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Effect of Carob(*Ceratonia Siliqua L.*) growing in Libya on cisplatin-induced nephrotoxicity in mice

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ABSTRACT

Reactive oxygen species and free radicals are involved in the nephrotoxicity induced by the synthetic anticancer drug cisplatin. The nephrotoxicity effects of carob pods and leaves (100 and 200 m/kg, p.o.) were investigated using cisplatin (10mg/kg body weight, i.p.) to induce oxidative renal damage in mice. The results showed that cisplatin administration caused abnormal renal functions in all studied mice. Serum urea and creatinine concentration were significantly higher ($p<0.5$) in the cisplatin alone treated (control) group compared to the normal group. The concentrations of serum creatinine and urea in the carob pods (200 mg/kg body weight) treated group were reduced to 57.5% and 51.5%, respectively, with respect to the control group. Also, cisplatin induced decline of renal antioxidant enzymes such as Superoxide dismutase (SOD), Catalase (CAT), Glutathione peroxidase (GP_X) activities, but the treatment of carob pods and leaves (100 and 200mg/kg, p.o) significantly attenuated the cisplatin- induced nephrotoxicity. Both pods and leaves of carob at 100 and 200 mg/kg increased the concentration of reduced lipid peroxidation .In addition, treatment with cisplatin increased the activity of cathepsin D, RNase II, DNase II and acid phosphatase. The treatment of carob pods and leaves (100 and 200 mg/kg, p.o.) improved the activity of lysosomal enzymes nearly to the normal group. In conclusion, carob leaves and pods may be effective to protect from oxidative renal damage and the leaves are the better nephroprotective agent than pods. The protection may be mediated partially by preventing the decline of renal antioxidant status.

Key word: Carob, nephrotoxicity**,** free radicals and antioxidant

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INTRODUCTION

Cisplatin is a widely Used anti-neoplastic agent for the treatment of metastatic tumors of the testis, metastatic ovarian tumors, lung cancer, advanced bladder cancer and many other solid tumors [1]. The cytotoxic action of the drug is often through its ability to bind DNA to form cisplatin-DNA adducts [2]. Although higher doses of cisplatin are more efficacious for the suppression of caner , high dose therapy manifests irreversible renal dysfunction and other toxicities yet [3,4]. Various data indicate that cisplatin induces oxidative stress (5), lipid peroxidation [6,7] and DNA damage [8]. Therefore administration of antioxidants has been show to ameliorate cisplatin- induced nephrotoxicity in various species of animals [9]. The mechanism of protective effects of antioxidants against cisplatin nephrotoxicity is not fully known. Ceratonia siliqua.L., Fabacae (Carob) has been widely cultivated in Mediterranean area [10]. The plant is grown locally in Egypt, and the pods are used mainly for preparing a popular beverage. Leaves and pods of carob of carob exerted diverse physiological function as antioxidant activity [10,11]. Also, carob pods and leaves extracts contain antiproliferative agents that could be practical importance in the development of finctional foods and/or chemopreventive drugs. In addition leaves and pods of carob are rich in polyphenols and flavonoids [11].

In the present study, the protective effect of carob pods and leaves by two doses (100 and 200 mg/kg,p.o.) on cisplatin-induced renal damage in mice were evaluated.

MATERIALS AND METHODS

PREPARATION OF SAMPLES:CAROB (C.Siliqa) pods and leaves samples were obtained from Al-Jabal Al Akhdar area in Libya during 2012. The pods and leaves were grinded to fine powder before extraction. Such powdered samples were kept in dark bottles.

Chemicals: Cisplatin (1mg/ml) Onco-Tain DBL was from Mayne Pharma PLC, UK., Rwduced glutathione (GSH), 5,5- dithiobis (2-nitrobenzoic acid) (DTNB),EDTA and thiobarbituric acid (TBA) were from Sigma-Aldrich Co, St Louis, USA. All other chemicals and reagents used were of analytical grade.

Animals : Albino male mice (30±6 g) were used in the present study. The animals were kept under standard laboratory conditions of light/ dark cycle (12/12h) and temperature (25±2ºC). They were provided with a nutritionally adequate standard laboratory diet.

Animal diet: The basal diet consists of casein 10%, cotton seed oil 4%, salt mixture 4%, vitamin mixture 1%, carbohydrates (sucrose, starch 1:1) 80.8% and choline chloride 0.2% [12] .

Plant extracts: 100g of pods and leaves of carob were separately extracted by percolation with 70% ethanol .The extracts were filtered, concentrated under vacuum and freeze dried.

Experimental design: Animals were included into 6 groups, of 6 animals each.

Group I : Treated with vehicle (gum acacia, 1%) was kept as normal.

