The cactus cladode (*Opuntia ficus indica*) modulates uricemia, improves endothelial dysfunction and corrects oxidative damage in rats fed a cafeteria diet

Received 11 May 2019
Revised 4 June 2020
Accepted 9 June 2020

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Abstract

Purpose – The effects of *Opuntia ficus indica* (*OFI*) cladodes on uricemia level, endothelial dysfunction and oxidative damage were studied in young rats fed a cafeteria diet (CD).

Design/methodology/approach – A total of 16 young male Wistar rats (weighing 110 ± 20 g and four weeks old) were divided into two homogenous groups. The first group received a CD containing 50% of hyperlipidic diet and 50% of junk food mix (processed mix: hyper-fat, hyper-salted and sweetened) (CD group), and the second group (CD + *OFI* nopalitos) received the same diet supplemented with 50 g of fresh *OFI* nopalitos (young cladodes) for 30 days.

Findings – *OFI* nopalitos regulate the hyperuricemia, improve the endothelial dysfunction by raising the bioavailability of nitric oxide(NO) and reduce prooxidant markers by reducing lipid peroxidation and protein oxidation ($p < 0.05$) and boosting antioxidant capacity and enhancing the antioxidant enzymes activities ($p < 0.05$) in blood and aorta tissues of rats early fed with a high-fat diet /junk food.

Social implications – By-products of *OFI* have specific functional properties that may be beneficial in metabolic disorders and offer a better alternative with an economic and sustainable development perspective.

Originality/value – By-products of *OFI* highlight potential functional properties mainly based on its potent antioxidant capacity. By-products of *OFI* can be used as a promising nutraceutical resource to prevent various metabolic disorders in relation with cardiovascular diseases or hyperuricemia in subjects consuming junk food and or living in the Western society to reach the objectives of health policy and maintain a sustainable health system development.

Keywords *Opuntia ficus indica*, By-products, Oxidative stress, Endothelial dysfunction, Hyperuricemia, Junk food

Paper type Research paper

Introduction

Lifestyle changes including unhealthy diets such as junk food; which is an unbalanced diet rich in calories from sugar or animal fat, with high salt content but little dietary fiber, protein, vitamins and minerals, and the products are prepared in such a way to be attractive, palatable and inexpensive (Payaba *et al.*, 2015); and sedentary lifestyle are the main risk factor for obesity development and its complications, contributing to the increased cardio-metabolic (CM) risk (Mendis *et al.*, 2011;. Schargrodsky *et al.*, 2008; Acosta-Cázares and Escobedo-de la Peña, 2010).

This work was funded by the Ministry of Higher Education and Scientific Research-Algeria (CNEPRU number D01N01UN310120150023).

Conflict of interest statement: The authors declare that they have no conflicts of interest to disclose.

World Journal of Science, Technology and Sustainable Development
Vol. 17 No. 4, 2020
pp. 355-365

2042-5945
DOI 10.1108/WJSTSD-05-2019-0023

Natural products have always been used to improve health and counteract metabolic disorders. In this context, there is an increasing interest for the nutritional benefit of *Opuntia* to prevent CM disease development (Santos Díaz *et al.*, 2017). The tender young part of the cactus cladodes or nopalitos, is frequently consumed as a vegetable (Ávila Curiel *et al.*, 2003). Previous studies on the chemical composition of the edible cladodes from *Opuntia ficus indica (OFI)* show that this food has a high nutritional value, mainly due to their proteins, fibers and phytochemical contents (Rodriguez-Garcia *et al.*, 2007; Hernández-Pérez *et al.*, 2005; Ayadi *et al.*, 2009; Rodríguez-Félix and Cantwell, 1998). Interestingly, antioxidant activity has also been reported (Kuti, 2004; Corral-Aguayo *et al.*, 2008; Harrat *et al.*, 2019; Chekkal *et al.*, 2020). The use of animal models with diet-induced obesity helps to evaluate the nutritional values and some biological parameters of *OFI* nopalitos (Morán-Ramos *et al.*, 2012; Kang *et al.*, 2013); among these models, the cafeteria diet (CD) makes use of grocery store-purchased food items that more closely approximate the human ultra-processed diet (processed foods are basically made by adding salt, oil, sugar or additives such as artificial colors flavors and stabilizers) (Monteiro *et al.*, 2019) than commercial high-fat or high-sugar rodent's diets (Gomez-Smith *et al.*, 2016).

