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Research Article

Comparative Study of Phenolic Compound Antioxidant and Antimicrobial Activities of Fruits Peel and Cladodes from Tunisian *Opuntia Stricta*

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Abstract

Opuntia stricta is a wild plant belonged to the *Cactaceae* family and used in traditional medicine such as a natural remedy. This work is a contribution to the study of the bioactive substances continuous in aqueous extracts of fruits peel and cladodes from *Opuntia stricta* from center Tunisia, specifically in Sidi Bouzid and quantifies their biological activities. In fact, these results demonstrated that fruit peels are richer in total polyphenols, flavonoids than cladodes extract, as confirmed by HPLC where the quinic acid and hyperoside were the most abundant in these various extracts. And, the antioxidant assays showed IC50 NO= 0.14 ±0.13 mg/mL and IC50 DPPH = 0.37±0.0 mg/mL were the little values for aqueous extract of fruit peels compared to aqueous extract of cladodes. FRAP (1.40± 1.31mg/mL), OH (34.02±0.01%) and TAC (62.73± 2.11 mg AAE/g) were the highest values noted in this extract. Similarly, the bacterial strains tested were most sensitive to fruit peels than especially against Staphylococcus *aureus* with inhibition zones (DIZ), minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) values of 15.22±2.14 mm, 4.68 mg/mL and 37.5 mg/mL respectively. However, aqueous extract of cladodes have high antifongical activity particularly against *Fusarium oxysporum* with DIZ (20±0.2 mm), MIC (4.68mg/mL) and MFC (75 mg/mL) value.

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Introduction

For decades, oxidative stress and microbial contamination have evolved to the point where they are currently a major and serious public health problem at the global level. The treatment of these problems is generally based on the use of synthetic antibiotics. The often use of these molecules has led to therapeutic failures, adverse and toxic side effects on human health [1]. Therefore their effectiveness decreases. That's why today several populations use medicinal plants to treat themselves, because these plants have given very encouraging therapeutic results and with less effects, they are less aggressive and less harmful to the body owing to its natural molecules [2], such as secondary metabolites or active ingredients [3].

Cactus (*Opuntia stricta*) a wild plant distributed firstly in Spain and later in South and North Africa [4]. It has been traditionally used for various medicinal purposes. Several studies in experimental models investigated that all parts of *Opuntia stricta* have demonstrated different potential activities including antioxidant and antibacterial activities [5] (fruit), protective effect against hypolipidaemic effect, and HepG2 cell death [6] (cladodes), reduces Blood Glucose [7] (cladodes), anti-inflammatory and cytotoxic activities [8] (cladodes). In spite of these various studies, there is no research reported the comparison of the chemical composition, the antioxidant, and antimicrobial effect between the fruits peels and cladodes from *Opuntia stricta*. To improve knowledge, the current study was undertaken to determine and compare the polyphenols, flavonoids and tannins content, the antioxidant property such as DPPH, CAT, ABTS, FRAP, OH, NO assays and antimicrobial effect (against *Bacillus subtilis*, *Bacillus cereus, Staphylococcus aureus*, *Micrococcus luteus*, *Escherichia coli*, *Klebsiella pneumoniae* , *Salmonella Enteritidis*, *Pythium catenulatum, Fusarium oxysporum, Fusarium sp)* of two different parts of *Opuntia stricta* (fruit peels and cladodes).

Materials and Methods

Plant material

The fruits and cladodes of *Opuntia stricta* used in this study were collected in the last week of February 2020 from Sidi Bouzid, Tunisia (Latitude: 35 ° 02′17 ″ North, Longitude: 9 ° 29′05 ″, Altitude: 332 m). This plant specimen was authenticated by Professor Mohamed Echaieb and deposited at the local herbarium of the biology department of from faculty of science of Sfax, Tunisia.

Microorganisms material

Microbiological material consist of seven pathogenic strains of bacteria and 3 strains of fungi including: *Bacillus cereus* ('BC' JN 934390), *Bacillus subtilis* ('BS' JN 934392), *Staphylococcus aureus* ('SA' ATCC 6538), *Micrococcus luteus* ('ML'), *Escherichia coli* ('Ec'ATCC 25922), *Klebsiella pneumoniae* ('Kp'), *Salmonella Enteritidis* ('Se'ATCC43972),*Pythium catenulatum* ('Pc'JX391934),-*Fusarium oxysporum*('Fo'AB586994), *Fusarium sp* ('Fs'JX391934)

Preparation of extracts

Fruits and cladodes of *Opuntia stricta* were initially rinsed with distilled water. In fact, the fruit was peeled to separate their peel from the pulp. Then the fruit peel and cladodes were cut into thin slices, dried at 50-60°C for 24 hours, and ground to a powder with a Nima electric grinder apparatus (nima ®, Japan).

