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Biological Evaluation of Prickly Pear Peels and Seeds (*Opuntia ficus-indica*) in CCL4-intoxicated Rats

Salem M. A.[1], Mariam A. El-Khatib[2], Badawy W. Z.[3] and El-Bana M.A.[4]

[1]Food Sci. and Tech. Dept., Fac. of Agric. Tanta Univ., Egypt.
[2,4]Food Tech. Res. Institute, Agricultural Research Center, Giza, Egypt.
[3]Food Technology Department, Faculty of Agriculture, Kafrelsheikh University, Egypt.

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ABSTRACT

This investigation was conducted to study the effects of feeding on prickly pear peels (PPP) and prickly pear seeds (PPS) at levels of 5, 10, and 15% for starch on body weight, serum liver function enzymes, serum lipid profile, and antioxidant enzymes in carbon tetrachloride (CCl4) intoxicated rats. Results showed that substitution of (PPP) and (PPS) for starch, especially at 10 and 15% in CCl4 - intoxicated rats, increased body weight gain. This substitution also decreased the levels of serum liver function enzymes, improved lipid profiles, and increased the activity levels of antioxidant enzymes in CCl4 intoxicated rats. Histopathological examination revealed alleviation of hepatic lesions caused by CCl4 by increasing the percentage of PPP and PPS used. In conclusion, it was suggested that PPP and PPS could protect the liver cells from CCl4 induced liver damages perhaps, by its antioxidative effect on hepatocytes, hence eliminating the deleterious effects of toxic metabolites from CCl4. So, the present study recommended that the use of PPP and PPS may be useful for patients suffering from liver diseases due to its hepatoprotective and hypolipidemic activities.

Keywords: PPP and PPS, liver function enzymes, lipid profile.

Abbreviations: (PPP): prickly pear peels, (PPS): prickly pear seeds

1. Introduction

The cactus *opuntia ficus-indica*, commonly known as the prickly pear, belongs to the family Cactaceae and produces nutritionally rich and sweet fruits. The prickly pear cactus is a member of the Opuntia genus and is also known as the nopal, tuna, and sabra (Salim *et al.,* 2009 and Milán-Noris, *et al.,* 2016). Furthermore, fruits and stems are eaten due to the richness of elements. It is also used in various products, including food, fodder for cattle, raw material for preparing plywood, soap, dyes, adhesives, glue, and cosmetics such as shampoo, cream, and body lotions (Salim *et al.,* 2009 and Jimenez-Aguilar *et al.,* 2014).

Antioxidant activity is one of the major mechanisms by which fruits and vegetables provide health benefits. Fruits and vegetable are also able to inhibit excessive oxidation due to free radicals, which are in the form of reactive oxygen species (Andreu *et al.,* 2017). Prickly pear is rich in antioxidant product, containing phenolic compounds, carotenoids, betalains, and vitamin C, all of which could be directly responsible for the health benefits (Jimenez-Aguilar *et al.,* 2014). Antioxidant activity in prickly pear fruit and peels may be affected by environmental factors, cultivar, genetic diversity, phenotype, agronomic practices, environmental and climatic conditions, and processing of the fruit, among others (Moussa-Ayoub *et al.,* 2014). Besides, the processing method and the extraction solvent affect antioxidant activity of *O. ficus-indica* extracts (Aruwa *et al.,* 2019).

The liver has a pivotal role in the metabolism and detoxification of the majority of substances entering the human body. Many factors, such as toxic chemicals, excessive consumption of alcohol, and virus infections, can cause liver injuries to different extent. Liver diseases have nowadays become

Corresponding Author: Salem M. A., Food Sci. and Tech. Dept., Fac. of Agric. Tanta Univ., Egypt.

one of the main concerns threatening human health at a high prevalence (Tanaka *et al.,* 2011 and Kebamo *et al*., 2015).

CCl4 is a widely used industrial solvent and it is the best-characterized animal model of xenobiotic-induced, oxidative stress-mediated hepatotoxicity (Hung *et al.,* 2012).