Dietary ingredients and food components are major modifiable factors preventing the progression of some diseases (Attanzio *et al.*, 2018). In this context, the health-promoting properties of edible cladodes from *OFI* as a vegetable have been the object of recent interest.

The literature has long been interested in the therapeutic effects of *OFI,* in particular its fruit and seed. However, the effect of *OFI* by-products on hyperuricemia, membrane fluidity, blood pressure, endothelial dysfunction and pro/antioxidant balance in specific tissues (blood and the aorta) has never been examined. Thus, the present investigation was carried out in order to study the possible cardio-preventive and antioxidant proprieties of *OFI* nopalitos in tissues of young rats fed a CD.

Methods

Plant material preparation

OFI nopalitos were collected during the months of May and June 2018 in region of Oran (west of Algeria). The plant was identified as *Opuntia.ficus-indica* (Cactaceae) at the Laboratory of Plant Physiology of our Faculty.

The collect was carried out in the morning; between 11 a.m and 12 a.m. when the photosynthetic activity is at its maximum. Fresh young nopalitos were washed with distilled water, their spines were manually removed and then they were cut into pieces, crushed in a blender and stored in glass vials protected from light until use.

Experimental animals

Male Wistar rats weaned ($n = 16$) were obtained from Pasteur Institute (Algiers, Algeria). The rats were housed at 22 ± 2 °C with free access to food and water "*ad libitum*", under at 12:12 hours light/dark cycle and a humidity of 60%. All experimental methods were approved by the Animal Care and Use Committee of University and the Algerian Ministry of Higher Education and Scientific, and the general councils for the care and use of laboratory animals recommended by the Council of European Communities (1987) were followed.

Animal grouping

After acclimation for ten days, at body weight (BW) of 110 ± 20 g and four weeks of age, the young rats were randomly divided into two groups: the first group consumes the CD (Darimont *et al.*, 2004) containing 50% of high-fat diet (casein 20%, corn starch 45%, sunflower oil 20%, sucrose 5%, cellulose 5%, mineral mixture 4% and vitamins 2%) and

50% of junk food mix (animal fat; cheese; biscuits; chips; chocolate and peanuts, with the following proportions: 2-2-2-1-1-1, respectively) supplemented with 50 g (g/100g of diet) of fresh *OFI* nopalitos (CD + *OFI* nopalitos), and the second group continues to consume the CD without supplementation (CD) during one month (Table 1).

Blood pressure

The arterial blood pressure was measured weekly by assessing systolic and diastolic pressures in awake rats, by a no invasive measurement using a blood pressure recorder *via* a device placed around the tail (sleeve and sensor) of the animal (CODA, Kent Scientific Corporation, USA).

Sample collection

The rats of each group were anesthetized by intraperitoneal injection with 10% chloral (3 ml/kg of BW) after overnight fasting, and blood samples are taken from the abdominal aorta and collected in tubes prepared by low-speed centrifugation (1000 g for 20 minutes at 4 °C). Serum was taken, and separated red blood cells (RBC) were then washed three times by resuspending in 0.9% NaCl solution and repeating the centrifugation. The washed cells were lysed in a similar volume of water and mixed thoroughly. The aorta was removed immediately, rinsed with cold saline and blotted on a filter paper. All samples are stored at −70ºC until use.

Membrane fluidity

Serum phospholipids (PL) contents were determined by enzymatic determination of PLs (kit CHO-POD; Cypress, Langdorp, Belgium). Serum nonesterified cholesterol (NEC)

Hyperlipidic diet		Junk food mix[8]		Experimental diets	
Ingredients	(g/100 g diet)	Ingredients	Proportion	Cafeteria diet (CD)[15]	CD + *OFI* nopalitos
Casein[1]	20	Animal fat[9]	*2*		
Corn starch[2]	45	Cheese[10]	*2*		
Sucrose[3]	4	Biscuits[11]	*2*		
Sunflower oil[4]	20	Chips[12]	*1*		
Cellulose[5]	5	Chocolate[13]	*1*		
Mineral mixture[6]	4	Peanuts[14]	*1*		
Vitamin mixture[7]	2				
Hyperlipidic diet (g)				*50*	*50*
Junk food mix (g)				*50*	*50*
Fresh cladodes (g)					*50*

