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Full Length Research Paper

Physico-chemical characterisation and antioxidant activity of some *Opuntia ficus-indica* varieties grown in North Algeria

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The composition and the antioxidant activity of the juicy pulp of four *Opuntia ficus-indica* varieties (green, yellow, orange and red) grown in North Algeria were investigated. The juicy pulp was characterized by a high humidity (87.4 to 89.6%), high pH (6.2 to 6.6), low acidity (0.04 to 0.07%), a few amount of proteins (0.35 to 0.49%) and high amount of solid soluble compounds (12 to 15%). Among the four varieties, the orange variety showed higher values concerning the last parameters. The same variety was also richer in phenolic compounds with 66.60 mg AGE/100 g, carotenoids (2.65 mg eq. β-carotene/100 g) and betaxanthin (6.79 mg/100 g). High ascorbic acid content has been recorded (28.76 mg AAE/100 g). However, betacyanin and total betalains contents were obtained in red juicy pulp. Following this rich composition in antioxidants, the four varieties studied showed performances in reducing iron F^{3+}, inhibiting hydrogen peroxide and decreasing the DPPH concentration by 50%. The best activities were obtained with the orange juicy pulp extract followed by the red one. In addition, direct relationship was noticed between the antioxidant and antiradical capacities of the ethanol extracts and the phenolic compounds concentration and also within the three activities.

Key words: *Opuntia ficus-indica*, physical and chemical properties, antioxidant, antiradical activities.

INTRODUCTION

Opuntia ficus-indica (OFI) locally known as cactus pear is native to semiarid parts of the United States, Mexico, and South America. Its cultivation was propagated around other continents with civilizations rhythm. Actually, it is cultivated in different parts of Europe, particularly, Mediterranean countries, in Africa and in Australia. Due to its ability to adapt to different environmental conditions, the cactus pear grows in plains, coastal regions, plateaus and among diverse vegetation. The success of *Opuntia* in these areas has been attributed to its Crassulacean Acid Metabolism (CAM) which promotes high drought resistance and high water-use efficiency (Nobel and Bobich, 2002). The fruit is a fleshy berry, consisting of a thick pericarp with a number of small prickles varying in shape, size and colour, and has a consistent number of hard seeds. It constitutes a source of nutrients and vitamins (Kuti, 2004; Feugang et al., 2006). The high sugar content and low acidity make them very sweet and delicious (Felker et al., 2005).

Cactus pear fruit and stem are traditionally utilized for medicinal and cosmetic purposes due to their ability to cure a number of afflictions, as forage, building material, and as a source for natural colours (Stintzing and Carle, 2005). In other countries, their use is mainly restricted to fresh fruit consumption. Recent studies revealed the high content of some chemical constituents, which can give added value to this fruit on a nutritional and technological functionality basis. High levels of vitamin C, betalains, taurine, calcium, magnesium, and antioxidants are

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noteworthy. Additionally, some of the constituents show promising characteristics that could be used in food industry as new plant derived colourants and sweet products (Sáenz et al., 1998; Moßhammer et al., 2005).

Moreover, scientists expect that in the future, declining water resources and global desertification may even increase *Opuntia* spp. importance as an effective food production system including both fruits and vegetable parts (Stintzing and Carle, 2005).

Beside, recent studies indicate that an increasing use of cactus pear fruit juice, concentrates, and powders as functional ingredients for the soft drink market, including betalainic colouring foodstuffs, is expected (Castellar et al., 2003; Moßhammer et al., 2005). Efforts have been made to improve its production and utilization in America (Mexico, Argentine), Europe (Italy and Spain) and Africa (South Africa, Morocco and Tunisia). In Algeria, OFI develops on the Mediterranean shore and particularly in Kabylie region but its cultivation is marginalized, its consumption is still seasonal and its production is always traditional.

In order to contribute to the valorization of this cultivation and to overcome the lack of knowledge about all aspects concerning this fruit in Algeria, current study has been designed to investigate indigenous OFI local varieties for their physical and chemical composition and their antioxidant and antiradical activities.

MATERIALS AND METHODS

Samples of four OFI varieties were obtained from Bejaia located at 260 km from Algiers, between August and September, 2008. Samples were processed within 24 h of collection. Each sample was made up of 10 units of undamaged fruits. The fruits were washed, peeled and finely chopped. The juicy pulp was separated from the seeds and weighed. The seeds were washed with distilled water, dried at room temperature and weighed. The obtained juicy pulp was stored at -20°C prior to the analysis.

