang Y.-S., Antioxidant property of an ethanol extract of the stem of Opuntia ficus-indica var. saboten. *J. Agric. Food Chem.* **50**(22): p. 6490-6496 (2002).

32. Cavalcanti A.L., Oliveira P.S.d., Evangelista A.P.d.A., Vieira F.F., Granville-Garcia A.F., and Cavalcanti C.L., pH and Total Soluble Solid Content in Concentrated and Diluted in Natura Tropical Fruit Juices. *Acta Stom Croat.* **42**(4): p. 229-234 (2008).

33. Slavin J.L. and Lloyd B., Health Benefits of Fruits and Vegetables. *Adv. Nutr*. **3**(4): p. 506-516 (2012).

34. Pravina P., Sayaji D., and Avinash M., Calcium and its role in human body. *Int. J. Res. Pharm. Biomed. Sci.* **4**(2): p. 659-668 (2013).

35. Huang W.-Y., Cai Y.-Z., and Zhang Y., Natural phenolic compounds from medicinal herbs and dietary plants: potential use for cancer prevention. *Nutr. Cancer*. **62**(1): p. 1-20 (2009).

36. Almeida M.M.B., de Sousa P.H.M., Arriaga Â.M.C., do Prado G.M., de Carvalho Magalhães C.E., Maia G.A., and de Lemos T.L.G., Bioactive compounds and antioxidant activity of fresh exotic fruits from northeastern Brazil. *Food Res. Int.* **44**(7): p. 2155-2159 (2011).

37. Morales P., Ramírez-Moreno E., de Cortes Sanchez-Mata M., Carvalho A.M., and Ferreira I.C., Nutritional and antioxidant properties of pulp and seeds of two xoconostle cultivars (Opuntia joconostle FAC Weber ex Diguet and Opuntia matudae Scheinvar) of high consumption in Mexico. *Food Res Int.* **46(**1): p. 279-285 (2012).

التقييم الغذائي و التحقق الكيميائي للمركبات الفلافونيديات والأحماض الفينولية و التاثير المضاد للاكسدة للثمار الناضجة لصبار الفيروكاكتس جلوسيسنس

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يهدف البحث الحالي إلى تقييم الخواص الغذائية للثمار الناضجة لصبار الفيروكاكتس جلوسيسنس لأول مرة. تم تعيين محتوي الفلافونيدات والفينولات الكلية عن طريق المقايسة اللونية للمستخلص الميثانولي للثمار وتم إجراء القياس الكمي لمكوناتها باستخدام كروماتوجرافيا السائل ذات الكفاءة العالية و قد تم تقييم نشاط مضادات الأكسدة في المستخلص باستخدام طريقة DPPH. وقد بلغ مجموع الفينولات والفلافونويدات المقدرة بحمض الغاليك وبالكيرسيتين (ملغم / غرام من المستخلص المجفف) 8.39 ± 0.074 و 3.82 ± 0.019 على التوالي. أتاح تحليل HPLC للمركبات الفينولية تحديد وتقدير 31 من المركبات الفينولية (12 فلافونويد و 19 أحماض فينولية). كان نارينجينين هو الفلافونويد الرئيسي المحدد (23.4 ± 1.2 ملغم / 100 جم). في حين كان حمض السينناميك العابر هو حمض الفينول الرئيسي المحدد (22.37 ± 0.9 ملغم / 100 جم). أيضا ، كشفت مقايسة DPPHنشاط مضادات الأكسدة ملحوظ للمستخلص الميثانولي. وقد تم الكشف عن محتوى الكربوهيدرات (18.8 جم / 100 جم) ، البروتين (1.2 جم / 100 جم) ، الدهون الكلية (1.3 ٪) والألياف الخام (10.1 ٪). كان فيتامين ج (503.12ملغم / 100 جم) أعلى مقارنةً بفيتامينين آخرين تم تقييمهما. كما تم تقدير ثماني معادن. هذه النتائج تشير إلى أن ثمار الفيروكاكتس جلوسيسنس هي مصدر غني من المواد الغذائية والمركبات المضادة للأكسدة مثل المركبات الفينولية ويوصى بشدة استهلاكها.