Note(s): [1]Prolabo-Paris, France. [2]SPA, Maghnia, Tlemcen, Algeria. [3]Cevital, SPA, Bejaia, Algeria. [4]Sunflower oil (15% AGS (saturated fatty acids), 25% AGMI (monounsaturated AG), 60% PUFA (polyunsaturates AG) Crevital, SPA, Bejaïa, Algeria. [5]Prolabo-Paris, France.5 UAR 205 B (Villemoisson, 91,360, Epinay / S / Barley, France). [6]Mineral mixture (mg / kg diet) $CaHPO_4$, 17,200; KCl, 4,000, NaCl, 4,000, MgO_2, 420, $MgSO_4$, 2000, Fe_2O_3, 120, $FeSO_4$, $7H_2O$, 200, $MnSO_4$, H_2SO_4, H_2O, 98, $CuSO_4$, $5H_2O$, $ZnSO_4$, 80, $CuSO_4$, 80, $CuSO_4$, $7H_2O$, KI, 0.32.10 UAR 200 (Villemoisson, 91,360, Epinay/S/Barley, France). [7]Vitamin mixture (mg/kg diet): Vit A, 39,600 IU, Vit D3, 5000 IU, Vit B1, 40 Vit B2, 30; Vit B3, 140; Vit B6, 20; Vit B7, 300; Vit B12, 0.1; Vit C, 1,600; Vit E, 340; Vit K, 3,80; Choline, 2,720; Folic acid, 10; Para-aminobenzoic acid, 180; Biotin, 0.6; Cellulose, qs, 20 g.[8] Junk food mix (Darimon *et al.*, 2004). [9]Sheep fat. [10]Pizza cheddar: 1,515 Kcal/100g, lipids (28 g), proteins (5.5 g), carbohydrates 1 g. [11]Biscuits: 413.46 Kcal/100g, lipids (10.87 g), proteins (11.02 g), carbohydrates (67.87 g). [12]Chips: 540 Kcal/100, lipids (33 g), proteins (6.5 g), carbohydrates (54 g). [13]Chocolate: 343 Kcal/100g, lipids (27.83 g), proteins (8.39 g), carbohydrates (60.55 g). [14]Peanuts (471.05 Kcal/100g; lipids (23.05 g), proteins (14.5 g), carbohydrates (51.40 g). [15]Cafeteria diet (CD) is prepared from hyperlipidic diet + junk food mix

Table 1. Composition of the diets

concentrations were assessed by an enzymatic method (kit CHOD-PAP; Biolabo, Maizy, France).The membrane fluidity ratio (NEC / PL) was calculated.

Red blood cells and aorta: susceptibility to lipid peroxidation

Lipid peroxidation in RBC was estimated by measuring thiobarbituric acid reactive substances (TBARS) concentrations and expressed in terms of the malondialdehyde content (Quintanilha *et al.*, 1982). TBARS concentration in the aorta was estimated (Ohkawa *et al.*, 1979). Lipid hydroperoxides (LPO) contents were estimated using Cayman's lipid hydroperoxides Assay kit.

Red blood cells and aorta: susceptibility to protein oxidation

The carbonyl derivatives level analysis was carried out (Levine *et al.*, 1990) using 2,4-dinitrophenylhydrazine (DNPH) (Sigma–Aldrich Chemie, Germany), which was the conventional reagent used with proteins.

Antioxidant capacity (AOxC) determination

The evaluation of AOxC in RBC and the aorta was carried out by a colorimetric method (Oxford Biomedical Research Kit, Oxford, Michigan, USA).

Evaluation of antioxidant enzymes activities

In RBC and the aorta, superoxide dismutase (SOD) activity was estimated by the method of Marklund and Marklund, 1974**.** One unit of SOD is defined as the amount required to inhibit 50% of the disproportionation of the superoxide radical. This technique makes it possible to simultaneously measure the three types of SOD (Cu/Zn, Mn and Fe). Glutathione peroxidase (GSH-Px) activity was measured (Flohe and Gunzler, 1984). Catalase (CAT; EC1.11.1.6) activity was estimated by measuring the decomposition rate of H_2O_2 (Aebi *et al.*, 1974). In the presence of CAT, the decomposition of H_2O_2 leads to a decrease in the absorption of the H_2O_2 solution as a function of time.

All enzyme activities were adapted to microplate titration with the microplate titrator IEMS reader MF (Kirial SA).