Physical and chemical analyses

All the analyses were carried out on the homogenate obtained from the prickly pears samples. Moisture content was determined at 103°C. Soluble solids and the pH were measured with an aus Jena refractometer (GERMANY) at 20°C**,** and a pH meter (Hanna instrument, pH 213, PORTUGAL), respectively. Acidity was determined by titration with NaOH (0.1 N) and expressed as percent of citric acid. Protein content was analyzed according to NANOCOLOR kits method; the nitrogen quantity was determined between 365 and 385 nm by the NANOCOLOR 500D (MACHEREY-NAGEL, GERMANY) apparatus and the protein concentration was deducted using the factor 6.25.

Antioxidant content

Ascorbic acid

The ascorbic acid contents were determined spectrophotometrically by the dichlorophenol indophenol (DCIP) procedure (Mau et al*.,* 2005). This acid was previously extracted from the juicy pulp samples using an oxalic acid solution (1%). The absorbance (515 nm) against the volume of DCIP added, was read using a UV-Vis spectrometer (1240 mini, Shimadzu, CHINA). The results were expressed as mg ascorbic acid equivalent (AAE) per 100 g of fresh juicy pulp.

Carotenoid

The method of Sass-Kiss et al. (2005) was adopted. Approximately 4 g of cactus pear juicy pulp were homogenized for 15 min and extracted with 10 ml of hexane/acetone/ethanol (1:2:2, v/v/v) before being centrifuged for 15 min (Sigma 2 to 16K, GERMANY) at 5500 rpm at 4°C. The top layer of hexane, containing the pigment, was separated. Total carotenoid determination was carried out on an aliquot of the hexane extract by measuring absorbance at 430 nm. The results were expressed as mg β-carotene equivalent per 100 g of fresh juicy pulp.

Betalains

Betalains were extracted from fruits juicy pulp according to the method reported by Maataoui et al*.* (2006) using 80% methanol (v/v). The mix was centrifuged at 4000 rpm/min for 20 min; the obtained supernatant contained the total of betalains. The betalains content (BC) was calculated as described by Stintzing et al. (2003): BC [mg/L] = (*A*DF*MW*1000/ξ*l*)] where A is the absorption value, *DF* is the dilution factor, and *l* is the path length (1 cm) of the cuvette. For quantification of betacyanins and betaxanthins, the molecular weight (*MW*) and molar extinction coefficient (*ξ*) of betanin (*MW* = 550 g/mol; *ξ***=** 60 000 L/mol.cm; λ**=** 538 nm) and indicaxanthin (*MW*= 308 g/mol; *ξ*= 48 000 L/mol.cm; *λ*=480 nm) were applied.

Total phenolic content

10 g of juicy pulp samples were homogenized with 50 ml of 70% ethanol (v/v). The mixtures were allowed to stand for 2 h at room temperature before filtration. The extracts were subjected to rotary evaporation at 40°C to remove the organic solvent. The samples were reconstituted in 10 ml of methanol and stored at -20°C. The total phenolic content was measured following the method described by Velioglu et al*.* (1998); 250 µl of the extract were mixed with 1.5 ml of the Folin-Ciocalteau reagent (previously diluted 10-fold) and after 5 min, 1.5 ml of sodium carbonate (6%) were added. The mixture was kept in the dark at room temperature for 1 h; the absorbance was then measured at 760 nm. The results were expressed as mg gallic acid equivalent (GAE) per 100 g of fresh OFI juicy pulp.

Antioxidant activity

Reducing power

The total reducing power of the OFI ethanol extracts was determined according to the method of Oyaizu (1986) modified by Amarowicz et al. (2004). Briefly, the OFI extracts (0.5 ml) were mixed with phosphate buffer (1.25 ml, 0.2 M, pH 6.6) and potassium ferricyanide [$K_3Fe(CN)_6$] (1.25 ml, 1%). After incubation at 50°C for 20 min, the reaction mixture was acidified with trichloroacetic acid (1.25 ml, 10%) and centrifuged for 10 min at 5000 rpm. The upper layer of solution (1.25 ml) was mixed with distilled water (1.25 ml) and $FeCl_3$ (0.25 ml, 0.1%), and the absorbance was measured at 700 nm. Results were expressed as mg ascorbic acid equivalent (AAE) per 100 g of fresh juicy pulp.

