Original article

Fresh figs (*Ficus carica* L.): pomological characteristics, nutritional value, and phytochemical properties

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Summary

***Ficus carica* L. (*Moraceae*) is a wild spread tree including more than 600 cultivars with different phenotypic characteristics. Their fruits are a good natural source of nutrients, minerals, and phytochemicals, which may improve human health. The pomological characteristics of nine Algerian cultivars of fresh figs were determined using descriptors resulting from the IPGRI and CIHEAM list. The consumer test was carried out using an in-store consumer test. The proximal components (dry matter, ash, titratable acidity, crude protein (Kjeldahl), ascorbic acid, and carbohydrates) were estimated using the AFNOR and Dubois methods. Minerals (Ca, K, and Na) were analyzed using a flame spectrophotometer. Phosphorus, phenolic, flavonoid, anthocyanin, and condensed tannin concentrations were quantified by UV-spectrophotometer. The antioxidant capacity was evaluated using the 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay. The pomological results obtained made it possible to discriminate between the different fig cultivars. Skin color results indicate two groups (light skin and dark skin groups). The consumers preferred 'Boughandjo', 'Bither', and 'Bakkor Biadh', with high percentages of acceptance (68.75, 70.31 and 75%). Figs are a good source of carbohydrates (especially 'Safra' pulp [26.02 ± 0.63 g 100 g^{-1} Fresh weight]), vitamin C (10.67 ± 0.31 mg 100 g^{-1} Fresh weight for 'Onk Elhamam' peel), and potassium and calcium (266.67 ± 2.78 and 125.44 ± 3.37 mg 100 g^{-1} Fresh weight for 'Bakkor Khal' peel, respectively). In the majority of the tested cultivars, peels exhibited higher phenolic (1.63 vs. 1.11 mg gallic acid equivalents g^{-1} Fresh weight), flavonoid (147.76 vs. 83.82 µg quercetin equivalents g^{-1} Fresh weight), anthocyanin (64.82 vs. 41.72 µg cyanidin-3-rutinoside equivalents g^{-1} Fresh weight) and condensed tannin (6.08 vs. 2,06 µg catechol equivalents g^{-1} Fresh weight) levels and antioxidant activities (18.91 vs. 29.51 mg mL^{-1}) than pulps. Peels of dark cultivars showed higher phytochemical and antioxidant properties than those of light cultivars. Antioxidant activity was correlated with total phenolic and condensed tannin concentrations (r = 0.521 and 0.659). The pomological characterization and consumer tests reported here are important for allowing farmers to judge about the potential of the tested cultivars and could be helpful during fig breeding and cultivar selection. Based on their diversity, tastes, nutritional and phytochemical attributes, we recommend figs (especially those with dark skin) as healthy food.**

Significance of this study

What is already known on this subject?

- The diversity of figs, their nutritional contribution in the diet, and their impact on human health has been studied for many cultivars around the world. Nevertheless, there are more than 600 fig tree cultivars. Here we describe novel cultivars from the Mediterranean region. We highlighted the nutritional value and phytochemical characteristics of fig peel because the majority of consumers tend to peel figs before consumption.

What are the new findings?

- By pomological characterization, we were able to discriminate between the studied cultivars. Also, using a sensory test, we found that consumers prefer some unknown and underutilized cultivars ('Bither', 'Boughandjo', 'Zarrouk', and 'Hamra'). Fig peel, especially of dark skin cultivars, is an important source of minerals such as calcium and potassium and of phytochemicals, which have a positive impact on human health.

What is the expected impact on horticulture?

- Our data will likely help farmers to select the most appropriate cultivars for fresh consumption, especially those of higher yield (e.g., 'Boughandjo') and precocious types (e.g., 'Bither'). Our data will also help farmers identify those cultivars with the greatest nutritional value and phytochemical properties.

Keywords
consumer test, cultivars, descriptors, minerals, *Moraceae*, phenolics, proximal components

Introduction

The Common Fig (*Ficus carica* L.) is a tree native to southwest Asia and the eastern Mediterranean region, belonging to the botanical family *Moraceae* (Duenas et al., 2008). The fig tree is cultivated for its fruit in warm and dry climates, and the dried fruit has been a familiar food for humans since 3000 BC (Hatano et al., 2008).

In the northern Mediterranean region, fig trees produce one or two crops per year, depending on the cultivar (Veberic et al., 2008). Annually, over 1 million tons of fresh figs are harvested from 308,460 hectares worldwide. Mediterranean countries are the main fig producers. Algeria produces 12.54% of the total global fig crop (FAO, 2016).

In Algeria, fig trees are grown all over the country (coastal, steppe and Saharan areas) because of its pedoclimatic adaptation, nutritional and therapeutic values, and its place in the culinary practices of the Algerians. Algerian fig production is concentrated primarily in the Kabyle mountainous area (Bejaia and Tizi-Ouzou account for 27% and 13% of total national production respectively) (MADR, 2012).

These fruits have forms, colors, tastes, technological and therapeutic properties that differ between varieties and are generally named according to their shape, color, and the region in which it is most cultivated. In 1850, more than 70 fig varieties were introduced to Algeria. However, these were not adopted by the local farmers, who continued to grow the fig trees that were familiar to them. Recently, the Technical Institute of Fruit-bearing Arboriculture in Algeria described 40 varieties, including comestible varieties and caprifig types (Chouaki, 2006; Meziant et al., 2015). However, the number of cultivars grown in Algeria is likely to be much greater than these 40 varieties.

Figs are an excellent source of minerals, vitamins, and dietary fiber; they are fat and cholesterol-free and contain a high number of amino acids (Slavin, 2006; Solomon et al., 2006). Similarly to other fruit species, figs contain sugars and organic acids that influence their quality (Veberic et al., 2008).

Several studies have been made on the phenolic compounds of figs such as phenolic acids, flavonoids, and anthocyanins with antioxidant capacity have been isolated from fig fruits (Duenas et al., 2008; Veberic et al., 2008; Çaliskan and Polat, 2011). Antioxidant compounds scavenge free radicals, thus inhibiting the oxidative mechanisms that lead to degenerative illnesses (Oliveira et al., 2009).

Here we aimed to characterize the genetic diversity of some fig genotypes grown in Algeria using pomological descriptors, and to evaluate their consumer acceptance. We also aimed to highlight the varietal influences on the nutritional value, the phytochemical composition, and the antioxidant activities of pulps and peels of those fig cultivars. This study is a contribution to the knowledge and the valorization of some dark and light, fresh figs. To our knowledge, this is the first such work on these cultivars.

Materials and methods

Standards and reagents

All standards and reagents used in this study were of analytical grade and purchased from Merck Chemicals, Sigma-Aldrich (Germany), Cheminova (France), Fluka or Rectapur.