CCl4 induces the production of several types of reactive effects such as reactive metabolites, reactive oxygen species (ROS), inflammatory reactions, and imbalances between cellular damage and protective responses, thereby causing liver injury (Xuan *et al.,* 2015). Antioxidant activity is one of the major mechanisms by which fruits and vegetables provide health benefits. Fruits and vegetables are also able to inhibit excessive oxidation due to free radicals, which are in the form of reactive oxygen species (Andreu *et al.,* 2017). As a traditional medicinal food, Cactus pears has a pharmacological effect in several of diseases and contain a wide variety of ascorbic acid, vitamin E, carotenoids, fibers, amino acids and antioxidant compounds (phenols, flavonoids, betaxanthin and betacyanin) which have been put forward to account for its health benefits such as hypoglycemic and hypolipidemic action, and antioxidant properties (Osorio-Esquivel *et al.,* 2011; Yeddes *et al.,* 2014). Although humans do not commonly eat prickly pear peel, it contains higher concentrations of bioactive substances compared to the edible fresh portion. Thus, the prickly pear byproduct has a great potential to be used as a raw material for the extraction and production of new bioactive food ingredients (Jiménez-Aguilar *et al.,* 2014). Cactus plants are also important sources of bioactive substances and are excellent candidates for nutraceutical and functional food preparation. Several authors confirm that prickly pear has a high bioactive potential, being an important source of bioactive compounds and an excellent source of dietary antioxidants, which may have beneficial effects on consumers' health (Albano *et al.,* 2015 and Akkol *et al.,* 2020). Sheha and El Gezery, (2018) reported that, prickly pears are a good source of soluble fiber in the form of pectin, as well as the insoluble fibers cellulose and lignin. A diet rich in soluble fiber may help control blood cholesterol levels and decrease the risk of diabetes. Insoluble fiber intake can regulate bowel movements and may lower your risk of digestive disorders such as colon cancer. Mohamed *et al.* (2005*)* showed that, phenolic compounds from sources (such as in Opuntia) reduced the increase in serum AST and ALT. Meanwhile, Singab *et al*., (2005*)* found that, flavone glycosides in prickly pear peels reduced the elevated levels of the serum enzymes: GOT, GPT and ALP. El-Nashar, (2007) reported that, the treatment with flavonoids was able to suppress the elevation of AST and ALT, reduce the damage of hepatocytes in vitro, and exhibited strong antioxidant activity against reactive oxygen species (ROS) in vitro. In addition, *Opuntia ficus-indica* aqueous extract at a dose of 2 mL/kg exerted a hepatoprotective effect against carbon tetrachloride-induced toxicity in rats, at least by decreasing AST activity (Djerrou *et al.,* 2015). According to Díaz *et al.,* (2017), opuntia species have been used for centuries as food resources and in traditional folk medicine for their nutritional properties and benefits in chronic diseases, specifically diabetes, obesity, cardiovascular disease, and cancer, these plants are largely distributed in America, Africa, and the Mediterranean basin. Opuntia spp. have great economic potential because they grow in arid and desert areas and *O. ficus-indica*, the domesticated o. species is used as a nutritional and pharmaceutical agent in various dietary and value-added products. El-Mostafa *et al.* (2014) found that the beneficial properties of opuntia spp. are related to their content of chemical compounds such as minerals, polyphenols, vitamins, polyunsaturated fatty acids, and amino acids. The present work aimed to study the possibility of using PPP and PPS on hepatic diseases, cholesterol, and the biological and histopathological effects of experimental rats that have had hepatic injury induced by CCl4.

2. Materials and Methods

2.1. Materials

I. Raw material

Mature fresh prickly pear fruit (*Opuntia ficus-indica*) with yellow skin free from defects was harvested from a local farm located in Al-Behayrah Governorate, Egypt during the summer season (August 2020) and stored in a deep freezer at -20°C until use.

II. Chemicals

All chemicals used in the current study were obtained from El-Gomhoria Company for Chemicals and Drugs and Merk Company for Chemicals and Biodiagnostica, Egypt.

2.2. Methods

I. Preparation of (PPP) and (PPS) samples

Fruits were cleaned with a brush to remove thorns and then washed with water to remove any dirty particles. Prickly pear peels were separated by hand peeling using a sharp knife. The peels were cut into slices and dried using the solar dryer system in the energy department of the National Research Center and indirectly dried by the solar drying system using forced circulation as described by Ibrahim, (2003). The dried peels were ground using a mixer grinder, kept in plastic bags, and preserved at -18 °C. The pulp was mixed for a few minutes in a mixer. The seeds were recovered from the resulting pulp juice by straining and washed several times using distilled water for several times. After drying at room temperature, the seeds were milled in a miller to pass through a 20 mesh sieve. The powder was immediately packed into clean, tight polyethylene bags and stored at -18 °C.

II. The gross chemical composition of PPP and PPS

AOAC methods (2005) were used to determine moisture, ether extract, crude protein, and ash content. The total carbohydrate content was calculated by difference.

III. Extraction of Total Phenolic Compounds

Total phenolic compounds were extracted according to the method described by Anagnostopoulou *et al.* (2006).