Group II: Injected with a single dose of cisplatin (CIS) (10 mg/kg b.wt, i.p.) was kept as control.

Group III and IV: Were treated with pods extract (P.), 100 and 200 mg/kg b.wt.

Group V and VI: Were treated with leaves extract (L.), 100 and 200 mg/kg b.wt.

The pods and leaves extracts were freshly prepared as fine suspension in gum acacia and administered by oral gavage one h before and 24 h and 48 h after cisplatin injection. Seventy two hours after cisplatin injection, animal were killed by cervical decapitation. Blood was collected and the separated serum was used for the estimation of creatinine [13] and urea [14].

After decapitation, kidney was rapidly removed and washed in cold isotonic saline. The kidney was divided into two portions. The first one was homogenized in 50 mM phosphate buffer (PH 7) using an electronic homogenizer to prepare 10% w/v homogenate. The homogenate was centrifuged at 3000 rpm for 10 min at 4ºC and the supernatant was used for the estimation of total protein [15], lipid peroxidation (TBARS) measured as malondialdehyde (MDA) [16], superoxide dismutase (SOD) [17], catalase (CAT) [18], Glutathione peroxidase (GP_X) [19], reduced glutathione (GSH) [20] and glutathione-S-transferase (GST) [21]. The second portion was used for lysosomal isolation according to [22]. The activities of four lysosomal acid hydrolases were measured. Cathepsin D, RNase II, DNase II and acid phosphatase activities were determined according to the method of [23,24] .

Statistical Analysis

The results are expressed as Mean± SEM. The collected data were statistically analyzed by the least significant differences (LSD) at the level 5% of the probability procedure according to [25].

RESULTS

Intravenous cisplatin administration caused abnormal renal functions in all injected mice. Serum urea and creatinine concentrations were significantly increased ($P<0.5$) in the cisplatin alone treated (control) group compared to the normal group (Table 1). The concentrations of serum creatinine and urea in the carob pods (200 mg/kg body weight) treated group were reduced to 57.5% and 51.5%, respectively, with respect to the control group. Similarly, the concentration of urea and creatinine in the carob leaves (200 mg/kg) treated group were reduced to 62.8% and 65.2%, respectively.

The activities of renal SOD, CAT and GP_X in the cisplatin plus carob pods or cisplatin plus carob leaves administered group are given in Table 2. Renal SOD activity was decreased significantly ($P<0.05$) in the cisplatin

alone treated group compared to the normal group. The SOD activity in the carob pods and leaves (200 mg/kg body weight) administered group were increased significantly ((P<0.05) when compared to that of control group.

The activity of CAT in the cisplatin alone treated group was found to be decreased significantly (P<0.05) when compared to the normal group .Treatment of carob pods and leaves affectivity prevented the cisplatin induced decline of the CAT activity. Similarly , GP_X activity was decreased significantly in cisplatin treated group. The enzyme activity was significantly increased ((P<0.05) except at low dose of carob pods that could not prevent the decline of GP_X activity.

The concentration of renal GSH was significantly decreased (P<0.05) and that of malondialdehyde was significantly increased (Table 3) in cisplatin treated animals. Administration of carob pods or leaves prior to cisplatin injection increased GSH and decreased the MDA concentrations. Administration of cisplatin induced significant decrease in renal GST activity (40.4%) in comparison to normal value (Table 3). Whereas, carob pods and leaves (200 mg/kg)significantly ameliorated the effect of cisplatin by 58.8% and 59.7%, respectively, compared to cisplatin group. The effects of cisplatin treatment on lysosomal enzyme activities are presented in Table 4. Cisplatin treatment increased the activities of the four enzyme, acid phosphatase, cathepsin D, DNase II and RNase II,significantly (p<0.05) compared to normal group. Administration of carob pods or leaves by two doses prior to cisplatin significantly (P<0.05) ameliorated the effect of cisplatin in all enzyme activities, compared to control group.

DISCUSSION

Cisplatin has been shown to cause nephrotoxicity in patients[26, 27] as well as in a variety of animal species [28, 29,30] .A minimum dose of cisplatin (5 mg/kg b.wt, i.p.) was sufficient to induce nephrotoxicity in rats [31, 32]. A higher dose of cisplatin (10 mg/kg b.wt.i.p) corresponds to that currently being used in clinical practice. Administration of cisplatin exerts significant increase in serum urea and creatinine concentrations compared to normal group, which clearly indicated the acute renal failure. The effects of cisplatin were similar to those previously described [33,34,35]. Carob pods and leaves ameliorated cisplatin- induced nephrotoxicity as indicated by significant less increase in serum urea and creatinine concentrations.