Plant materials

Local fresh and ripe figs (*Ficus carica* L.) of nine cultivars ('Bakkor Biadh', 'Bakkor Khal', 'Bidha', 'Bither', 'Boughandjo', 'Hamra', 'Onk Elhamam', 'Safra', and 'Zarrouk') (Supplementary Figure S1) were collected during August and September 2015 and 2016 from an orchard in Lakhdaria (the mountain), Department of Bouira (Northeast of Algeria). For the pomological assessment, 25 fruits were randomly taken from three to five trees for each cultivar (age: 15 to 20 years) in each year and were immediately transferred to the laboratory and analyzed. The fruit pulp (500 g) and peel (500 g) of each cultivar (production of 2016) were separated, blended and frozen at -18°C until used for nutritional and phytochemical analyses.

Pomological assessment

Twenty-eight qualitative and quantitative pomological descriptors resulting from the IPGRI and CIHEAM (2003) list were used to discriminate between the studied fig cultivars. Qualitative descriptors concerned: beginning of maturation, harvest period, production type, fruit internal and external color, fruit skin cracks, peeling of skin, fruit shape [index (width/length)= I], fruit shape according to the location of the maximum width, pulp juiciness and flavor, drop at the eye, color of liquid drop at the eye, fruit lenticels quantity, lenticels color, and fruit cavity. The quantitative descriptors comprised: fruit weight, pulp weight, peel weight, fruit length, fruit width, fruit skin thickness, neck and stalk length, ostiole width, and titratable acidity.

Fig skin color

Fig skin color measurements were made using a portable tristimulus color analyzer (Konica MINOLTA CM-2600 d) and expressed in International Commission on Illumination (CIE) L*, C*, h*, a* and b*. The colorimeter was calibrated using the manufacturer's standard reference black and white calibration tiles. Skin color was measured on four fresh fruits by cultivar and at three random positions per fruit (Crisosto et al., 2010; Çaliskan and Polat, 2011).

Table S1. Correlation coefficients (r) of phytochemical, color and antioxidant parameters of fig cultivars.

Parameters	Y	PC	FC	AC	CTC	IC50	L*	C*	h*
Y	1.000	0.321	0.145	0.351	0.176	-0.207	0.266	0.291	0.250
PC	**0.321**	1.000	0.227	0.364	0.779	-0.521	0.386	0.444	-0.084
FC	**0.145**	**0.227**	1.000	0.656	0.455	-0.275	0.197	0.104	0.109
AC	**0.351**	**0.364**	**0.656****	1.000	0.519	-0.345	0.595	0.433	-0.154
CTC	**0.176**	**0.779*****	**0.455**	**0.519***	1.000	-0.659	0.347	0.348	0.144
IC50	**-0.207**	**-0.521***	**-0.275**	**-0.345**	**-0.659****	1.000	0.071	0.097	0.055
L*	**0.266**	**0.386**	**0.197**	**0.595**	**0.347**	**0.071**	1.000	0.979	-0.138
C*	**0.291**	**0.444**	**0.104**	**0.433**	**0.348**	**0.097**	**0.979*****	1.000	-0.124
h*	**0.250**	**-0.084**	**0.109**	**-0.154**	**0.144**	**0.055**	**-0.138**	**-0.124**	1.000

Abbreviations: Y: yield, PC: polyphenol concentration, FC: flavonoid concentration, AC: anthocyanins concentration: CTC: condensed tannin concentration. L*: luminosity, C*: Chroma, h*: hue°. * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Consumer test

The consumer acceptance evaluation of the nine fresh fig cultivars was carried out using an in-store consumer test, as described by Crisosto et al. (2010). Sixty-four consumers (40 males and 24 females) with an interval age ranging from 16 to 55 years were surveyed at a fruit and vegetable store in August 2016.

For each sample, the consumers were asked to taste one half-fig and then to indicate, all things considered, which statement best describes how they feel about the sample on a 9-point hedonic scale (1 = dislike extremely to 9 = like extremely). Consumer acceptance was measured as both degrees of liking (1 to 9) and percentage of acceptance.

Nutritional analysis

Nutritional analyses were carried out on 500 g of peel and pulp of each cultivar resulting from the production of 2016. Dry matter was determined by weighing the fresh sample before and after oven drying at 103 ± 2°C for 16 h and ash by muffle incineration at 550°C (AFNOR, 1982), titratable acidity content was analyzed by titration with 0.1 N NaOH up to pH 8.1 and expressed as g citric acid 100 g^{-1} FW (Sen et al., 2008). Total carbohydrates were estimated by Dubois method (Dubois et al., 1956) and crude protein by Kjeldahl method (AFNOR NEV 03-050, 1970). The content of ascorbic acid was determined as described by Tareen et al. (2015). The minerals including calcium (Ca), potassium (K) and sodium (Na) were analyzed by a flame spectrophotometer. Phosphorus concentration was estimated by the phospho-vanado-molybdic method described by Youshida et al. (1976).

Extraction

For the phytochemical analyses, 10 g of fruit materials were macerated in 100 mL pure methanol for 24 h at room temperature. Extracts were filtered through filter paper n° 1 and solvent was evaporated under reduced pressure at 40°C using a rotary vacuum evaporator (Büchi). The residues were kept under refrigerated conditions until used. The yield (percentage) of evaporated dried extracts was calculated as 100 EW/SW, where EW is extracted weight after evaporation of solvent and SW is sample weight.

Phytochemical analyses

Total polyphenols were measured by the Folin-Ciocalteu method: 200 µL of each extract was mixed successively with 1 ml of Folin-Ciocalteu reagent (10% v/v) and 800 µL of sodium carbonate solution (Na_2CO_3) at 7.5% (w/v). The mixture was incubated for 10 min in a bath at 40°C., and absorbencies were measured at 760 nm. Total polyphenols were expressed as milligrams gallic acid equivalents per gram of fresh weight (mg GAE g^{-1} FW) using a gallic acid calibration curve (Fu et al., 2011). To determine flavonoid concentration, equal volumes of the extract and aluminum trichloride solution at 2% (w/v) were mixed. After 10 min of incubation at room temperature, the absorbencies were read at 430 nm. Total flavonoid concentration was expressed as micrograms quercetin equivalents per gram of fresh weight (µg QE g^{-1} FW) using a quercetin calibration curve (Koolen et al., 2013).

Total monomeric anthocyanin pigment concentrations were measured using the AOAC Official Method 2005.02, as described by Lee et al. (2005): absorbencies of test portions diluted with pH 1.0 buffer, and pH 4.5 buffer were determined at both 520 and 700 nm. Anthocyanin pigment concentration was expressed as micrograms of cyanidin-3-rutinoside equivalents g^{-1} FW and calculated as follows: Anthocyanin pigment = A×MW×DF×1000/ε×l. Where A = (A 520 nm – A 700 nm) pH 1.0 – (A 520 nm – A 700 nm) pH 4.5; MW (molecular weight) = 595.2 (g mol^{-1}) for cyanidin-3-rutinoside; DF = dilution factor; l = path-length (cm); ε = 28 800 molar extinction coefficient (L mol^{-1} cm^{-1}) and 10^3 = factor for conversion from g to mg.