The extraction method used was maceration; it consists of soaking 200 g of the powder obtained in water for 24 hours with continuous agitation. The macerates was centrifuged at 4500 rpm for 15 minutes, filtered by Whitman paper, and then lyophilized in a lyophilizer at 4°C. Finally, the extracts were recovered dry and kept in the freezer for further analysis

Phytochemical screening

The phytochemical composition of Aqueous Extract of Fruits peel (AEF) and Aqueous Extract of Cladodes (AEC) was quantified as described by Bakari et al., [9]. In fact, the total phenolic, flavonoid, condensed Tannin were determined using respectively the *Folin Ciocalteu*, the aluminum chloride and the vanillin methods whose described by Zourgui et al., [10]. Moreover, the absorbance was measured by a spectrophotometer (Thermo Fisher Scientific, Genesys, USA). And, results were declared firstly, as mg of gallic acid equivalents per g of dry matter (mg of GAE/g of dry extract weight) for total phenolic and flavonoid, and secondly, in mg of catechin equivalent per g of dry matter (mg CE/g of dry extract weight) for condensed Tannin.

HPLC analysis

Polyphenols and flavonoids continuous in aqueous extract of fruit peels and cladodes from *Opuntia stricta* were extracted by the modified method described by Ayaz et al., [11]. In fact, 1 g of AEF and AEC were added to 20 ml of ultra pure water and let them at a room temperature. After 24h, the mixture were centrifuged at 4000 rpm for 25 min, filtered and analyzed by the HPLC system. Finally, 0.5 mL of each samples were injected.

The composition analysis was performed in a Shimadzu LC-20ADXR pump with an automatic SIL-20AXR (40°C) sampler. And the separation is done at 75°C in a Disco Very BIO Wide Pore C18 column (250 mm x 4 mm, 5 µm) according to a gradient program.

Determination of antioxidant activity

DPPH free radical-scavenging assay: The measurement of antiradical activity on *Opuntia stricta* extracts was performed by the 2,2'-Diphenyl-1-Picrylhydrazyl (DPPH) free radical scavenging test using the procedure described by Kadri et al., [12]. In fact, Reaction mixtures containing 200 µl of each extract at different concentrations (0.0125 to 5 mg/ml) and 3.8 ml of a DPPH solution. Then, the samples were incubated for 30 min at dark room and ambient temperature. And, the absorbance was measured at 517 nm against a control (vit C). Finally, for each concentration, the test was performed thrice.

FRAP assay: The antioxidant activity was carried out using the reducing power assay (FRAP) according to the method slightly modified by Bougandoura et al., [13].This method is based on the reduction of ferric iron (Fe^{3+}) to ferrous iron salt (Fe^{2+}) by the antioxidants that give the colour blue [14]. In this test, 1 ml of AEF and AEC at different concentrations (0.5 to 10mg/ml) was combined with 2,5ml of phosphate buffer (0.2 M, ph= 6,6) and 2.5 ml of potassium ferricyanide $K3Fe(CN)_6$ (1%). The mixture was incubated in a water bath at 50°C for 20min. Then 2.5 ml of trichloracetic acid (10%) was added to stop the reaction. Then, 2,5ml of the mixture is combined with 2,5ml of distilled water and 0.5ml of aqueous solution of $FeCl_3$ (0.1%). The absorbance of the reaction medium is read at 700nm against a similarly white prepared, by replacing the extract with distilled water which allows the apparatus to be calibrated (UV-VIS spectrophotometer).

Total Antioxidant Capacity (TAC) assay: The total antioxidant capacity was evaluated by phosphomolybdenum method as mentioned by Prieto et al., [15] that relies on the reduction of Mo (VI) to Mo (V) and formation of green phosphate/Mo (V) complex. In this assay, 0.3 ml of AEF and AEC was mixed with 3 ml of reagent solution (sulfuric acid (0.6 M), sodium phosphate (28 mM) and ammonium molybdate (4 mM)). Moreover, the reaction mixture and the control were incubated at 95°C for 90 min. After that the absorbance was measured at 695 nm. The total antioxidant activity was expressed as milligram ascorbic acid equivalents per gram dry matter (mg EAA/g extract).