The renal antioxidant status, such as SOD, CAT, GP_X activities and GSH concentration is significantly deceased in the cisplatin alone treated group of animals compared to normal group. The decline of antioxidant status partially explains the mechanism of nephrotoxicity induced by cisplatin. The renal accumulation of platinum and covalent binding of platinum to renal protein could, also, play a role in the nephrotoxicity [36]. Cisplatin induced suppression of renal antioxidant enzyme activity was also supported by the published experimental results [37,38].

Carob pods and leaves (200 mg/kg b.wt. i.p.) along with cisplatin could significantly improve the depletion of the renal antioxidant system.

GSH depletion increases the sensitivity of organ to oxidative and chemical injury. Studies with a number of models show that the metabolism of xenobiotics often produced GSH depletion [39 , 40]. The depletion of GSH, also, seems to be a prime factor that permits lipid peroxidation in the cisplatin treated group. Treatment of carob pods and leaves reduced the depletion of GSH levels and provided protection to the kidney. The protection of GSH is by forming the substrate for GP_X activity that can react directly with various aldehyde produced from the peroxidation of membrane lipid.

The initiation and propagation of lipid peroxidation in the cisplatin treated group could be caused by the decreased SOD activity. Such decreased activity may be either due to loss of copper and zinc, which are essential for the activity of enzyme or due to eeactive oxygen species-induced inactivation of the enzyme protein [41,42].

The activity of CAT and GP_X, also, decreased in the cisplatin treated group, which in turn increased the hydrogen peroxide concentration and enhanced the lipid peroxidation. Hence the concentration of MDA, as a result of lipid peroxidation, increased in the cisplatin treated group. Treatment with leaves and pods of carob prevented the lipid peroxidation by enhancing the renal SOD ,CAT and GP_X activities. It is well known that many phenolic compounds, which are found in carob, exert powerful antioxidant effects. They, also, inhibit lipid peroxidation by scavenging reactive oxygen species (ROS), such as $OH^{\cdot}$ [43].

From the data presented (Table 4), it is clear that cisplatin treatment in general resulted in increase in the activity of all lysosmal enzymes under study. In the carob pods and leaves treated groups this effect was improved nearly to normal group.

There is a correlation between lipid peroxidation and the release of lysosomal enzymes from lysosomes. Hence the process of lipid peroxidation activates phospholipases and removes the peroxidized lipid from the membrane [44]. The oxidation of unsaturated fatty acids in biological membranes by freeradical leads to a decrease in membrane fluidity and disruption of membrane structure and function [45].

The increase in activities of RNase II and DNase II is a mater of concern, since this can lead to indiscriminate degradation of RNA and DNA ultimately resulting in necrosis of the cells in the tissues, i.e. kidney and liver [46]. Also , [47] reported that the cathepsin D activity increased substantially in experimental thyrotoxicosis. It was found that the acid phosphatase activity increased after cisplatin treatment (Table 4). [48] showed that lysosomal acid phosphatase preferentially acts on nucleotides and that AMP is the preferred substrate. The concerned action of activated nucleases and acid phosphatase would lead not only to the breakdown of nucleic acids but also to the further dephosphorylation of mononucleotides, thereby leading to the acceleration of the process of cell degeneration.

Ethanolic extract of carob leaves possessed strong radical scavenging activity in vitro as measured by DPPH assay. Furthermore, the in vivo studies confirmed the antioxidant efficacy of this extract as well as its hepatoprotective activity [11]. Polyphenols in carob pods have antioxidant activity [10]. In addition the crude polyphenol extracts of carob pods showed strong antioxidant activity [49]. The protective effect of carob pods and leaves, in the present study, against cisplatin- induced nephrotoxicity is in harmony and supports the previous reports indicating the antioxidant and cytoprotective potential of carob pods and leaves. In conclusion, carob pods and leaves ethanol extracts improve the nephrotoxicity of cisplatin in mice. The nephroprotective effects of carob pods and leaves may be partially mediated by preventing the cisplatin- induced decline of renal antioxidant status and lysosomal membrane.

Table (1): Effect of carob pods and leaves on serum urea and creatinine in mice treated with cisplatin

Groups	Urea (m mol/l)		Creatinine (m mol/l)	
	Mean ±SE	% Change	Mean ±SE	% Change
Normal	6.8±1.1	------	28.1±4.2	-------
Control (CIS)	23.1±2.1[a]	372↑	260.4±50.2[a]	825.3↑
P100+(CIS)	15.7±1.0[b]	32.0↓	152.6±13.6[b]	41.4↓
P200+(CIS)	11.2±1.2[b]	51.5↓	110.7±27.9[b]	57.5↓
L100+(CIS)	14.2±1.4[b]	38.5↓	108.2±10.9[b]	58.4↓
L200+(CIS)	8.6±1.0[b]	62.8↓	90.5±12.2[b]	65.2↓

Values are Means ±SEM (n=6 animals). [a] p<0.05, (student's t test) significantly different from normal group. [b] p<0.05, significantly different from control group. ns, non significant different from control group. P, pods and L, leaves of carob.