Condensed tannins were quantified using the spectrophotometric method of vanillin in the acid solution described by Ba et al. (2010). A proportion (200 µL) of each extract was mixed with 1 mL of vanillin reagent (a mixture in an equal volume of HCl at 8% [v/v] in methanol and vanillin solution at 4% [w/v] in methanol). The mixture was shaken, incubated at room temperature for 20 min, and the absorbance was determined at 500 nm using a spectrophotometer. The condensed tannin concentration was expressed as micrograms of catechol equivalents per gram of fresh weight (µg CE g^{-1} FW) using a catechol calibration curve.

Antioxidant activity was determined according to Koh et al. (2012). A proportion (0.3 mL) of each extract at different concentrations was mixed with 2.7 mL of DPPH reagent (6×10^{-5} mol L^{-1}). The mixture was incubated in darkness at room temperature for 60 min, and the absorbance was measured at 517 nm. Antioxidant activity (%) was calculated as: antioxidant activity = $((A_{control}-A_{sample})/A_{control}) \times 100$, where $A_{control}$ is the absorbance of the DPPH solution without extract and A_{sample} is the absorbance of the DPPH solution with extract (various concentrations).

Statistical analysis

Results were shown as mean ± SEM. Statistical significance at $p < 0.05$ was determined by ANOVA (one- and two-way) followed by Tukey's multiple comparison tests using GraphPad Prism 6 statistics program.

Results and discussion

Pomological assessment

The qualitative and quantitative pomological characteristics are presented in Tables 1 and 2, respectively. The cultivars 'Bakkor Biadh', 'Bither' and 'Bakkor Khal' are biferous types bearing two crops by year, whereas the others are uniferous types producing the fruits of the second crop in August and September. Except 'Bakkor Biadh' and 'Bither', which were categorized as very early (fruit ripening started at the end of July) with a very short harvesting period (<15 days), the other varieties produce in mid-season (fruit ripening started in the middle of August) and mostly have a short harvesting period (15–20 days). Periods of fruit ripening and of harvestings of the studied cultivars varied from year to year, depending on the climate conditions. Generally, in hot summers, fig ripening starts earlier and the period of harvesting is shorter than in cool summers.

In all biferous cultivars and 'Hamra', no ostiole drop was observed. For the other cultivars, the color of the ostiole drop varied from transparent to red.

Easy skin peeling is an important character for consumer acceptance (especially for the cultivars that have a thick skin, such as 'Bakkor Biadh' and 'Onk Elhamam') because consumers tend to peel figs before eating. This result is in agreement with Ilgın (1995). Concerning the skin cracks, all of the cultivars presented skin cracks, except 'Bakkor Biadh' and 'Bither'. Skin cracks influence consumer acceptance because consumers think that this parameter indicates the degree of fruit ripening.

Table 1. Qualitative pomological descriptors of some fig cultivars grown in Algeria (results of 2015 and 2016).

Cultivars	FM	HP	FT	DE	CDE	EP	FSC	FLQ	FLC	SGC	PLC	PF	PJ	FC	FSI	FSW
BAB*	V. early**	V. Short	Biferous	Absent	Absent	Easy	Absent	Intermediate	White	Yellow-green	Pink	Neutral	Juicy	V. small	Oblate	Bell shaped
BAK*	Mid-season***	Medium	Biferous	Absent	Absent	Easy	Longitudinal	Scarce	Pink	Black	Dark red	Aromatic	Little juicy	V. small	Oblong	Ovoid
BID	Mid-season	Short	Uniferous	Present	Transparent	Difficult	Longitudinal	Numerous	White	Yellow-green	Pink	Strong	Juicy	V. small	Globose	Bell shaped
BIT*	V. early	V. Short	Biferous	Absent	Absent	Easy	Absent	Numerous	White	Yellow-green	Amber	Aromatic	Juicy	None	Globose	Pyriform
BOG	Mid-season	Short	Uniferous	Present	Transparent	Easy	Longitudinal	Intermediate	White	Yellow-green	Pink	Strong	Juicy	None	Oblong	Ovoid
HAM	Mid-season	Short	Uniferous	Absent	Absent	Medium	Longitudinal	Numerous	White	Green-purple	Dark red	Little flavor	Little juicy	Small	Oblong	Bell shaped
OKH	Mid-season	Short	Uniferous	Present	Red	Medium	Longitudinal	Intermediate	Pink	Purple	Dark red	Little flavor	Little juicy	None	Oblong	Pyriform
SAF	Mid-season	Short	Uniferous	Present	Pinkish	Easy	Longitudinal	Scarce	White	Yellow	Red	Little flavor	Little juicy	None	Oblate	Bell shaped
ZAR	Mid-season	Short	Uniferous	Present	Pinkish	Difficult	Cracked skin	Numerous	White	Green-purple	Red	Little flavor	Little juicy	Small	Globose	Bell shaped

Abbreviations: BAB: 'Bakkor Biadh', BAK: 'Bakkor Khal', BID: 'Bidha', BIT: 'Bither', BOG: 'Boughandjo', SAF: 'Safra', OKH: 'Onk Elhamam', ZAR: 'Zarrouk'. FM: Full maturity, HP: Harvest period, FT: Fructification type, DE: Drop at the eye, CDE: Color of liquid drop at the eye, EP: Ease of peeling, FSC: Fruit skin cracks. FLQ: Fruit lenticels quantity, FSI: Fruit shape [index (width/length) = I], FSW: Fruit shape according to the location of the maximum width, SGC: Fruit skin ground color. FLC: Fruit lenticels color, PLC: Pulp internal color, PF: Pulp flavor, PJ: Pulp juiciness, FC: Fruit cavity. * Second crop accessions, ** End of July, *** From 11 August to early September.

Table 2. Quantitative pomological descriptors of some fig cultivars grown in Algeria (results of 2015 and 2016).

Cultivars	FL (cm)	FWd (cm)	FNL (mm)	OW (mm)	FST (mm)	FSL (mm)	FW (g)	PW (g)	SW (g)	TA (g 100 g^{-1})
BAB*	3.59±0.74	4.83±0.99	3.7±3.03	7.08±2.58	7.54±2.40	2.14±1.12	50.74±19.95	45.15±12.68	12.71±4.05	0.28±0.04
BAK*	4.46±0.53	3.67±0.35	0.00±0.00	4.10±1.04	3.30±0.67	6.43±1.05	29.97±4.42	25.13±4.36	4.13±1.75	0.39±0.04
BID	4.09±0.50	3.84±0.43	0.00±0.00	5.63±1.21	3.00±0.82	9.33±0.47	33.12±5.90	28.84±6.08	5.16±1.71	0.21±0.04
BIT*	3.34±0.37	3.72±0.42	8.74±3.14	5.48±1.20	1.50±0.53	3.00±0.63	39.27±8.49	35.89±6.43	9.67±3.39	0.21±0.03
BOG	4.63±0.64	3.64±0.33	4.88±2.36	6.29±1.05	3.40±0.52	2.00±0.76	35.42±5.71	27.50±5.42	7.00±1.47	0.39±0.04
HAM	4.68±0.52	4.07±0.50	8.10±1.73	6.32±1.83	2.77±1.01	2.71±1.03	37.80±8.39	30.39±5.14	6.33±2.25	0.35±0.04
OKH	5.73±0.71	4.82±0.46	16.75±3.55	7.67±2.14	6.23±1.36	3.86±1.25	54.57±8.68	42.56±9.66	13.41±4.17	0.32±0.02
SAF	4.31±0.46	5.16±0.37	0.00±0.00	7.24±1.85	2.91±0.70	4.50±0.5	59.88±12.81	56.50±8.17	9.27±3.39	0.35±0.04
ZAR	4.01±0.44	4.30±0.44	0.00±0.00	5.81±1.08	2.00±0.71	5.75±1.09	37.79±7.87	30.88±8.13	5.29±1.93	0.32±0.02