Determination of antimicrobial activity

The assessment of antimicrobial activities of *Opuntia stricta* extracts was done in vitro using two methods: the method of agar-well diffusion and the method of micro-dilution well.

Microorganisms and culture conditions

The antimicrobial activities of AEF and AEC was tested against a large panel of microorganisms such as 7 strains of bacteria including *Bacillus subtilis* ('BS' JN 934392)*,, Bacillus cereus* ('BC' JN 934390), *Staphylococcus aureus* ('SA' ATCC 6538)*, Micrococcus luteus* ('ML'), *Salmonella Enteritidis* ('Se'ATCC43972), *Escherichia coli* ('Ec'ATCC 25922), *Klebsiella pneumoniae* ('Kp') and 3 stains of fungi including *Fusaruim oxysporum*

('Fo'AB586994), *Pythium Catenulatum* ('Pc'JX391934) and *Fusarium sp* ('Fs'JX391934) These strains belong to the local culture collection from microbiology laboratory of the department of life sciences of the faculty of science of Sfax, Tunisia.

For the determination of these activities, bacteria and fungi strains were cultured on the surface of culture media (Mueller Hinton for bacteria and agar Sabouraud for fungi) and incubated at 37°C for 24 hours and at 30°C for 36 hours respectively. Then, bacteria was inoculated in 3 mL of Mueller Hinton and incubated during 24 H, with an agitation of 200 rpm at 37°C whereas fungi was inoculated in 10 ml of sterile water containing 0.1% Tween 80. The optical density was adjusted to 0,08- 0,10 in order to obtain a solution equivalent to 10^6 UCF/ml for bacteria and 10^6 spores/ml for fungi and all tests were performed at three resumes [16].

Antimicrobial activity detection by agar diffusion method

The antimicrobial assay was detected firstly by agar diffusion method described by Daoud et al., [17]. In this well-known procedure, the specific culture medium for each microorganism (Mueller Hinton for bacteria and agar Sabouraud for fungi) was cast in petri dishes under well-studied sterility conditions until they solidify. Then, 100 µL for each suspension (10^7 CFU bacteria/ml and 10^6 spores/ml) were seeded on the culture media surface using a sterile flue brush. After that, a few 6 mm wells were installed in the culture medium solidified with a sterile Pasteur pipette. Then, each well was filled with 60 µl of each extract (150 mg/ml DMSO). A Positive test was out with chloramphenicol (15 µg/wells) and cycloheximide (20 µg/wells) and the DMSO has been used us negative test. Moreover, all petri dishes

have been have been added +4°C for 2 hours to facilitate the dissemination of extracts in the culture medium thereafter incubated at 37°C, during 24h and to 30°C, during 4-7 days, for the bacteria and fungi, respectively. Antimicrobial activity was determined by measuring the diameter of the zones inhibition in millimeters and all experiments were carried out in triplicate.

Antimicrobial activity detection by micro-dilution well method

The Determination of minimum inhibitory concentration (MIC) and Minimum Bactericidal/Fongicidal Concentration (MBC/MFC) was used, according to Sen et al., [18]. For the antimicrobial activity of AEF and AEC. This method was determined using a sterile 96-well microplate. The first step corresponded to the refilling of each well with 90 µl of Mueller Hinton and Sabouraud agar for bacteria and fungi respectively with 100 µl of each dilution of the extract and 100 µl of each dilution of the two extracts which were obtained by the dissolution of the extracts in the DMSO and preparation of the series of concentrations of 150 mg with 1.10 mg /ml. In step 2, plates were incubated at 37°C for 24 hours for bacterial strains and 30°C for 3 days for fungal strains after homogenization. A negative and positive control wells were prepared simultaneously in separate wells. In this assay, the viability of bacteria and fungi becomes very clear after the addition of 25 µl of MTT (3-(4,5-dimethyl-2-thiazolyl)-2,5-diphenyl-2 H-tetrazolium bromide) to each cavity (an indicator of microorganism growth) and the mixture was incubated at 37°C for 30 min. After incubation, cavities exhibit inhibition of microbial growth remains clear [19]. The lowest concentration of the extracts that inhibited growth was recorded as the MIC and MBC for bacteria and MFC for fungi.

Statistical analysis

The results were expressed as a Standard Error Mean (MES) and a statistical analysis was performed using an SPSS. All values obtained represent mean values of 3.