Table (2): Effect of carob pods and leaves on renal SOD, CAT and GP_X in mice treated with cisplatin

Groups	SOD (U/mg protein)		CAT(U/mg protein)		GP_X (U/mg protein)	
	Mean ±SE	% Change	Mean ±SE	% Change	Mean ±SE	% Change
Normal	22.2±2.6	-----	60.9±6.8	------	53.1±6.1	------
Control (CIS)	10.6±1.9[a]	52.3↓	41.7±2.8[a]	31.5↓	30.7±3.5[a]	42.2↓
P100+(CIS)	15.2±2.8[ns]	43.4↑	49.1±2.6[b]	17.7↑	37.2±3.0[ns]	21.2↑
P200+(CIS)	17.2±3.1[b]	62.3↑	56.9±2.8[b]	36.5↑	42.9±4.1[b]	39.7↑
L100+(CIS)	17.9±2.7[b]	68.3↑	52.8±3.3[b]	26.6↑	40.1±3.2[b]	30.6↑
L200+(CIS)	19.1±3.6[b]	80.2↑	58.1±5.2[b]	39.3↑	48.2±5.2[b]	57.0↑

Values are Means ±SEM (n=6 animals). [a] p<0.05, (student's t test)significantly different from normal group. [b] p<0.05, significantly different from control group. ns, non significant different from control group. P, pods and L, leaves of carob.

Table (3): Effect of carob pods and leaves on renal GSH , TBARS and GST in mice treated with cisplatin

Groups	GSH (n mol/mg protein)		TBARS (n mol /mg protein)		GST (n mol /min/mg protein)	
	Mean ±SE	% Change	Mean ±SE	% Change	Mean ±SE	% Change
Normal	5.0±0.6	------	1.5±0.20	------	20.1±3.9	-------
Control (CIS)	2.4±0.5[a]	52.0↓	3.6±0.26[a]	140.0↑	11.9±1.2[a]	820.0↓
P100+(CIS)	3.8±1.0[ns]	58.3↑	3.1±0.16[ns]	13.9↓	15.1±4.0[ns]	26.9↑
P200+(CIS)	4.2±0.7[b]	75.0↑	1.8±0.19[b]	50.0↓	18.9±3.5[b]	58.8↑
L100+(CIS)	3.9±0.2[b]	62.5↑	1.9±0.15[b]	47.2↓	17.1±5.1[b]	43.7↑
L200+(CIS)	5.1±1.1[b]	112.5↑	1.6±0.21[b]	55.6↓	19.0±3.0[b]	59.7↑

Values are Means ±SEM (n=6 animals). [a] p<0.05, (student's t test)significantly different from normal group. [b] p<0.05, significantly different from control group. ns, non significant different from control group. P, pods and L, leaves of carob.

Table (4): Effect of carob pods and leaves on reanal Cathepsin D, Acid Phosphatase, DNase II and RNase II in mice treated with cisplatin

Group	Cathepsin D (n mol/ min/ mg protein)	Acid phosphatase (n mol/ min/ mg protein)	DNase II (n mol/ min/ mg protein)	RNase II (n mol/min/ mg protein)
Normal mean ±SE %change	30.0± 9.5 --------	0.45 ±0.02 ---------	0.10±0.02 ----------	0.30±0.04 ---------
Control (CIS) mean ±SE %change	68.2±10.1[a] 127.3↑	0.97±0.09[a] 115.6↑	0.52±0.01[a] 420.0↑	0.81±0.09[a] 170.0↑
P100+(CIS) mean ±SE %change	35.2±5.9[b] 48.4↓	0.52±0.09[b] 46.4↓	0.26±0.07[b] 50.0↓	0.62±0.05[b] 23.5↓
P200+(CIS) mean ±SE %change	34.1±6.8[b] 50.0↓	0.48±0.07[b] 50.5↓	0.21±0.05[b] 59.6↓	0.48±0.06[b] 40.7↓
L100+(CIS) mean ±SE %change	31.2±9.7[b] 54.3↓	0.51±0.09[b] 47.4↓	0.20±0.08[b] 61.5↓	0.53±0.08[b] 34.6↓
L200+(CIS) mean ±SE %change	29.2±8.9[b] 57.2↓	0.48±0.06[b] 50.5↓	0.18±0.06[b] 65.4↓	0.44±0.07[b] 45.7↓

Values are Means ±SEM (n=6 animals). [a] p<0.05, (student's t test)significantly different from normal group. [b] p<0.05, significantly different from control group. P, pods and L, leaves of carob.

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