DPPH• free radical scavenging activity

The hydrogen atom or electron donation abilities of some pure compounds were measured by the bleaching of a purple coloured methanol solution of the stable 2,2-diphenyl-2-picrylhydrazyl (DPPH) radical. The method of Brand-Williams et al. (1995) was used. For each sample, five different concentrations were tested. A 60 µl aliquot of ethanol extract was mixed with 2440 µl of DPPH in methanol. After 60 min incubation in darkness, at ambient temperature, the resultant absorbance was recorded at 517 nm. A solution of DPPH in methanol alone was used as blank. DPPH• decreases significantly upon exposure to radical scavengers. The DPPH• concentration in the reaction medium was calculated from the following calibration curve formula, determined by linear regression.

A_{517nm}= 40.44 C, R^2 = 0.996

The percentage of the remaining DPPH· (for each remaining sample, at the steady state) was calculated as follows:

$$\%DPPH_{rem.} = [DPPH\cdot]_t / [DPPH\cdot]_{t=0}$$

These values were then plotted against mg OFI juicy pulp extract/µg DPPH• to obtain the amount of antioxidant necessary to decrease the initial DPPH• concentration by 50% (EC_{50}) using the exponential curve.

Hydrogen peroxide scavenging activity

Hydrogen peroxide scavenging activity was measured as reported by Büyükbalci and Nehir El (2008). 1 ml of the ethanol extract was mixed with 2.4 ml of 0.1 M phosphate buffer (pH 7.4), and then 0.6 ml of a 43 mM solution of H_2O_2 in the same buffer were added. After 40 min, the absorbance at 230 nm of the reaction mixtures was recorded against a control solution containing phosphate buffer without H_2O_2 for each sample. The percentage inhibition activity was calculated from: $[(A_0-A_1)/A_0] \times 100$, where A_0 is the absorbance of the control and A_1 is the absorbance in the presence of the extract.

Statistical analysis

Data obtained were subjected to least significance difference (LSD) test to evaluate the statistical significance of the treatments using analysis of variance (ANOVA) and the significance was established at $p < 0.05$. Correlation analysis of antioxidant and antiradical activities versus the total phenolic content and other constituents were carried out using Pearson's correlation coefficient.

RESULTS AND DISCUSSION

Physical and chemical analyses

Physical and chemical properties of the different varieties of OFI are given in Tables 1 and 2. The ripe fruits of OFI were either oval or elongated, accounted for 64.50 to 106.30 g with a thick skin (26.43 to 48.13 g), which is covered with barbed spines, hosting the edible portion (37.67 to 57.49 g) and many hard seeds (2.78 to 3.92 g). The juicy pulp (26.64 to 38.02 g) offers a wide spectrum of colour from green, yellow, orange and red. The fruit properties differed significantly ($p < 0.05$) among the varieties. The green variety comprised higher fruit weight and diameter with high fruit skin, core, juicy pulp and seeds weight followed by the orange and red ones, while the yellow variety constitutes physically the smallest fruit. The large variability observed may be due to different varieties, cultural practices, fruit load, lighting period, climate, and harvesting season (Barbera et al*.*, 1992)

Chemically, the juicy pulp of the four varieties studied was composed of water (87.4 to 89%). Their pH values were determined in the range of 6.2 to 6.6. These results are in the range already described (5.8 to 6.6) in other OFI cultivars, confirming that this fruit is a low acidic food (Guirrieri et al., 2000; Kaanane and Fadili, 2000). Whereas, the total acid content in our varieties juicy pulp was of the order of 0.04 to 0.07%, which is very low in comparison with the acidity of other fruit such as grape (0.35%), banana (0.56%), pineapple (0.72%), orange (1.13%), apple (0.77%), strawberry (1.05%), apricot (1.40%) and kiwi (1.49%) (Souci et al., 1994). The results obtained are in good agreement with data from Mexican and Chilean cultivars (Hernandez-Perez et al., 2005; Diaz et al., 2007).