Abbreviations: BAB: 'Bakkor Biadh', BAK: 'Bakkor Khal', BID: 'Bidha', BIT: 'Bither', BOG: 'Boughandjo', SAF: 'Safra', OKH: 'Onk Elhamam', ZAR: 'Zarrouk'. * Second crop accessions, FL: Fruit length, FWd: Fruit width, FNL: Fruit neck length, OW: Ostiole width, FST: Fruit skin thickness, FSL: Fruit stalk length, FW: Fruit weight, PW: Pulp weight, SW: Skin weight, TA: Titratable acidity. Each value represents the mean ± *SD* of 25 measurements each year.

The fruit skin color of the fig cultivars was yellow-green, green-purple, yellow, purple and black. Fruit pulp color was brilliant, varying between amber, pink, red and dark-red. Regarding the fruit lenticels quantity, it was scarce to numerous, and their colors ranged between white and pink. Skin color is an essential parameter, which affects consumer perception of fresh figs and used to determine their ripening period.

The figs tested were neutral to strongly aromatic and little juicy to juicy. The fruit shape [index (width/length) = I] was globose, oblong or oblate, whereas it is pyriform, ovoid or bell-shaped according to the localization of the maximum width.

Fruit length and width varied from 3.34 to 5.73 cm and from 3.64 to 5.16 cm, and ostiole width ranged between 4.1 and 7.7 mm (Table 2). The ostiole width values in our study are much higher than those (1.1 to 4.9 mm) reported by Çaliskan and Polat (2008). It is important to note that a large ostiole in the fig is an undesirable characteristic. The smaller the ostiole width, the better the fruit can be stored and protected from infectious agents (Trad et al., 2012). Neck length, skin thickness, stalk length, pulp weight, and skin weight varied among the cultivars. The fruit of the variety 'Onk Elhamam' is the longest (5.73 cm) whereas that of 'Safra' is the broadest (5.16 cm). 'Bakkor Khal', 'Safra', 'Bidha', and 'Zarrouk' presented no neck, and 'Onk Elhamam' had the longest neck (16.75 mm). The 'Onk Elhamam' cultivar takes its name of the length of its neck. The presence of a neck in figs facilitates picking the fruit from the tree, and is thus associated with easier harvesting (Trad et al., 2012).

In general, all studied cultivars exhibited light to medium fruit weight (29.97 to 59.88 g). Additionally, the titratable acidity of figs varied between 0.21 and 0.39% citric acid equivalents. In similar studies of figs, the fruit weights varied from 35.6 to 55.6 g (Crisosto et al., 2010) and 22.2 to 52.5 g (Çaliskan and Polat, 2008). Those authors recorded an interval of acidity that ranged from 0.22 to 0.42% and from 0.09 to 0.26%. Acidity decreases with the fig maturity and the fruit sizes differ according to the genotype and the tree age (Çaliskan and Polat, 2008; Crisosto et al., 2010).

Fig skin color

Our results indicate variability in fig skin color of the tested cultivars from the mountainous region of Lakhdaria. Fig skin colors varied from purple to black for the dark skin group ('Bakkor Khal', 'Hamra', 'Onk Elhamam' and 'Zarrouk') and from yellow to green-yellow for the light skin group ('Bakkor Biadh', 'Bidha', 'Bither', 'Boughandjo' and 'Safra') (Table 3).

The luminosity (L*) and chroma (C*) values of the light skin group were higher than those of dark skin group. Whereas the dark skin group had a* positive values (mean: 6.52) and the light skin group had a* negative values (mean: -4.21). Hue° (h*) values ranged from 90.65 to 98.01 for the light skin group (range of the green-yellow colors) and from 20.14 to 50.74 (range of red-yellow colors) and 280.2 (range of blue colors) for the dark skin group. The b* values varied from -2.63 ± 1.03 to 5.79 ± 3.08 for the dark skin group and from 32.07 ± 2.59 to 55.00 ± 2.14 for the light skin group (Table 3).

The higher values of luminosity and chroma of the green cultivars denote lighter and more intense colors (Crisosto et al., 2010). Chroma is one of the most important characteristics used to define the quality of food and has a decisive influence on consumer's acceptance (Hendry et al., 1996).

Consumer test

According to the results reported in Table 4, the consumers slightly preferred 'Boughandjo', 'Bither', 'Bakkor Biadh', 'Onk Elhamam', and 'Hamra', with a high percentage of acceptance for the biferous varieties 'Bakkor Biadh' (75%) and 'Bither' (70.31%) than the other tested varieties. Consumers probably prefer 'Bakkor Biadh' because the fruit of this cultivar is less sweet than the others; its flesh is juicy, its skin is thick but easy to peel, and it contains a few grains.

The percentage of consumers who neither liked nor disliked the various varieties of figs (18.23% on average) is 3.23-times less than the consumers that liked the different cultivars (58.85% on average).

In this study, it was observed that the 'Safra' and 'Bidha' cultivars are the less preferred cultivars (42.19 and 48.44%) (Table 4). The 'Bidha' variety is very sweet and tasty but its skin is very rigid, rough and difficult to peel, and it contains a lot of grains; the 'Safra' variety has an attractive shape and color, but it is little juicy and has little flavor. Although the 'Bidha' cultivar is less appreciated for fresh consumption, it is very suitable for drying thanks to its fine skin, its high degree of sweetness, and its attractive shape and color after drying.

The majority of consumers tend to peel their fig at least until halfway, and for them, ease of peeling, pulp flavor, juiciness, sweetness, and acidity are the most important factors which determine their acceptance. Crisosto et al. (2010) reported that maturity stage and flavor perception had a significant effect on consumer acceptance. Nevertheless, preferences in flavor change according to the demand of consum-

Table 3. Chromaticity values (L*, C*, h*, a* and b*) of fig skin of nine cultivars (results of 2016).