Endothelial dysfunction and uricemia evaluation

The endothelial dysfunction was measured by the determination of nitric oxide (NO) contents in the different samples. This analysis is carried out by the Griess reagent (sulfanilamide and N-naphthylethylenediamine) based on the reduction of nitrate (NO3-) to nitrite (NO2-) (Cortas and Wakid, 1990). The serum uric acid content is determined by an enzymatic colorimetric method (Kit Spinreact, Spain).

Statistical analysis

The results are expressed as mean ± standard error of the mean for eight rats per group. The comparison of the means was carried out by the Student *t*-test using Statistica software (version 6, Statsoft, United States) between CD + *OFI* nopalitos and CD group. A *P*-value less than 0.05 was used to designate the statistical significance in all analyses.

Results

Blood pressure, membrane fluidity and uricemia

Membrane fluidity ratio and arterial systolic and diastolic pressures did not differ between the both groups. However, serum uric acid concentration was decreased (−52%) in the CD + *OFI* nopalitos group compared to CD (Table 2).

Lipid peroxidation and protein oxidation

In CD + *OFI* nopalitos group compared with the CD, the levels of TBARS in RBC and the aorta were, respectively, reduced by 43% and 26%. Similarly, LPO and carbonyl concentrations were decreased in RBC (−35%; −73%) and the aorta (−50%; −25%), respectively (Table 3).

Endothelial dysfunction and antioxidant capacity

In the CD + *OFI* nopalitos group, NO levels were enhanced in RBC (+23%) and the aorta (+29%) than the CD group (Table 4). Similarly, antioxidant capacity was improved in rats fed *OFI* nopalitos by 124% and 61% in RBC and aorta, respectively, compared to the CD group (Table 4).

Antioxidant enzymes activities

In RBC, a significant increase was noted in SOD (+38%), GSH-Px (+84%) and CAT (+17) activity in rats fed *OFI* nopalitos, In the aorta, SOD and GSH-Px activity remains unchanged between two groups, while the CAT activity was increased by 55% in CD + *OFI* nopalitos compared to the untreated group (Table 5)

Parameters	CD	CD + *OFI* nopalitos
Arterial pressure (mmHg)		
Diastolic	121.42 ± 9.00	117.42 ± 9.34
Systolic	81.71 ± 7.22	84.71 ± 5.59
Serum uric acid (mmol.L^{-1})	179.38 ± 14.13	85.65 ± 4.56**
Membrane fluidity	2.03 ± 0.78	2.01 ± 0.18

Note(s): The results are expressed as mean ± standard error of the mean for eight rats per group. Statistical analysis was performed by Statistica software (Statistica 5.1 for Windows software, Statsoft Inc. software, Tulsa, Oklahoma, USA). The comparison of the averages is carried out by Student's test. Means are significantly different at $^{*}P < 0.05$; $^{**}P < 0.01$. CD: group fed CD; CD + *OFI* nopalitos: group fed CD supplemented with OFI nopalitos
Membrane fluidity: nonesterified cholesterol/phospholipids

Table 2.
Arterial blood pressure, membrane fluidity ratio and uricemia

Parameters	CD	CD + *OFI* nopalitos
Thiobarbituric acid reactive substances contents		
RBC (µmol.g^{-1} hemoglobin)	96.80 ± 3.55	54.32 ± 4.52**
Aorta (µmol.g^{-1} of tissue)	18.29 ± 4.25	9.14 ± 2.97**
Hydroperoxide contents		
RBC (nmol Eq CUOOH.g^{-1} hemoglobin)	93.18 ± 3.35	60.30 ± 4.25**
Aorta (nmol Eq CUOOH.g^{-1} of tissue)	44.38 ± 4.10	32.60 ± 2.83*
Carbonyls contents		
RBC (nmol .mg^{-1} protein)	11.26 ± 2.00	3.01 ± 0.55**
Aorta (nmol .mg^{-1} protein)	4.39 ± 0.36	3.27 ± 0.35*

Note(s): The results are expressed as mean ± standard error of the mean for eight rats per group. Statistical analysis was performed by Statistica software (Statistica 5.1 for Windows software, Statsoft Inc. software, Tulsa, Oklahoma, USA). The comparison of the averages is carried out by Student's test. Means are significantly different at $^{*}P < 0.05$; $^{**}P < 0.01$. CD: group-fed CD; CD + *OFI* nopalitos: group-fed CD supplemented with *OFI* nopalitos

Table 3.
Lipid peroxidation in red blood cells (RBC) and the aorta

Discussion

OFI cladodes should attract great interest because of their nutritional and antioxidant properties (Ginestra *et al.*, 2009; Msaddak *et al.*, 2015). So the present study was undertaken to examine whether *OFI* cladodes can prevent CM complications associated with obesity, in rats exposed prematurely to a CD (high-fat diet /junk food).