It has been reported that the major organic acid in cactus pear is citric acid, followed by malic acid (0.02%), quinic (0.02%), shikimic (0.03%) and oxalic acids. Isocitric, fumaric, glycolic and succinic acids were only found in traces (Stintzing et al., 2001). Total soluble solids ranged between 12 and 17%, with glucose being the predominant sugar and fructose being the second sugar, thus the fruit pulp is very sweet (Sáenz, 1995). A slightly higher content of sugars was found in the orange and green varieties, compared to the red and the yellow ones. Moreover, our results are in good agreement with data reported in the literature (Maataoui and Hilali, 2002; Diaz et al., 2007) for other varieties studied, and when compared with that of other common fruit, the total solid soluble content was similar or higher, such as banana (20.03%), pineapple (12.40%), apple (11.43%), kiwi (9.12%), orange (8.25%) and strawberry (5.51%) (Souci et al*.,* 1994).

The high pH, low acidity, and high soluble-solids content make cactus-pear pulp a very attractive media for growth of microorganisms. Significant but small differences at $p < 0.05$ were also observed with other components. For the protein content analysis, the NANOCOLOR method was employed. Such measurements yielded values varying from 0.34 to 0.49% recorded in orange variety. These results are well within the range of literature data reported for other varieties, for which values as low as 0.2% and as high as 1.6% have been registered by Saenz and Sepulveda (2001). In addition, Stintzing et al. (2001) showed that the fruit has a high content of free amino acids, particularly proline and glutamine, the highest level being that of nutraceutical taurine, up to 0.057%. The largest amounts of proteins were mainly found in orange variety.

Table 1. Physical characteristics of OFI cultivars.

Cultivar	Fruit characteristic	Length (cm)	Diameter (cm)	Fruit (g)	Skin (g)	Edible portion (g)	Juicy Pulp (g)	Colour index of the juicy pulp	Seed (g)
Green	Spineless, skin green clear, ovoid, edible portion green clear	6.68±0.34^{b}	5.29±0.24^{a}	106.31±15.65^{a}	48.13±8.13^{a}	57.49±9.423^{a}	40.96±7.30^{a}	Y= 20 R= 1.5 B= 1.8	3.92±0.78^{a}
Yellow	With spins, skin yellow, elongated, edible portion yellow orange	6.68±0.30^{b}	4.45±0.23^{c}	64.50±7.87^{c}	26.43±3.10^{c}	37.67±5.17^{c}	26.64±4.90^{b}	Y= 71 R= 10.3	2.88±0.81^{b}
Orange	With spins. skin orange, ovoid, edible portion orange	7.06±0.61^{b}	4.549±0.13^{bc}	76.28±8.38^{b}	42.65±5.55^{b}	33.37±3.72^{bc}	31.62±5.67^{b}	Y= 69 R= 20	2.42±0.41^{b}
Red	With spins, skin red, elongated, edible portion red	7.58±0.46^{a}	3.92±0.33^{b}	77.08±12.95^{b}	28.35±4.33^{c}	48.12±9.90^{b}	38.02±7.48^{a}	Y= 79.9 R= 46.9	2.78±0.71^{b}

Y, yellow; R, red; B, blue. Values having same letter within the column did not differ significantly from each other according to LSD test at $p < 0.05$.

Table 2. Relevant chemical characteristics of OFI cultivars.

Cultivars	Humidity (%)	pH	Acidity (%)	Brix (%)	Protein (%)
Green	87.50±0.09^{b}	6.55±0.02^{a}	0.04±0.00^{b}	14.33±0.15^{b}	0.38±0.01^{b}
Yellow	89.62±0.08^{a}	6.44±0.01^{b}	0.05±0.00^{b}	12.00±0.00^{d}	0.35±0.01^{c}
Orange	87.67±1.15^{b}	6.23±0.02^{c}	0.05±0.00^{b}	15.00±0.00^{a}	0.49±0.01^{a}
Red	89.58±0.03^{a}	6.22±0.03^{d}	0.07±0.00^{a}	12.50±0.00^{c}	0.34±0.01^{c}

Values having same letter within the column did not differ significantly from each other according to LSD test at $p < 0.05$.