Results and Discussion

Opuntia stricta fruits peel and cladodes extracts yields

The yields of aqueous extracts of fruits peels and cladodes from *Opuntia stricta* were illustrated in table 1. In this table, is very remarkable that the aqueous extract from the peel produces a major yield (0.32%) compared to that of cladodes (0.20%). Thus, a significant difference was observed between the two parts of the plant. And, this difference can be attributed to the differences in the structure of phytochemical compounds [20].

Aqueous extracts	Yields %
Fruits peel	0.32±0.01
Cladodes	0.20±0.18

Table 1: The yields of the aqueous extracts of Opuntia stricta.

Phytochemicals screening

The compositional content of polyphenols, flavonoids, and condensed tannins was carried out on aqueous extracts prepared from fruits peel and cladodes of *Opuntia stricta*. In fact, the total polyphenol content was determined by the *Folin ciocalteu* method where gallic acid was used as a standard. Then, for flavonoids and condensed tannins, the assays were conducted using respectively the aluminum trichloride method and the method of vanillin where catechin used as a standard.

The results of this study given in table 2 shown that in *Opuntia stricta*, polyphenols and flavonoids were highly accumulated in the peels than in the cladodes and there is no difference in condensed tannins. The fruits peel were richer in polyphenols with a concentration of 46.2 ±0.08 mg EAG/g MS and flavonoids with a concentration of 22.1 ± 0.28 mg EC/g MS than cladodes with 38.8 ± 0.01 mg EAG/g MS in polyphenols, 16.3 ± 0.18 mg EC/g MS in flavonoids. Also, the both extracts presented a low concentration in condensed tannins with 4.7 ± 0.3 mg EC/ g MS and 2.8±08 mg EC/g MS respectively for fruits peel and cladodes. The current levels of polyphenol and flavonoids content in aqueous extract of fruit peels and cladodes was higher than the values found by firstly Beltaief et al., [21] confirmed that fruit peels and cladodes of *Opuntia dellini* contain respectively 15.00±0.09 mg GAE /g and 13.97±0.05 mg GAE/g dw of TP, 4.6±0.01 mg CATE/g and 6.45±0.23 mg CATE/g dw of TF and 1.94±0.08 mg CAT/g and 1.64±0.08 mg CATE/g dw of TT. According to Aruwa et al., [22], the concentration of phenolic compounds in fruit peels of *Opuntia ficus indica* was 9.10±0.06 mg GAE/g of polyphenols and cladode *Opuntia ficus indica* is approximately 32.6 ± 0.8 mg GAE/gdw of polyphenols, 18.6 ± 0.6 mg CE/g dw of flavonoids, 1.5 ± 0.0 mg CE/g dw. It appears that *Opuntia stricta* contained more secondary metabolites than other spices.

No	Compounds name	Concentration (ppm)	Retention time
	EAF	-	-
1	Quinic acid Caffeic acid Syringic acid	631.02	2.02
2	P-coumaric acid	0.51	15.12
3	Trans ferrelic acid	0.70	19.54
4	Naringin	1.55	23.02
5	Cinnamic acid	0.82	26.30
6	Luteolin	0.89	30.58
7		0.33	33.46
8		0.05	36.81
	EAC		
	Quinic acid	-	-
1	Protocatechuic acid	69.25	1.76
2	Cafeic acid	0.56	5.03
3	Syringic acid	0.22	16.35
4	P-coumaric acid	0.01	22.01
5	Naringin	0.2	23.33
6	Trans ferulic acid	2.99	24.96
7	Cinnamic acid	1.23	28.32
8		0.36	33.42

Table 2: Chemical composition in the AEF and AEC by HPLC.

High-performance liquid chromatography analysis (HPLC analysis)

The qualitative and quantitative analysis of phenolic compounds of aqueous extracts prepared from fruit peels and cladodes of *Opuntia stricta* were determined by High-Performance Liquid Chromatography (HPLC). In fact, the major bioactive compounds contained in AEF and AEC were expressed as ppm of content. Moreover, 6 phenolic acids and 2 flavonoids are detected in the aqueous extract of fruits peel while the aqueous extract from the cladodes contains only 7 phenolic acids and 1 flavonoid presented in table 2. Data in this table indicates that the major compound was the Quinic acid (631.02 ppm and 69.25 ppm respectively for fruit peel and cladodes. As we can see, a high level of bioactive compounds in the aqueous extract of fruit peels than of cladodes. This allows concluding that there is a difference between two organs of *Opuntia stricta* and the content of phenolic was higher in fruit peels than those found previously in cladodes. Thus, these high levels make fruit peels richer in

antioxidant molecules especially as Quinic acid was the most dominant. In literature, this compound was known to display the antioxidant; antimicrobial, anticancer capacity [23]. In addition, caffeic acid possesses an effect against the oxidative stress, diabetes [24]. Also, studies have been demonstrated that p-coumaric acid was a major component in the fight against oxidative stress (*in vivo*), cancer, microbial strains [25].