Our recent study has shown that *OFI* cladodes supplementation in a high-fat diet improved effectively blood pressure in rats with diabete type 2 (DT2) (Harrat *et al.*, 2019). Similarly, others authors (Bakour *et al.*, 2017) showed that the intravenous administration of the freeze-dried extract of *OFI* stems generates a significant decrease in blood pressure in rabbits as well as a rise in urinary volume and urinary excretion of sodium, which could explain its hypotensive effect. Indeed, several studies have shown that the *OFI* stems had diuretic properties (Vieira *et al.*, 2008 ; Menezes *et al.*, 2010). However, our results did not reveal any effect on arterial tension and in membrane fluidity. This discordance could be explained probably by the difference in animal model, type of diet as well as the quantity or texture of *OFI* administered.

Over the last decades, oxidative stress has been shown to be a major component of several biological and pathological processes (Zou *et al.*, 2005), and numerous studies support the fact

	CD	CD + *OFI* nopalitos
Antioxidant capacity		
AOxC-RBC (μmol Eq Trolox.g^{-1} hemoglobin)	2,210 ± 477.54	4,950 ± 250.95***
AOxC-Aorta (μmol Eq Trolox.g^{-1} tissue)	567.93 ± 81.95	917.91 ± 64.12**
Endothelial dysfunction		
RBC-NO (μmol.g^{-1} hemoglobin)	6.89 ± 0.50	8.50 ± 0.43*
Aorta-NO (μmol.g^{-1} tissue)	3.17 ± 0.27	4.10 ± 0.41**

Note(s): The results are expressed as mean ± standard error of the mean for eight rats per group. Statistical analysis was performed by Statistica software (Statistica 5.1 for Windows software, Statsoft Inc. software, Tulsa, Oklahoma, USA). The comparison of the averages is carried out by Student's test. Means are significantly different at $^{**}P < 0.01$; $^{***}P < 0.001$. CD: group fed CD; CD + *OFI* nopalitos: group fed CD supplemented with *OFI* nopalitos

Table 4. Antioxidant capacity (AOxC) and nitric oxide (NO) contents in red blood cells (RBC) and the aorta

Antioxidant enzymes	CD	CD + *OFI* nopalitos
SOD		
RBC (U. g^{-1} Hemoglobin)	1.76 ± 0.36	3.25 ± 0.84*
Aorta (U. g^{-1} of tissue)	0.86 ± 0.15	1.07 ± 0.12
GSH-Px		
RBC (nmol.min^{-1}. g^{-1} Hemoglobin)	132.53 ± 27.22	182.57 ± 32.92*
Aorta (nmol.min^{-1}. g^{-1} of tissue)	12.83 ± 2.06	18.73 ± 2.01
CAT		
RBC (U. min^{-1}. g^{-1} Hemoglobin)	85.32 ± 2.14	100 ± 3.91**
Aorta (U. min^{-1}. g^{-1} of tissue)	8.45 ± 0.41	13.10 ± 1.31**

Note(s): The results are expressed as mean ± standard error of the mean for eight rats per group. Statistical analysis was performed by Statistica software (Statistica 5.1 for Windows software, Statsoft Inc. software, Tulsa, Oklahoma, USA). The comparison of the averages is carried out by Student's test. Means are significantly different at $^{*}P < 0.05$; $^{**}P < 0.01$. CD: group fed CD; CD + *OFI* nopalitos: group fed CD supplemented with *OFI* nopalitos
SOD : superoxide dismutase; GSH-Px : glutathione peroxidase; CAT : catalase