Antioxidant content

Ascorbic acid

Ascorbic acid was present in significant amounts in the four cultivars. Values in the range of 23 to 32 mg/100 g were commonly measured. The green, yellow and the orange cultivars showed the largest amount of ascorbic acid, while the red one the lowest amount (Table 3). Our results are within the range reported by Piga (2004) (18 to 30 mg/100 g) and are close to those obtained for different Sicilian varieties of Gurrieri et al. (2000) (31 to 38) and Kugler et al. (2006) (23.9 to 31.5 mg/100 g). However, values up to 81.5 mg/100 g were obtained by Kuti (2004) in varieties from Texas (USA).

The variability observed in the measurements may be explained by the biosynthetic pathway of the ascorbic acid that is intrinsically slightly more "efficient" in some cultivars than in the others. Beside, factors like climates conditions and type

Table 3. Ascorbic acid, betalains, carotenoid and phenolic compounds of OFI cultivars (mg/100 g).

Cultivars	Ascorbic acid	Betacyanin	Betaxanthin	Total Betalains	Carotenoids	Phenolic compounds
Green	32.19±1.73[a]	0.39±0.06[c]	0.41±0.05[d]	0.79±0.11[d]	1.82±0.02[b]	48.92± 0.32[b]
Yellow	30.07±3.06[a]	0.30±0.01[c]	3.44±0.08[c]	3.74±0.07[c]	1.83±0.09[b]	47.23±1.90[b]
Orange	28.76±2.94[a]	0.90±0.11[b]	6 .79±0.64[a]	7.69±0.67[b]	2.65±0.04[a]	66.60±2.58[a]
Red	23.65±2.03[b]	2.93±0.17[a]	6.04±0.23 [b]	8.97±0.48[a]	1.77±0.04[b]	49.31±0.64[b]

Values having same letter within the column did not differ significantly from each other according to LSD test at $p < 0.05$.

of soil could also be a reason for this variability.

Moreover, the ascorbic acid content in prickly pear on average turned out to be higher than in some common fruits such as apricot (9 mg/100 g), apple (12 mg/100 g) and pineapple (25 mg/100 g) (Souci et al., 1994).

Betalains

Another important antioxidant factor is the presence of pigments, which give particular attractiveness to fruit and products. Betalains are detected in some fruits such as beet and *Opuntia* ssp. The yellow betaxanthin and the purple-red betacyanin are the characteristic pigments of the prickly pear. The orange cultivar showed the highest content of betalains, betaxanthin averaging 6.79 mg/100g followed closely by the red one. Betacyanin appears most concentrated in the red cultivar, averaging 2.93 mg/100g with betaxanthin: betacyanin ratio of 2, while the green cultivar showed the lowest content of betalains (Table 3).

It has been reported that cactus pear pulps offer different colours based on betalains covering a wide spectrum from white to purple with pigment contents of 6.6 to 114 mg/100g fruit pulp (Castellar et al., 2003). Other studies; Tresoriere et al. (2004) recorded 1.21 and 9.30 mg of betacyanin and indicaxanthin, respectively, in the yellow Italian cultivar, whereas, Kugler et al. (2006) recorded betacyanines and betaxanthines values varying, respectively between 0.6 to 5.9 mg/100 g and 3.3 to 4.8 mg/100 g in white and yellow Sicilian cultivars.

Beside, betaxanthin: betacyanin ratio varying between 0 to 11.7 has been found (Butera et al., 2002). The yellow cultivar production was more important than the red and the white ones which are less abundant. For example, 90% of the Italian prickly pear production was of the yellow cultivar (Guirrieri et al., 2000). In Algeria, the orange cultivar is the most abundant and the most consumed.

Carotenoids content

Different studies on carotenoids content in OFI, showed that these components are generally present in fewer amounts compared to the ascorbic acid and the total betalains contents. The results ranged from 1.77 to 2.65 mg eq. β-carotene/100 g with the orange cultivar as the richest among the other cultivars. Our data are close to those reported by other authors like Kuti (2004) who analyzed different colored prickly pear from Texas (USA) (green, yellow red, and purple) and found that carotenoid contents presented highest values for yellow one with orange juice (0.60 to1.77 mg/100 g) and the lowest for the green ones (0.12 to 0.17 mg/100 g). However, they are much higher to what Tesoriere et al. (2004) (Sicily) recorded (1.50 µg/100 g).