Determination of Antioxidant activity

The antioxidant activity of the two aqueous extracts of *Opuntia stricta* was evaluated DPPH free radical scavenging activity, the total antioxidant capacity (CAT), Ferric-Reducing Antioxidant Power (FRAP).

DPPH free radical-scavenging activity: To detect the anti-radical activity of AEF and AEC of *O. stricta*, we used 2,2 Diphenyl-2-Picrylhydrazyl (DPPH). In fact, the results obtained are given as IC_{50} and compared with a positive control. As shown in table 3, It was found that the aqueous extract of fruit peel was characterized by a low IC_{50} in the order of 0.37±0.0 mg/ml than the one of cladodes extract with IC_{50}= 0.63±0.8 mg/ml whereas trolox had IC_{50} in the range of 0.33±0.01mg/ml. So, we can conclude that fruit peel have a high antioxidant power than the cladodes. In fact, a similar values obtained by Benltaief and al., [21] which founded that the aqueous extract of fruit peels of *Opuntia dellini* from Djerba (Tunisia) has a DPPH around IC_{50}= 0.37 mg/mL. In contrast, [10] indicated that fruit peels of *Opuntia streptacantha* confirmed that the concentration able of inhibiting 50% DPPH value at 0.61±0.002 mg/ml.

	DPPH IC50 (mg/mL)	TAC * (mg AAE/g)	FRAP * (700nm)
AEF	0.37±0.0	62.73± 2.11	1.40± 1.31
AEC	0.63±0.8	55.32 ±1.24	1.12±0.05
Ascorbic acid	0.014±0.01b	81.24±0.14	2.41±0.01a
Trolox	0.33±0.01	Nd	1.86±0.01c

Table 3: Antioxidant activity of fruit peel and cladodes of *Opuntia stricta* and standards.

a,b,c : letters indicate significant differences ($p<0.05$).

DPPH: 2,2 diphenyl-2-picrylhydrazyl

TAC (Total antioxidant capacity

FRAP (ferric reducing antioxidant power)

OH: hydroxyl radical

NO: Nitric oxide

AAE: Ascorbic acid equivalent.

*The concentration of fruit peel extracts used in antioxidant activities (DPPH, TAC, FRAP, OH and NO) assays was 1mg/mL.

Total Antioxidant Capacity (CAT): The total antioxidant capacity ranges from 62.73± 2.11 mg EAA/g extracted in the aqueous extract from the peels to 55.32 ±1.24 mg EAA/g in the aqueous extract from the cladodes. The results obtained show that both extracts have the same total antioxidant capacity which was increased to 81.24±0.14 mg AAE/g for ascorbic acid. Therefore, these results show that the best total antioxidant activity was achieved with the standard (ascorbic acid) and that Aqueous Extract of Fruit peels (AEF) has the strongest total antioxidant capacity than Aqueous of Cladodes (AEC). The current value was on one hand similarly than the report of Zourgui et al., [10] which demonstrated that TAC of fruit peels *Opuntia streptacantha* was in the order of 55.40±2.65 mg AAE/g dried extract and on the other hand were lower than those found previously in fruit peels of *Opuntia dellini* (64.18±0.67 $^{mg\ AAE/g}$) according to Benltaief et al., [21].

Ferric-Reducing Antioxidant Power (FRAP): The reducing power of the different extracts was determined using the potassium ferricyanide method [26] and compared with ascorbic acid. This method was based on the ability of the extracts to reduce potassium ferricyanide Fe^{3+} to Fe^{2+}. The product of the reaction is detectable at 700 nm. In fact, the higher absorbance indicated the greater the reducing power of an extract. The results presented in table 3. are expressed as absorbance and indicated that the ferric reducing antioxidant power of extracts was increased with increasing concentration and the maximum absorbance were about 1.18± 1.31 and 1.40±0.05 and 0.4 for AEF, AEC and ascorbic acid respectively at 1 mg/mL. Likewise, fruit peel of *Opuntia streptacantha* from Kasserine present the same ferric-reducing antioxidant power which was 1.12±0.01 mg/ml [10].