IV. Determination of total phenolic compounds

Total phenolic compounds of the extracts were determined rophotometricallyspect using Folin-ciocalteau reagent according to the method described by Kahkonen *et al.* (1999*)* and used to estimate the phenolics-acid content using a standard curve prepared using Gallic Acid.

V. Determination of total flavonoids

Total flavonoid was determined by the method of Djeridane *et al.* (2006) and used to estimate the flavonoids content using a standard curve prepared using rutin (RE).

VII. Determination of DPPH· radical scavenging capacity

Antioxidant activity (DPPH) assay antioxidant activity was measured using the (2, 2-diphenyl-1- picrylhydrazyl) DPPH method described by Lim and Quah, (2007).

2.3. Animal and experimental design

For the biological evaluation, forty-eight male Albino rats with an average weight of 180-186g were used. All animals were housed in individual cages with screen bottoms and fed on a basal diet for 7 days, under laboratory conditions. Rats were given free access to food and water during the 9-week trial period after the acclimation period. All 48 rats were divided into two main groups; the first group (6 rats) was fed a basal diet and kept as a negative control (C-ve). The second group (42 rats) was given carbon tetrachloride (CCl4) for the induction of acute liver damage. CCl4 was diluted in paraffin oil (1:1) and injected intraperitoneally at a dose of 1 ml/kg body weight. Hepatotoxic rats were divided into 7 groups and fed experimental diets for 6 weeks as shown in the following table (A) as mentioned by Lanepeter and Person, (1971).

Blood sampling: Blood samples were taken from rats at the beginning and end of the experiment, as mentioned by El-Khamissy, (2005).

The collection of organs: All the rats were sacrificed and the organs (liver, kidney, and heart) were separated with care and then weighed. The relative weights of the organs were calculated from the following equation:

Relative organ weight (R.w) = (Organ weight / Final B.W) × 100.

Table A: Composition of various hepatotoxic diets (g/Kg).

Ingredient	Experimented diets							
	G1 Control (-ve)	G2 Control (+ve)	G3 PPP 5%	G4 PPP 10%	G5 PPP 15%	G6 PPS 5%	G7 PPS 10%	G8 PPS 15%
PPP	-	-	50	100	150	-	-	-
PPS	-	-	-	-	-	50	100	150
Starch	650	650	600	550	500	600	550	500
Casein	150	150	150	150	150	150	150	150
Corn Oil	100	100	100	100	100	100	100	100
Cellulose	50	50	50	50	50	50	50	50
Mineral Mix.	40	40	40	40	40	40	40	40
Vitamin Mix.	10	10	10	10	10	10	10	10

G1: Control (-ve) hepatotoxic-non- Rats were fed on basal diet.
G2: Control (+ve) hepatotoxic– Rats were fed on basal diet.
G3: hepatotoxic– Rats were fed on basal diet substitutes 5% of PPP for starch.
G4: hepatotoxic– Rats were fed on basal diet substitutes 10% of PPP for starch.
G5: hepatotoxic– Rats were fed on basal diet substitutes 15 % of PPP for starch.
G6: hepatotoxic– Rats were fed on basal diet substitutes 5`% of PPS for starch.
G7: hepatotoxic– Rats were fed on basal diet substitutes 10 % of PPS for starch.
G8: hepatotoxic– Rats were fed on basal diet substitutes 15% of PPS for starch.

The determination of body weight gain (BWG) according to the method of Chapman et al. (1959) using the following equation: $\mathbf{BWG}\% = \left(\frac{\text{Final B.W} - \text{Intial B.W}}{\text{Intial B.W}}\right) \times 100.$

Lipid profile determination

Triglycerides, total cholesterol, and density-high lipoprotein cholesterol (HDL-C) levels were measured by enzymic colorimetric procedures using commercially available kits. Triglycerides were carried out according to the method of Fossati and Principe, (1982). Total cholesterol (TC) and HDL-C were carried out according to the methods of Richmond, (1973). density-Low lipoprotein cholesterol (LDL-c) and very density-low lipoprotein cholesterol (VLDL-c) were calculated mathematical According to Friedwald's equations (Friedewald *et al.,* 1972). LDL-c = TC – [HDL-c+ (TG/5)] while, VLDL-c = Triglycerides/5.

Determination of kidneys functions

Urea, Uric acid and Creatinine concentrations in serum were determined according to Chaney and Marbach, (1962); Trinder, (1969) and Fabiny and Ertingshausen, (1971) respectively.

Determination of liver enzymes

Determination of aspartate and alanine aminotransferase (AS.T and AL.T) activities were measured by Varley *et al.* (1980) and alkaline phosphatase enzymes (AL.P) according to King, (1965).