Cultivars	Color	L*	C*	h*	a*	b*
Bakkor Biadh*	Green-yellow	67.52±4.01	46.34±3.38	96.22±3.18	-6.13±1.89	43.27±3.73
Bakkor Khal*	Black	32.03±3.09	3.00±0.94	280.20±13.22	0.69±0.26	-2.63±1.03
Bidha	Green-yellow	65.90±2.15	48.23±2.90	96.14±2.34	-6.15±1.45	47.98±3.02
Bither*	Green-yellow	63.55±2.68	47.33±2.55	97.70±3.59	-5.15±2.78	45.83±2.78
Boughandjo	Green-yellow	62.37±1.21	31.83±2.33	98.01±4.84	-5.38±1.19	32.07±2.59
Hamra	Green-purple	37.17±3.11	8.95±2.28	44.37±24.44	6.86±0.66	-0.49±1.01
Onk Elhamam	Purple	38.06±1.01	9.45±1.15	20.14±5.34	11.22±2.49	1.74±1.71
Safra	Yellow	79.20±4.48	54.70±2.14	90.65±2.01	1.78±1.82	55.00±2.14
Zarrouk	Green-purple	38.97±2.02	10.26±1.53	50.74±25.64	7.31±2.63	5.79±3.08

Abbreviations: *: Second crop accessions, L*: luminosity (ranging from darkness to lightness), C*: Chroma (indicating intensity or saturation of the color), h*: hue° (Angle that indicates the pure spectrum color), a*: negative values indicate green color and positive values indicate red color. b*: negative values indicate blue color and positive values indicate yellow color. Each value represents the mean ± *SEM* of 12 measurements.

TABLE 4. Consumer acceptance of nine local fresh fig cultivars (results of 2016).

Cultivars	Note (1-9)^{s}	Dislike (%)	Neither like nor dislike (%)	Acceptance (%)
Bakkor Biadh*	6.33^{h}	10.94^{a}	14.06^{c}	75.00^{f}
Bakkor Khal*	5.58^{b}	20.31^{b}	28.13^{b}	51.56^{b}
Bidha	5.29^{e}	34.38^{e}	17.19^{ace}	48.44^{c}
Bither*	6.56^{a}	10.94^{a}	18.75^{a}	70.31^{a}
Boughandjo	6.61^{a}	10.94^{a}	20.31^{a}	68.75^{a}
Hamra	6.01^{g}	26.56^{c}	12.50^{cf}	60.94^{e}
Onk Elhamam	6.11^{f}	17.19^{b}	20.31^{a}	62.50^{e}
Safra	4.95^{d}	46.88^{d}	10.94^{cf}	42.19^{d}
Zarrouk	5.67^{c}	28.13^{c}	21.88^{ad}	50.00^{bc}

* Second crop accessions, ^{s} Degree of liking: 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely. Each value represents the mean of 64 measurements. $^{a, b, c, d, e, f, g, h}$ Mean values in the same column with different letters are significantly different at $p<0.05$ by mean of the Tukey's multiple comparison test.

ers. Cultivars with high sugar concentrations are in demand in domestic and Middle Eastern markets, whereas cultivars low in sugar are requested in European markets (Polat and Çaliskan, 2008).

Nutritional analysis

The physical and chemical characteristics of the fig pulps and peels are shown in Table 5. The fig pulps were more acid ($p<0.05$) than their peels (0.4 ± 0.11 and 0.2 ± 0.05%). This is in agreement with Oliveira et al. (2009) who reported that fig peels exhibited lower contents of organic acids than pulps. Organic acids contained in fruit are an important factor of its flavor development.

The pulp is juicier than the peel, having mean dry matter contents of 23.97 ± 4.53% and 26.13 ± 3.74% respectively. The 'Bakkor Biadh' and 'Bither' cultivars are the most humid. Fruit dry matter (DM) has emerged in recent years as another indicator of internal quality. DM is essentially a reflection of fruit carbohydrate content (Travers, 2013). The percentage of total ashes varied significantly ($p<0.05$) according to the fruit part and cultivar.

Minerals are micronutrients involved in many biochemical processes, and a suitable intake of these minerals is essential for the prevention of diseases related to minerals insufficiency (Leterme et al., 2006). Potassium was the most abundant mineral in the figs, which is in agreement with Sadia et al. (2014). Of the tested cultivars, the peel and pulp of 'Bakkor Khal' had the highest sources of potassium (266.7 ± 2.8 and 254.2 ± 6.9 mg 100 g^{-1} FW). Potassium is one of the important nutrients for controlling human blood pressure, therefore fig fruits were recommended for hypertension in previous studies (Sadia et al., 2014).

TABLE 5. Physical and chemical characteristics of fig pulps and peels (results of 2016).