Table 5. Antioxidant enzymes activities in red blood cells (RBC) and the aorta

that various dietary phytochemicals redox active/antioxidant are promising compounds to prevent oxidative mechanisms taking place in many pathological states (El-Mostafa *et al.*, 2014). In this context, obesity and its complications (hyperlipidemia and dysglycemia) lead to an increased oxidative stress (Tran *et al.*, 2012; Rupérez *et al.*, 2014; Jung and Choi, 2014). Natural products may counteract the harmful effects of oxidative stress, thus the nutritional strategy using nopalitos could improve the pro/antioxidant balance and therefore the CM risk factors related to obesity. According to several studies, *OFI* cladodes yield high values of important nutrients and exhibit antioxidant functions (Tesoriere *et al.*, 2005; Harrat *et al.*, 2019). Our results showed that oxidative stress is reduced in rat fed cladodes by decreasing the markers of lipid peroxidation and protein oxidation (TBARS, LPO and carbonyls, in tissues studied) compared to the untreated group. This decrease in radical attack may be the result of a modification in redox cellular status in favor of antioxidants, associated with stimulating enzymatic endogenous antiradical defenses as a compensatory mechanism to be protected from the moderate level damage of toxic reactants inducing a rise in antioxidant enzymes (Ikediobi *et al.*, 2004). Indeed, the determination of antioxidant capacity showed a higher activity in rats fed *OFI* cladodes. In addition, the cladodes supplementation in CD seems effective against the radical attack due to lower levels of proxydants markers, and this can be explained probably by blood lipids reduction (parameter not shown in this study), which therefore leads to less lipid peroxidation. (Volek *et al.*, 2009) have shown that generation of free radicals is positively correlated with total cholesterol and triacylglycerols levels.

Human studies showed that consumption of *OFI* cladodes at dietary-achievable amounts was associated with a remarkable reduction of oxidative stress in healthy subjects (Tesoriere *et al.*, 2004). Lee *et al.* (2014) investigated the antioxidant activity of cactus nopalitos and concluded that this antioxidant property was due to several compounds, particularly flavonoids and vitamins. Our results are in accordance with published studies in rats with diabete type 2, which underlined the relevant preventive potential of *OFI* cladodes (Ncibi *et al.*, 2008: Zourgui *et al.*, 2008; Harrat *et al.*, 2019). The phenolic components and their specific effects on human metabolism have been reviewed (Stintzing and Carle, 2005), and polyphenolics are antioxidants with well-known cardioprotective properties (Tapiero *et al.*, 2002; Feugang *et al.*, 2006). These are generally attributed to the ability of antioxidants to neutralize reactive oxygen species such as singlet oxygen, hydrogen peroxide or H_2O_2 or suppression of the xanthine/xanthineoxidase system; in fact, serum uric acid concentration is clearly lower in the group supplemented with nopalitos. Uric acid is a terminal product of purine metabolism with a nonnegligible extracellular antioxidant function. However, it is currently well established that high levels of uric acid are closely related to certain metabolic diseases (Feugang *et al.*, 2006). Serum uric acid levels seem to be associated with insulin resistance in obese patients (Maiuolo *et al.*, 2016). In our recent study (Harrat *et al.*, 2019), we showed that *OFI* nopalitos administration in the hyperlipidic diet decreased glycemic markers and homeostasis model assessment insulin resistance in rats with diabete type 2.

This study reveals too the capacity *OFI* nopalitos to reduce the level of uricemia. Thus, the low uric acid level induced by *OFI* nopalitos supplementation confirms the link between hyperuricemia and insulin resistance (Elizalde-Barrera *et al.*, 2017). All cardiovascular risk factors have a common effect on the arterial wall: they increase the production of free radicals and thus lead to a decrease in the availability of NO that is manifested by an attenuation of endothelium-dependent vasodilation (Griendling and Alexander, 1997). Our results revealed that NO levels were decreased in serum and tissues in rats consuming *OFI* nopalitos. Bioactives compounds of *OFI* nopalitos (Harrat *et al.*, 2019), could have a protective effect against endothelial dysfunction via underlying mechanisms including, increased bioavailability of NO.

Conclusion

OFI cladodes were able to moderate hyperuricemia and improve the endothelial dysfunction by raising the bioavailability of NO. In addition, *OFI* cladodes may play an important role in suppressing oxidative stress caused by a diet which contains an assortment of highly palatable and energy dense foods predominant in the Western society. The *OFI* by-products because of their biological properties are a potential candidate as we are increasingly moving toward multifunctional foods with health effects (low-calorie, cholesterol-free, rich in fiber, vitamins and antioxidants). In our country, this vegetable is not exploited by our farmers, and not consumed by Algerian population, due to the lack of information on its nutritional and medicinal potentials. Their development could offer a new nutritional alternative (a low-cost dietetic vegetable) in order to prevent and/or treat a cardiovascular risk. Thus, in perspective, using these results by conducting a clinical study on a cohort of human subjects predisposed to cardiovascular diseases or hyperuricemia follower of junk food would be of great interest for public health.

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