Finally, we can conclude that EFOS have a stronger antioxidant power. This antioxidant activity in the extract of the peel seems to be linked to their richness in polyphenols and flavonoids according to Olelaye and Rocha [27]. which report that cactus polyphenols significantly protect against oxidative aggression and proved that the high antioxidant activity of cactus peel is related to the high content of phenolic compounds in this extract.

Determination of antimicrobial activity

The determination of antimicrobial activity of *Opuntia stricta* extracts was determined by two complimentary methods: the agar diffusion method by measuring the diameters of the inhibition zones and the method of micro-dilution well by measuring the minimum inhibitory concentrations, the minimum bactericidal concentrations and the minimum fungicidal concentrations. In fact, the results obtained are reported in table 4 and compared to the chloramphenicol and cycloheximide witch are the standard antibiotic. As shown in this table that AEF exhibits a significant antimicrobial activity against a panel of 7 bacteria (including four $Gram^+$ and three $Gram^-$) and 3 fungi than AEC.

For the bacteria strain, the results showed that fruit peel possesses a strongest antibacterial power whereas AEC has almost little effect on bacteria. Moreover, the largest zone of inhibition produced by AEF of *Opuntia stricta* was registered mainly against Gram-positive bacteria such as *Staphylococcus aureus* (15.22±0.14), *Micrococcus luteus* (13±0.7). Our results was in line with other variety, Zourgui et al., [10] proved that *Staphylococcus aureus* is the most sensitive with 15.22±2.14 mm for aqueous extract of fruits peel and 13.10 ±0.8 mm for aqueous extract of *Opuntia stresptacantha*.

For the fungi strains, cladodes and fruits peel extracts have a high antifungical activity against *Fusarium oxysporum* (16.25± 0.5 mm for AEF and 20±0.2 mm for AEC) and no antifungal effect was noted against *Fusarium sp* and *Pythium Catenulatum*. This lack of antifungal activity could be explained by the fact that these fungi have developed resistance mechanisms against the antifungal molecules present in the extract. It is also possible that the solvents used during extraction, which is the cause of the lack of activity of the extract of the plant. Undoubtedly, the solvent used may not have been able to retain the molecules sought because of its polarity.

	DIZ (mm)	
Strains	AEF AEC	
Bacteria strains		**Chloramphenicol**
Gram+		
Bacillus cereus	8.30 ± 0,2 8.13±1.0	25.5 ± 0.7a
Bacillus subtilis	8.12 ± 0.6 8.0±0.6	24.3 ± 0.2a
Staphylococcus aureus	15.22±2.14 13.10 ±0.8	15 ± 0.6a
Micrococcus luteus	13±0.7 Ni	21.8 ± 1.5a
		Chloramphenicol
Gram-		
Salmonella enteritidis	11±00 Ni	16.9 ± 0.6a
Escherichia coli	Ni Ni	23.8 ± 0.7
Klebsiella pneumonia	8,0±0.1 9.1±1.03	22.8±0.5a
Fungal strains		**Cycloheximide**
Fusarium oxysporum	16.25± 0.5 20±0.2	20.2 ± 0.4a
Fusarium sp	Ni Ni	19.5 ± 0.3
Pythium Catenulatum	Ni 8.1±1.0	15.8 ± 0.6a

Table 4: Antimicrobial profile of fruit peel and cladodes extracts of *Opuntia stricta*.

a,b,c : letters indicate significant differences ($p<0.05$).

The data are expressed as mean ± S.D (n=3)

DIZ: Diameter of inhibition zones of extract including diameter of well 6 mm.

Chloramphenicol: a standard antibiotic at a concentration of 15 µg/well. Cycloheximide: a standard antibiotic at a concentration of 20 µg/well.