Cultivars	Part	TA	DM	A	VC	Na	K	Ca	P
BAB*	Pulp	0.28 ± 0.04^{bcd}	13.47 ± 0.31^{e}	0.90 ± 0.03^{b}	2.89 ± 0.10^{ade}	7.64 ± 0.47^{caf}	206.9 ± 1.4^{bc}	20.83 ± 2.78^{b}	9.29 ± 0.48^{d}
	Peel	0.25 ± 0.03^{A}	17.70 ± 0.24^{BD}	1.02 ± 0.04^{BD}	2.22 ± 0.06^{D}	6.71 ± 0.62^{ACD}	213.9 ± 5.6^{ABCD}	61.11 ± 1.85^{D}	7.62 ± 0.32^{BDE}
BAK*	Pulp	0.42 ± 0.04^{ab}	26.03 ± 0.09^{d}	0.51 ± 0.04^{ae}	2.89 ± 0.03^{ae}	6.48 ± 0.77^{cag}	254.2 ± 6.9^{ab}	28.22 ± 2.15^{bc}	16.59 ± 0.53^{ae}
	Peel	0.18 ± 0.04^{A}	28.69 ± 0.94^{B}	0.84 ± 0.07^{AB}	3.78 ± 0.09^{E}	4.63 ± 0.31^{AC}	266.7 ± 2.8^{ABE}	125.44 ± 3.37^{C}	12.06 ± 0.37^{AC}
BID	Pulp	0.18 ± 0.02^{c}	29.33 ± 0.98^{b}	0.98 ± 0.05^{b}	8.67 ± 0.56^{b}	6.25 ± 0.46^{cd}	205.6 ± 8.3^{bc}	16.67 ± 2.78^{b}	13.25 ± 0.27^{ab}
	Peel	0.14 ± 0.01^{A}	26.19 ± 0.07^{A}	0.82 ± 0.01^{A}	5.33 ± 0.22^{B}	4.40 ± 0.31^{AC}	180.6 ± 2.8^{BCF}	105.11 ± 4.93^{B}	12.38 ± 0.48^{C}
BIT*	Pulp	0.25 ± 0.02^{c}	14.41 ± 0.26^{e}	0.59 ± 0.01^{a}	2.00 ± 0.04^{ac}	14.12 ± 1.08^{e}	226.4 ± 6.9^{b}	22.22 ± 1.85^{b}	12.54 ± 0.53^{ab}
	Peel	0.14 ± 0.04^{A}	17.76 ± 0.03^{D}	0.53 ± 0.03^{C}	2.89 ± 0.06^{DF}	1.62 ± 0.31^{B}	165.3 ± 6.9^{BCF}	75.00 ± 5.56^{AD}	8.73 ± 0.11^{B}
BOG	Pulp	0.53 ± 0.04^{a}	33.28 ± 0.38^{c}	1.26 ± 0.01^{c}	2.00 ± 0.07^{ac}	9.03 ± 0.93^{a}	215.3 ± 1.4^{abc}	30.56 ± 3.70^{bcd}	23.18 ± 0.42^{c}
	Peel	0.25 ± 0.04^{A}	29.61 ± 0.08^{BC}	0.99 ± 0.01^{BD}	1.78 ± 0.05^{AD}	7.87 ± 0.62^{AD}	244.4 ± 5.6^{ABE}	81.94 ± 4.63^{A}	11.91 ± 0.32^{ADC}
HAM	Pulp	0.53 ± 0.02^{a}	24.68 ± 0.12^{ad}	0.70 ± 0.01^{ad}	1.56 ± 0.08^{acf}	11.11 ± 0.93^{ab}	206.9 ± 4.2^{bc}	13.94 ± 1.93^{ab}	16.11 ± 0.53^{ae}
	Peel	0.14 ± 0.02^{A}	29.94 ± 0.45^{BC}	0.97 ± 0.02^{B}	1.33 ± 0.03^{A}	9.03 ± 0.46^{AD}	204.2 ± 4.2^{BCD}	81.33 ± 2.89^{A}	10.24 ± 0.48^{AB}
OKH	Pulp	0.39 ± 0.03^{b}	24.83 ± 0.37^{ad}	0.60 ± 0.02^{a}	9.33 ± 0.52^{b}	7.41 ± 0.77^{ca}	209.7 ± 6.9^{bc}	14.24 ± 2.39^{abc}	14.21 ± 0.27^{ab}
	Peel	0.21 ± 0.01^{A}	27.61 ± 0.49^{AB}	0.79 ± 0.03^{A}	10.67 ± 0.31^{C}	4.40 ± 0.31^{AC}	187.5 ± 1.4^{C}	78.89 ± 2.59^{A}	10.56 ± 0.21^{AB}
SAF	Pulp	0.53 ± 0.01^{a}	$23.63\pm0,31^{a}$	0.63 ± 0.04^{a}	2.22 ± 0.07^{a}	10.65 ± 0.77^{ab}	241.7 ± 5.6^{ab}	13.89 ± 1.85^{ab}	14.79 ± 0.30^{a}
	Peel	0.25 ± 0.02^{A}	26.07 ± 0.27^{A}	0.83 ± 0.03^{A}	1.33 ± 0.04^{A}	6.94 ± 0.46^{A}	240.3 ± 4.2^{AB}	88.89 ± 4.63^{A}	9.37 ± 0.58^{ABD}
ZAR	Pulp	0.46 ± 0.02^{ab}	26.08 ± 0.44^{d}	0.60 ± 0.05^{a}	2.44 ± 0.03^{acde}	6.94 ± 0.46^{ca}	215.3 ± 4.2^{abc}	19.06 ± 2.37^{b}	10.40 ± 0.42^{d}
	Peel	0.25 ± 0.01^{A}	31.58 ± 0.05^{C}	0.85 ± 0.02^{AB}	1.56 ± 0.05^{AD}	4.63 ± 0.31^{AC}	181.9 ± 1.4^{BCDF}	121.39 ± 4.82^{C}	8.18 ± 0.42^{BD}

Abbreviations: BAB: 'Bakkor Biadh', BAK: 'Bakkor Khal', BID: 'Bidha', BIT: 'Bither', BOG: 'Boughandjo', SAF: 'Safra', OKH: 'Onk Elhamam', ZAR: 'Zarrouk'. * Second crop accessions, TA: Titratable acidity (g citric acid equivalents 100 g^{-1} FW). DM: Dry matter (%), A: Ash (%), VC: Vitamin C (mg 100 g^{-1} FW), Na: sodium (mg 100 g^{-1} FW), K: potassium (mg 100 g^{-1} FW) , Ca: calcium (mg 100 g^{-1} FW), P: phosphorus (mg 100 g^{-1} FW). Each value represents the mean ± *SEM* of 3 measurements. $^{a, b, c, d, e, f, g}$ Mean values of pulps in the same column with different letters are significantly different at $p<0.05$ by mean of the Tukey's multiple comparison test. $^{A, B, C, D, E, F}$ Mean values of peels in the same column with different letters are significantly different at $p<0.05$ by mean of the Tukey's multiple comparison test.

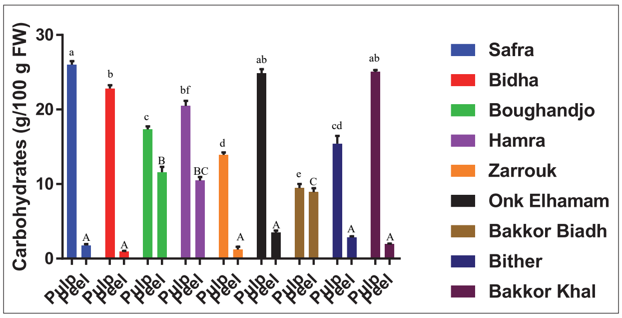

FIGURE 1. Total sugars in pulps and peels of figs (g 100 g^{-1} FW). (Mean ± *SEM* of three measurements). $^{a, b, c, d, e, f}$ Mean values of fruit pulps with various letters correspond to a significant difference at p<0.05 by mean of the Tukey's multiple comparison test. $^{A, B, C}$ Mean values of fruit peels with various letters correspond to a significant difference at p<0.05 by mean of the Tukey's multiple comparison test.

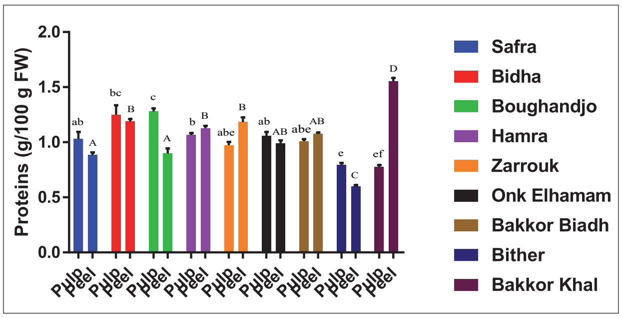

FIGURE 2. Total proteins in pulps and peels of figs (g 100 g^{-1} FW). (Mean ± *SEM* of three measurements). $^{a, b, c, d, e, f}$ Mean values of fruit pulps with various letters correspond to a significant difference at p<0.05 by mean of the Tukey's multiple comparison test. $^{A, B, C, D}$ Mean values of fruit peels with various letters correspond to a significant difference at p<0.05 by mean of the Tukey's multiple comparison test.

Calcium is another important mineral for health, particularly with regard to maintaining a suitable bone mass. Although dairy products are the principal contributors of calcium intake in humans, its content in fruits should not be ignored (Barea-Álvarez et al., 2016). Our results indicated that fig peel is four-times richer ($p<0.05$) in calcium than its pulp (91.01 vs. 19.96 mg 100 g^{-1} FW) and that the 'Bakkor Khal', 'Zarrouk' and 'Bidha' peels are the richest in calcium among the tested cultivars. According to O'Brien et al. (1998), figs are a very important vegetable resource of calcium.