Total phenolic content

The phenolic compounds content in the four cultivars of prickly pear was also checked. The amount of total phenolics varied in different cultivars and ranged from 47.23 to 66.60 mg GAE/100 g. The highest total phenolic levels were detected in orange cultivar, while lowest content was measured for the yellow cultivar. Our results are also in the range obtained by Coria Cayupán et al. (2007) (54 to 112 mg /100 g of fresh fruits from Argentina). They are, however higher than those found by Maataoui et al. (2006) in OFI from Chaouia-Morocco (22 and 30 mg/100 g in orange and purple varieties, respectively) and to those registered by Diaz et al. (2007) for the green and orange prickly pears from island of Tenerife (17.1 and 17.2 mg/100 g, respectively). Factors like type of cultivar, climate condition and soil composition could explain this variability.

Antioxidant capacity

Reducing power

Transition metal ions have a great importance in the generation of oxygen free radicals in living organisms. Reduced iron is the dangerous form; it can be oxidized through Fenton type reactions, with production of hydroxyl radicals or Haber-Weiss reactions with superoxide anions thereby contribute to oxidative stress (Kehrer, 2000). It has been shown that the antioxidation effect exponentially increases as a function of the development of the reducing power (Tanaka et al., 1988).

In the present study, we have checked the ethanol extract effect on the oxidation of the ferrous ion (Fe^{2+}). Results, expressed as mg ascorbic acid equivalent per

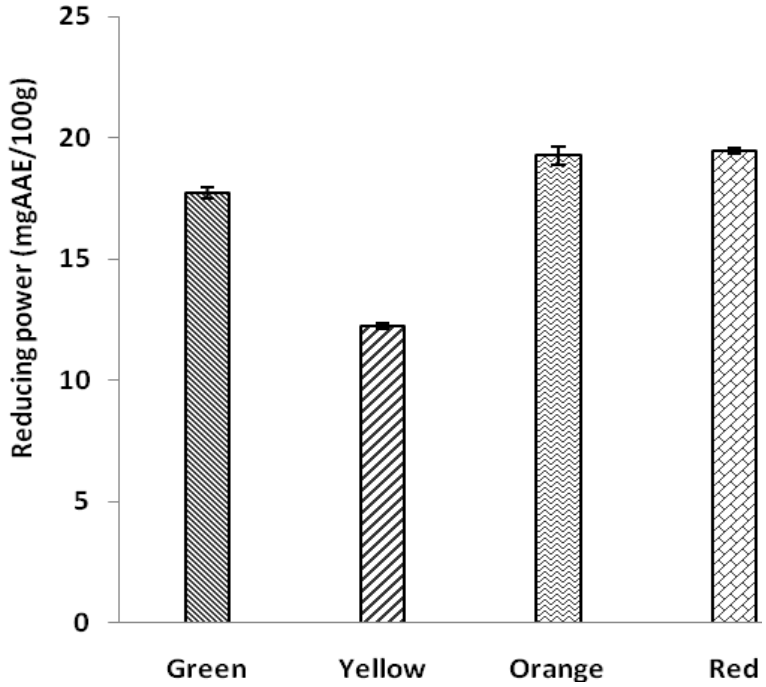

Figure 1. Reducing power of OFI ethanol extracts.

100 g juicy pulp, are shown in Figure 1. It appears that the extracts of OFI cultivars may well act as electron donors and can react with free radicals to convert them to more stable products and terminate radical chain reactions. The red cultivar and at the same level of the orange cultivar exhibited highest reducing power at more than 19 mg AAE/100 g followed by the green then the yellow fruits.

The difference were significant at $p < 0.05$. The activity exhibited by the juicy pulp extracts may be assigned to polyphenols and betacyanin. Positive correlations of respectively 0.55 and 0.53 was obtained but not significant. The reducing effect would be beneficial and could be promising approach to prevent oxidative stress induced diseases in the organism.