To better delve into the study of antimicrobial activity, we determine the MIC, MBC and MFC those considered criteria to measure also the antimicrobial activity. The results obtained were presented in table 5 and have shown that they are compatible with those recorded for the diameters of the inhibition zones. As presented in table 5, the lowest MIC and MBC were for *Staphylococcus aureus* (4.68 mg/ml and 37.5 mg/ml respectively) in the case of fruit peel extract and for cladodes extract (9.37 mg/ml and 75 mg/ml respectively). For fungal strains, *Fusarium oxysporum* presented the lowest MIC and MFC in AEF with 9.37 mg/ml and 75 mg/ml respectively; 4.68 mg/ml and 75 mg/ml for AEC. Also, these results are in agreement with those

	Concentration (mg/mL)	
Strains	**AEF MIC /MBC**	**AEC MIC/MBC**
Gram+		
Bacillus cereus	- / -	- / -
Bacillus subtilis	- / -	- / -
Staphylococcus aureus	4.68/ 37.5	9.37 / 75
Micrococcus luteus	9.37/ 37.5	- / -
Gram-		
Salmonella enteritidis	9.37/75	- / -
Escherichia coli	- / -	- / -
Klebsiella pneumonia	- / -	- / -
	AEF	AEC
Fungal strains	MIC/MFC	MIC/MFC
Fusarium oxysporum		
Fusarium sp	9.37 / 75	4.68/75
Pythium Catenulatum	- / -	- / -
	- / -	- / -

Table 5: MIC, MBC and MFC (mg/mL) of fruit peel and cladodes of *Opuntia stricta* extract.

MIC: Minimum Inhibitory Concentration

MBC: Minimum Bactericidal Concentration

MFC: Minimum Fongicidal Concentration

obtained by Zourgui and al. 2020 where *Fusarium oxysporum* is the most sensitive than the other (18,63 ± 0.5 mm for AEF).

Conclusion

In conclusion, the present study declared that fruits peel and cladode of *Opuntia stricta* were marked by the variability in polyphenols and flavonoids. Then, aqueous fruits peel extract present a strong antioxidant activity and exhibits a high antibacterial effect. While cladodes present a strong antifungal activity.

In the future, more extensive research will be demanded to determine the purified compounds responsible for these activities and conduct in vivo studies on the antibacterial properties.

Conflict of Interest

No known conflicts of interest.

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References

1. Marchese A, Shito GC (2001) Resistance patterns of lower respiratory tract pathogens inEurope. International Journal of Antimicrobial Agents 16: 25-29.
2. Combrinck S, Plooy GW, McCrindle RI, Botha BM (2007) Morphology and Histochemistry of the Glandular Trichomes of Lippia scaberrima (Verbenaceae). Annals of Botany 99: 1111-1119.
3. Oussou KR (2009) Etude chimique et activité biologiques des huiles essentielles de sept plantes aromatiques de la pharmacopée Ivoirienne. Doctorat de l'Université de Cocody-Abidjan 241.
4. Arba M (2009) Le cactus, *Opuntia*, une espèce fruitière et fourragère pour une agriculture durable au Maroc. Symposium International Agriculture durable en region 14-16.
5. Kharrat N, Salem H, Mrabet A, Aloui F, Triki S, et al. (2018) Synergistic effect of polysaccharides, betalain pigment and phenolic compounds of red prickly pear (*Opuntia stricta*) in the stabilization of salami. Biological macromolecules 111: 561-568.
6. Harrabi B, Athmouni K, Hamdaoui L, Mahmoud LB, Hakim A, et al. (2017) Polysaccharides extraction from *Opuntia stricta* and their protective effect against HepG2 cell death and hypolipidaemic effects on hyperlipidaemia rats induced by high-fat diet. Arch Physiol Biochem 123: 225-237.
7. Kalungia AC, Mataka M, Kaonga P, Bwalya AG, Prashar L, et al. (2018) *Opuntia stricta* Cladode Extract Reduces Blood Glucose Levels in Alloxan-induced Diabetic Mice. International Journal of Diabetes Research 7: 1-11.
8. Izuegbuna O, Otunola G, Bradley G (2019) Chemical composition, antioxidant, antiinflammatory, and cytotoxic activities of Opuntia stricta cladodes. PLoS ONE 14: 0209682.
9. Bakari S, Ncir M, Felhi S, Hajlaoui H, Saoudi M, et al. (2015) Chemical Composition and in vitro Evaluation of Total Phenolic, Flavonoid, and Antioxidant Properties of Essential Oil and Solvent Extract from the Aerial Parts of *Teucrium polium* Grown in Tunisia. Food Science and Biotechnology 24: 1943-1949.
10. Zourgui M, Hfaiedha M, Brahmi D, Affi W, Gharsallah N, et al. (2020) Phytochemical screening, antioxidant and antimicrobial activities of *Opuntia Streptacantha* fruit skin. Journal of Food Measurement and Characterization 25: 198-288.