The mean quantity of sodium and phosphorus in the fig peels and pulps were 5.58 and 8.85 mg 100 g^{-1} FW (sodium) and 10.12 vs. 14.48 mg 100 g^{-1} FW (phosphorus) respectively. The pulp is the richest fig part in sodium and phosphorus ($p<0.05$). The quantity of sodium of peel and pulp in our study is higher than that of the whole fig fruit (mean: 3 mg 100 g^{-1} FW), where the reverse is true of phosphorus (mean: 23 mg 100 g^{-1} FW) (Favier et al., 1993).

The concentrations of vitamin C in pulps and peels of 'Onk Elhamam' (9.33±0.52 and 10.67±031 mg 100 g^{-1} FW) and 'Bidha' (8.67±0.56 and 5.33±0.22 mg 100 g^{-1} FW) are higher ($p<0.05$) than those of the other cultivars. These concentrations are lower than those recorded by Pande and Akoh (2010) in pulp and peel of the variety 'Brown Turkey'.

According to the data shown in Figure 1, the average content of total sugars of pulp for the nine fig cultivars varied between 9.453±0.729 g 100 g^{-1} FW and 26.016±0.625 g 100 g^{-1} FW, while that of the peel varied between 0.958±0.118 g

TABLE 6. Extract yield, phytochemical concentrations and antioxidant activity of fig peels and pulps (results of 2016).

Cultivars	Parts	Y	PC	FC	AC	CTC	IC_{50}
BAB*	Pulp	14.60	0.934±0.006^{ae}	102.933±4.545^{g}	20.618±0.671^{abf}	0.824±0.032^{afe}	35.028±0.350^{f}
	Peel	14.27	2.066±0.051^{D}	116.954±3.359^{F}	0.000±0.000^{F}	5.674±0.113^{D}	27.564±0.365^{C}
BAK*	Pulp	22.00	0.842±0.012^{a}	50.980±3.508^{a}	48.327±0.240^{e}	1.722±0.130^{d}	15.870±0.255^{h}
	Peel	18.73	3.829±0.073^{F}	188.896±1.473^{H}	159.608±2.706^{G}	18.468±0.109^{F}	2.479±0.044^{F}
BID	Pulp	23.07	3.495±0.016^{b}	37.418±1.720^{c}	32.242±1.059^{c}	4.146±0.087^{b}	24.085±0.069^{c}
	Peel	19.40	0.893±0.009^{B}	161.718±1.315^{C}	63.481±1.782^{C}	1.949±0.069^{B}	31.984±0.101^{B}
BIT*	Pulp	14.40	0.664±0.010^{c}	104.050±0.000^{hg}	54.064±1.323^{e}	0.607±0.049^{af}	48.772±0.528^{g}
	Peel	11.00	0.592±0.004^{E}	56.753±1.754^{G}	8.336±0.505^{F}	0.388±0.021^{E}	32.416±0.091^{B}
BOG	Pulp	21.20	0.790±0.009^{ad}	149.456±4.152^{d}	144.725±2.827^{d}	1.138±0.076^{ae}	36.778±0.224^{d}
	Peel	21.00	1.597±0.012^{AG}	216.067±1.419^{D}	65.823±1.929^{C}	7.099±0.038^{A}	27.595±0.181^{C}
HAM	Pulp	18.13	0.874±0.010^{a}	69.487±1.425^{fe}	19.175±0.958^{abf}	1.356±0.458^{ade}	31.760±0.471^{e}
	Peel	15.87	0.945±0.032^{B}	112.429±0.946^{F}	31.698±1.457^{E}	1.658±0.065^{B}	17.590±0.076^{E}
OKH	Pulp	17.80	0.672±0.008^{c}	70.550±2.019^{e}	22.072±1.226^{ab}	3.275±0.056^{c}	32.392±0.241^{e}
	Peel	17.93	1.668±0.031^{CG}	254.255±1.081^{E}	109.334±6.177^{D}	4.630±0.040^{C}	8.045±0.145^{D}
SAF	Pulp	17.00	0.874±0.007^{a}	53.302±4.650^{a}	22.251±0.781^{a}	1.052±0.059^{a}	18.882±0.009^{a}
	Peel	16.20	1.520±0.006^{A}	83.237±1.002^{A}	17.242±0.670^{A}	7.329±0.043^{A}	11.483±0.101^{A}
ZAR	Pulp	19.40	0.846±0.009^{a}	116.210±3.135^{b}	12.028±1.336^{bf}	4.420±0.061^{b}	21.989±0.154^{b}
	Peel	16.80	1.557±0.006^{A}	139.531±1.169^{B}	127.885±1.543^{B}	7.554±0.133^{A}	11.037±0.038^{A}

Abbreviations: BAB: 'Bakkor Biadh', BAK: 'Bakkor Khal', BID: 'Bidha', BIT: 'Bither', BOG: 'Boughandjo', SAF: 'Safra', OKH: 'Onk Elhamam', ZAR: 'Zarrouk'. * Second crop accessions, Y: yield (%), PC: polyphenol concentration (mg GAE g^{-1} FW), FC: flavonoid concentration (µg QE g^{-1} FW), AC: anthocyanin concentration (µg Cy 3-Rut E g^{-1} FW), CTC: condensed tannin concentration (µg CE g^{-1} FW). IC_{50} (mg mL^{-1}): amount of extract required to scavenge 50% of radicals present in the reaction mixture. The IC_{50} values were obtained by linear regression analysis. Each value represents the mean ± SEM of three measurements. $^{a, b, c, d, e, f, g, h}$ Mean values of pulps in the same column with different letters are significantly different at $p<0.05$ by mean of the Tukey's multiple comparison test. $^{A, B, C, D, E, F, G, H}$ Mean values of peels in the same column with different letters are significantly different at $p<0.05$ by mean of the Tukey's multiple comparison test.

100 g^{-1} FW and 11.594 ± 0.958 g 100 g^{-1} FW.

For all the studied cultivars, the pulp is four times sweeter than the peel (19.475 vs. 4.843 g 100 g^{-1} FW). The sugar composition of fig fruit can influence perceived fruit sweetness. The perception of sweetness in fig accessions is likely due to the prevalence of fructose (Çaliskan and Polat, 2011).

The concentrations of proteins in the pulps and the peels of figs (Figure 2) varied between 0.773 ± 0.023 and 1.279 ± 0.037 g 100 g^{-1} FW and between 0.599 ± 0.016 and 1.552 ± 0.038 g 100 g^{-1} FW respectively. The mean protein concentration of the fig peel is slightly higher ($p > 0.05$) than that of the pulp (1.055 vs. 1.025 g 100 g^{-1} FW). The protein concentration of fresh figs varies from 0.8 to 1.3 g 100 g^{-1} (Favier et al., 1993).