DPPH radical scavenging activity

The ability of the samples to donate hydrogen was checked by using the free radical DPPH•. It is one of the known mechanisms by which antioxidants inhibit lipid peroxidation. The amount of sample needed to decrease the initial DPPH• concentration by 50% (EC_{50}) is a parameter widely used to measure the antioxidant activity. A lower value of EC50 indicates a higher antioxidant power. As shown in Figure 2, there were significant differences among the antioxidant capacity of the OFI cultivars. The EC_{50} values varied from 6.33 to 4.31 mg juicy pulp/µg DPPH which correspond to 6.33 to 4.31 µl juicy pulp extract/µg DPPH. The best values were obtained for orange cultivar, followed by the red cultivar, while the yellow one was the weakest of all. The activity exhibited by the juicy pulp extracts, could be assigned to total phenol content and betalains; the inversely linear and significant correlations $r = -0.85$ and $r = -0.87$, respectively, were noticed between the amount of these compounds and EC_{50} values.

In the study of Galati et al. (2003), the antiradical activities of fruit juice, the fruit hydro-soluble and the organic-soluble fractions were measured; the two first extracts showed higher activity, the aliquot that produce a 50% decreased of DPPH absorbance were 6.75 and 7.68 µl, respectively. Fruit organic fraction has not shown any antiradical activity. This property was attributed to polyphenols as ferulic acid and flavonols, ascorbic acid and betalains.

Again, Maataoui et al. (2006) tested the scavenger activity of different extracts of two varieties orange and purple (ascorbic acid, phenolic compounds, pigments and the crude juice) on DPPH• radical; the best effect was obtained by the three last extracts with the purple crude juice as the most powerful. This observation finds its explanation, in the synergic effect of the juice constituents.

Scavenging of hydrogen peroxide

The scavenging ability of various extracts on hydrogen peroxide is given in Figure 3. It was noticed that all the samples were capable of scavenging hydrogen peroxide

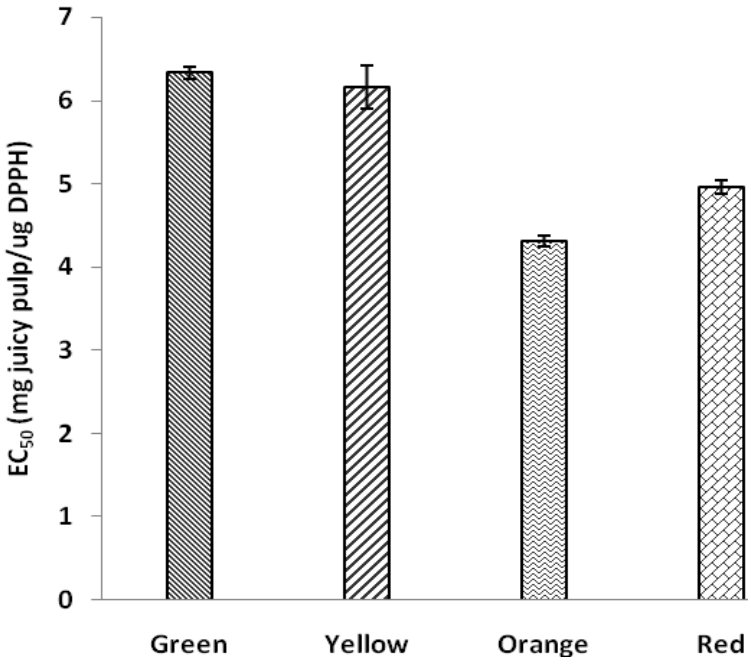

Figure 2. Scavenging activities of OFI ethanol extracts on the DPPH radical (EC_{50}).

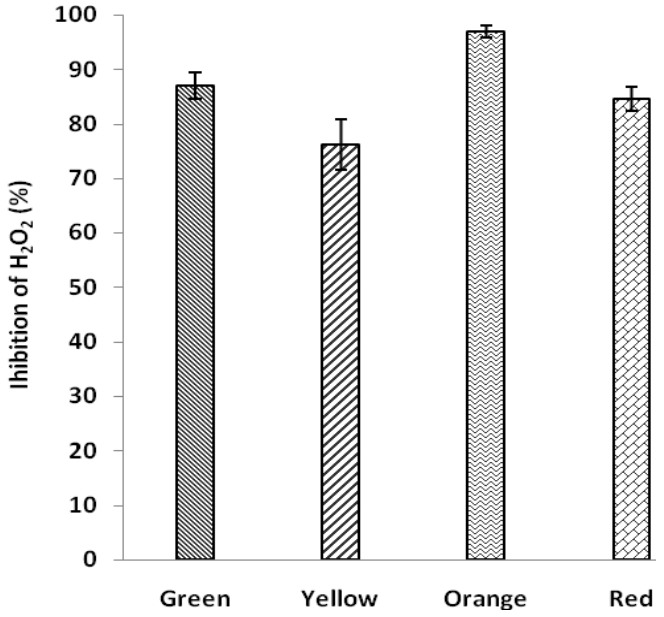

Figure 3. Scavenging activity of OFI ethanol extracts on hydrogen peroxide.