11. Ayaz FA, Ayaz SH, Gruz J, Novak O, Strnad M (2005) Separation, characterization, and quantitation of phenolic acids in a little-known blueberry (*Vaccinium arctostaphylos* L.) fruit by HPLC-MS. Journal of Agricultural and Food Chemistry 53: 8116-8122.

12. Kadri A, Zarai Z, Chobba IB, Gharsallah N, Damak M, et al. (2011) Chemical composition and in vitro antioxidant activities of Thymelaea hirsuta L. essential oil from Tunisia. African Journal of Biotechnology 10: 2930-2935.

13. Bougandoura N, Bendimerad N (2013) Evaluation de l'activité antioxydante des extraits aqueux et méthanolique de Satureja calamintha ssp. Nepeta (L.) Briq. Nature and Technologie 9: 15.

14. Ou B, Hampsch WM, Prior RL (2001) Development and validation of an improved oxygen radical absorbance capacity assay using fluorescein as the fluorescent probe. Journal Agricultural and Food Chemistry 49: 4619-4626.

15. Prieto P, Pineda M, Aguilar M (1999) Spectrophotometric quantitation of antioxidant capacity through the formation of a phosphomolybdenum complex: specific application to the determination of vitamin E. Anal Biochem 269: 337-341.

16. Chang SF, Hsieh CL, Yen GC (2007) The protective effect of Opuntia dillenii Haw fruit against low-density lipoprotein peroxidation and its active compounds. Food Chemistry 106: 569-575.

17. Daoud A, Smaoui S, Kadri A, Gharsallah N (2016) Proximate analysis, mineral composition, phytochemical contents, antioxidant and antimicrobial activities. Arabian Journal of Chemistry 37: 234-287.

18. Sen A, Batra A (2013) Evaluation of antimicrobial activity of different solvent extracts of medicinal plant: Melia azedarach L. International Journal of Current Pharmaceutical Research 4: 67-73.

19. Hsouna A, Trigui M, Mansour R, Jarraya R, Dammak M, et al. (2011) Chemical composition, cytotoxicity effect and antimicrobial activity of *Ceratonia siliqua* essential metal elements oil with preservative effects against *Listeria* inoculated in minced beef meat. International journal of food microbiology 148: 66-72.

20. Felhi S, Noura B, Hichem BS, Slim S, Noureddine A, et al. (2016) Nutritional constituents, phytochemical profiles, in vitro antioxidant and antimicrobial properties, and gas chromatography–mass spectrometry of various solvent extracts from grape seeds (Vitis vinifera L.). Food Science and Biotechnology 25: 1537-1544.

21. Lataief B, Zourgui S, Rahmani M, Affi R, Daoud W, et al. (2020) Phytochemical composition and evaluation of antioxidant and antimicrobial activities of Tunisian Opuntia dellini peel fruits. European journal of pharmaceutical and medical research 7: 149-160.

22. Aruwa C, Amoo S, Kudanga T (2019) Extractable and macromolecular antioxidants of *Opuntia ficus-indica* cladodes: Phytochemical profiling, antioxidant and antibacterial activities. South African Journal of Botany 125: 402-410.

23. He X, Rui HL (2006) Cranberry phytochemicals: Isolation, structure elucidation, and their antiproliferative and antioxidant activities. Journal of Agricultural and Food Chemistry 54: 7069-7074.

24. Agunloye OM, Oboh G, Ademiluyi AO, Ademosun AO, Akindahunsi AA, et al. (2019) Cardio-protective and antioxidant properties of caffeic acid and chlorogenic acid: Mechanistic role of angiotensin converting enzyme, cholinesterase and arginase activities in cyclosporine induced hypertensive rats. Biomedicine and Pharmacotherapy 109: 450-458.

25. Shen Y, Song X, Li L, Sun J, Jaiswal Y, et al. (2019) Protective effects of p -coumaric acid against oxidant and hyperlipidemia-an in vitro and in vivo evaluation. Biomedical and Pharmacology 111: 579-587.

26. Yildirim A, Mavi A, Kara AA (2001) Determination of antioxidant and antimicrobial activities of Rumex crispus L. extracts. Journal of Agricultural Food and Chemistry 49: 4083-4089.

27. Olelaye M, Rocha B (2007) Acetaminophen-induced liver damage in mice: effects of some medicinal plants on the oxidative defense system. Experimental and Toxicologic Pathology 59: 319-327.

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