Phytochemical characteristics

The peel of 'Bakkor Khal' and pulp of 'Bidha' were richest in polyphenols (3.829 ± 0.073 and 3.495 ± 0.016 mg GAE g^{-1} FW) and those of 'Bither' register the lowest concentrations (0.592 ± 0.004 (peel) and 0.664 ± 0.01 (pulp) mg GAE g^{-1} FW) (Table 6). The peel of 'Onk Elhamam' and pulp of 'Boughandjo' had the highest levels of flavonoids (254.255 ± 1.081 and 149.456 ± 4.152 µg QE g^{-1} FW) whereas those of 'Bither' and 'Bidha' had the lowest amounts. The total anthocyanin amount ranged from 0.00 ± 0.00 to 159.608 ± 2.706 µg C-3-RE g^{-1} FW for peels and from 12.028 ± 1.336 to 144.725 ± 2.827 µg C-3-RE g^{-1} FW for pulps. The concentrations of condensed tannins in the peel of 'Bakkor Khal' and the pulp of 'Zarrouk' were the highest (18.468 ± 0.109 and 4.420 ± 0.061 µg CE g^{-1} FW) while in those of 'Bither' are the lowest (0.388 ± 0.021 and 0.607 ± 0.049 µg CE g^{-1} FW).

In general, fig pulps had a higher mean yield than their peels (18.62 vs. 16.8%). Whereas, fig peels had higher ($p < 0.05$) mean quantities of polyphenols, flavonoids, anthocyanins, and condensed tannins than the pulps (1.63 vs. 1.11 mg GAE g^{-1} FW; 147.760 vs. 83.821 µg QE g^{-1} FW; 64.823 vs. 41.722 µg C-3-R E g^{-1} FW; and 6.083 vs. 2.060 µg CE g^{-1} FW).

In this study, peels of all fig cultivars, except 'Bidha' and 'Bither' (green varieties), had a higher phenolic concentration than its pulps. This is in agreement with Vallejo et al. (2012) and Oliveira et al. (2009), who found that fig peel had

Figure S1. Photographs of the studied fig cultivars (Original, 2015).

a higher phenolic concentration than its pulp, and with Harzallah et al. (2016) and Solomon et al. (2006), who reported that total phenolic concentrations of 'Bidhi' and 'Kadota' pulps (green varieties) were higher compared with peels.

Flavonoid concentration, in our study, was significantly ($p < 0.05$) higher in peels than in pulps (except in 'Bither'). Several other authors (Viuda-Martos et al., 2015; Harzallah et al., 2016) have reported similar. Phenolic acids and flavonoids (3-*O*- and 5-*O*-caffeoylquinic acids, ferulic acid, quercetin-3-*O*-glucoside, quercetin-3-*O*-rutinoside, psoralen, and bergapten) have been previously isolated from the pulps and peels of two Portuguese varieties of fig (Oliveira et al., 2009).

The anthocyanin concentrations registered in our study were higher than those reported by Duenas et al. (2008), but were much lower than those mentioned by Harzallah et al. (2016) and Viuda-Martos et al. (2015). Those authors also found that the fig peel had a higher amount of anthocyanin than the pulp. Fifteen anthocyanin pigments have been isolated from the peels and pulps of fresh figs. Cyanidin 3-rutinoside was the predominant component in fig fruit, followed by the Cyanidin 3-glucoside (Duenas et al., 2008).

For the light-skinned figs, pulps showed higher mean phenolic, flavonoid, and anthocyanin concentrations than those of dark skin figs (1.351 vs. 0.808 mg GAE g^{-1} FW; 89.430 vs. 76.810 µg QE g^{-1} FW and 54.78 vs. 25.4 µg C-3-RE g^{-1} FW). While peels of dark cultivars showed higher mean phytochemical amounts than those of light cultivars (2.000 vs. 1.334 mg GAE g^{-1} FW; 173.8 vs. 126.9 µg QE g^{-1} FW; 107.1 vs. 30.98 µg C-3-RE g^{-1} FW; and 8.077 vs. 4.488 µg CE g^{-1} FW).

Several authors (Solomon et al., 2006; Çaliskan and Polat, 2011; Harzallah et al., 2016) have previously reported that dark-skinned figs have a higher phenolic level than light-skinned figs.

We found that the peel and the pulp of 'Bakkor Khal' exhibited the highest antioxidant activity (Table 6), whereas the peel and pulp of the 'Bither' variety had the lowest antioxidant activity. Except for 'Bidha', the fruit peel had a higher mean antioxidant activity than the pulp (IC50 = 18.910 vs. 29.506 mg mL^{-1}, $p < 0.05$). Oliveira et al. (2009), in their study on two Portuguese varieties ('Pingo de Mel' and 'Branca Tradicional') also found that the peels were more effective as an antioxidant than pulps.

The peels and pulps of the dark-skinned group had a lower mean IC50 than the light skinned group (9.788 vs. 25.503 mg mL^{-1}), indicating that dark-skinned cultivars are most effective as an antioxidant than the light skinned cultivars. Solomon et al. (2006) and Crisosto et al. (2010) found that fig varieties with dark skin contain higher levels of polyphenols, anthocyanins, and flavonoids than lighter skin types and that this is associated with higher antioxidant activity. The cultivar is the most important variable influencing the phytochemical composition of figs (Yeh et al., 2003).

We found that the fig phenolic concentration is well correlated with condensed tannin amount ($r = 0.779$) but only moderately correlated with yield extract and flavonoid and anthocyanin concentrations. We detected a strong correlation between anthocyanin amount and flavonoid and tannin levels ($r = 0.656$ and $r = 0.519$ respectively) (Supplementary Table S1). The IC50 was negatively correlated with the condensed tannin and phenolic concentration. This means that the antioxidant activity of fig peels and pulps is dependent on tannin and phenolic concentrations.

Luminosity (L*) values were positively correlated with anthocyanin content ($r=0.595$) and moderately correlated with other parameters. We detected a strong correlation ($r=0.979$) between the Chroma (C*) values and luminosity values.

Conclusion

Here we describe the important pomological traits of fresh fig cultivars, including fruit length and diameter, fruit weight, fruit skin and pulp color, fruit neck length, and fruit shape. Consumer acceptance of fresh figs was significantly affected by ease of peeling, pulp flavor, juiciness, sweetness, and acidity. Among the tested cultivars, fruits of 'Boughandjo', 'Bither' and 'Bakkor Biadh' were the most accepted for the fresh consumption.

We found that the peels and pulps of fig have good nutritional value. The fruit pulps are rich in carbohydrates and the peel of the 'Onk Elhamam' cultivar had the highest vitamin C content. Of the tested varieties, the pulp of the 'Boughandjo' cultivar contained the highest concentration of phosphorus and the peel of the 'Bakkor Khal' cultivar was richest in potassium and calcium.

The peels and pulps of the tested cultivars had variable levels of polyphenols, flavonoids, anthocyanins, tannins, and antioxidant activity. Generally, fig fruit peels, especially those with a dark color, contained the highest concentrations of phytochemicals and exhibited the highest antioxidant activity compared to fig fruit pulps. Based on our mineral and phytochemical analyses, we recommend consumption of the whole fig fruit.

Acknowledgments

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