at 0.33 ml of extract (0.33 g of juicy pulp). The percentage of scavenging hydrogen peroxide varied from 76 to 96%. The highest value was obtained with the green and orange cultivars followed by the red and yellow ones at the same level. These results show that phenolic compounds present in the extracts are good electron donors; they may accelerate the conversion of H_2O_2 to H_2O. The percentage of inhibition of hydrogen peroxide increased according to the phenolic content; the more the phenolic compounds content the more the scavenging effect. Besides, a positive correlation was obtained between these two parameters (r = 0.85).

Table 4. Correlations between OFI antioxidants (mg/100 g) and the three activities.

Activities	Ascorbic acid	Betacyanin	Betaxanthin	Total Betalains	Phenolic compounds
EC_{50} (mg juicy pulp/µg DPPH)	0.498	-0.488	-0.905**	-0.866**	-0.809*
Reducing power (mg/100 g)	-0.402	0.565	0.408	0.505	0.573
Inhibition of H_2O_2 (%)	0.043	0.047	0.376	0.308	0.866**

*, **, Significant at P <0.05 and p <0.01, respectively.

Table 5. Correlations between the three activities.

Activity	EC_{50} (mg juicy pulp/µg DPPH)	Inhibition of H_2O_2 (%)
EC_{50} (mg juicy pulp/µg DPPH)		0.779*
Reducing power (mg/100 g)	0.680	0.666

*Significant at p<0.05.

Dok-Go et al. (2003) demonstrated that antioxidative flavonoids isolated from *O. ficus-indica* var. Saboten have neuroprotective effects. They evaluated their protective effects against oxidative neuronal injuries induced by H_2O_2 or xanthine/xanthine oxidase. Quercetin 3-methyl ether appears to be the most potent neuroprotectant of the flavonoids isolated from this plant.

Numerous other studies came after to confirm the beneficial effects of colourless phenolics and also betalains (Tesoriere et al., 2004; Stintizing et al., 2005; Siriwardhana et al., 2006). These effects are, generally, attributed to the ability of antioxidants to neutralize reactive oxygen species such as singlet oxygen, hydrogen peroxide, or suppression of the xanthine/xanthine oxidase system, all of which may induce oxidative injury, that is, lipid peroxidation (Feugang, 2006).

The three activities studied correlate more with polyphenol contents than betalains and ascorbic acid contents (Table 4). Similar results were noticed by other authors (Cai et al., 2003; Stintzing et al*.,* 2005). Using the results of the three antioxidant assays of the OFI ethanol extracts, relationships were also observed. Significant correlations were obtained between the three different activities (Table 5). DPPH scavenging activity was negatively correlated with the two other activities tested; the coefficients values were very close (r = -0.67 and r = -0.68). Whereas, a positive correlation r = 0.80 was noticed between the reducing power and H_2O_2 scavenging activity. These results confirm those reported in a lot of studies.

Conclusion

The OFI cultivars used in the present study were revealed to be a good source of various functional components such as ascorbic acid and betalains. OFI consumption may provide nutritional and health benefits to our organism. Moreover, because of the broader range of colour shades, colored cactus juices may be a further promising feature for industrial applications. In addition to their use as colorants, the recently reported effects of betalains on human health may open broader uses. This investigation shows also the potential value of *Opuntia* cactus pear fruits as a good source of phenolic compounds. Based on the available data in this study and the phytochemical contents of cactus pear fruits, the orange and the red cultivars are the most challenging for fruit exploitation in different sectors. However, the present findings on the potential of the phenolic compounds of OFI juicy pulp remain to be evaluated from a nutritional, biological and a technological point of view.

A study examining the composition of the OFI ethanol extracts and determining the specific compounds responsible for their antioxidant activity, using mass spectrometry liquid chromatography is in progress. In the other hand, these results would help to overcome the lack of knowledge about this fruit in Algeria and promote its cultivation.

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