Determination of total protein

Serum total protein was analyzed according to Henry, (1974) using spectrophotometer DU 7400adjusted at 550 nm.

Determination of albumin

Serum Albumin was determined as g/dl according to the method described by Doumas *et al.,* (1971) modified by Spencer and Price, (1977).

Determination of Serum antioxidants

The concentration of serum glutathione peroxidase (GP.X.), superoxide dismutase (SO.D), and catalase (CA.T) activity were described by Oyanatui, (1984).

Histopathological

A final of the experiment, Tissues from the liver and kidney of the sacrificed rats were examined as described by Yoon *et al.* (2001).

Statistical analysis

Data were analyzed according to Steel and Torrie, (1980) procedures (Duncan's multiple range test DMRT).

3. Results and Discussion

3.1. Gross chemical composition (%) and bioactive compounds of PPP and PPS:

The chemical composition of (PPP) and (PPS) is given in Table (1). The results reveal that PPS contains crude protein, ether extract, crude fiber, and carbohydrates at significantly higher levels than that of PPP. In contrast, they contain significantly lower ash content. These results are in agreement with those found by (Tlili *et al.,* 2011; El-Shahat *et al.,* 2019; Abd elFattah *et al.,* 2020; Ali *et al.,* 2020 and Fiad *et al.,* 2020).

Also, results presented in Table (1) show the total phenolic compounds, total flavonoids and antioxidant activity of peel and seed in the *Opuntia ficus indica*. It was observed from these results that the total phenolic compounds and total flavonoids content were higher in the peel than the seed, while the seeds were higher than them in DPPH, this agrees with Chang *et al., (*2008) who reported that methanolic extracts of O. dillenii fruit possessed notable antioxidant activity, and the activities of seed extracts were stronger than those of peel and pulp extracts. These results were in agreement with data obtained by (Toure, *et al.,* 2015; Anwar and Sallam, 2016; Belviranl, *et al.,* 2019 and Parafati, *et al.,* 2020), they reported that total phenolic compounds and total flavonoids contents are depending on the type of compounds present in the extract, methods, and solvents used for the extraction, fruit maturity, climate, and quantification methodologies .

Table 1: Chemical composition (%) and bioactive compounds of PPP and PPS (on a dry weight basis).

Parameter %	Prickly pear peels	prickly pear seeds
Moisture	$4.27^{b} \pm 0.081$	$5.36^{a} \pm 0.330$
Crude protein	$6.48^{b} \pm 0.085$	$8.18^{a} \pm 0.175$
Ether extract	$1.46^{b} \pm 0.302$	$8.84^{a} \pm 0.135$
Ash content	$10.97^{a} \pm 0.075$	$1.52^{b} \pm 0.000$
Crude fiber	$5.25^{b} \pm 0.155$	$49.02^{a} \pm 0.770$
Total Carbohydrates*	$81.09^{b} \pm 0.227$	$81.46^{a} \pm 0.142$
TPC (mg GAE /100g)	$1106.4^{a} \pm 3.797$	$89.79^{b} \pm 0.160$
TF (mg RE/00g)	$43.40^{a} \pm 0.417$	$3.18^{b} \pm 0.040$
DPPH (%)	$67.18^{b} \pm 0.385$	$91.75^{a} \pm 0.102$

Means are an average of three determinations± standard deviations (SD).
In a column; means with the same letters are not significantly different at <0.05.
Total Carbohydrates* were calculated by differences. TPC: Total phenolic compounds, TF: total flavonoids.

3.2. Effect of feeding on substituting prickly pear peels (PPP) and prickly pear seeds (PPS) for starch on hepatotoxic rats.

3.2.1. Feeding and growth parameters of hepatotoxic rats.

Data in Table (2) indicated that **the** effect of substituting PPP and PPS on body weight gain (BW. G) in hepatotoxic rats for 10 weeks was not significant. The results point out that the mean values of initial body weight of all examined rat groups were almost identical and showed no significant difference ($P \leq 0.05$). It ranged between 182.25and 183.73g). While, in the final period (10 weeks), the body weight gain indicated that the hepatotoxic rats in group 2 (control +ve) had a lower weight gain among all examined groups. The body weight decrease as a result of CCl4 injection was considered to be the result of direct toxicity of CCl4 and/or indirect toxicity related to liver damage.

Furthermore, the body weight gain observed in the substituting PPP and PPS groups was significantly more pronounced than the hepatotoxic rats in group 2 (control +ve).

Table 2: Effect of feeding on replacing PPP and PPS for starch on feeding and growth parameters of hepatotoxic rats.

Parameters / Animal groups	Initial Weight (g)	Final weight (g)	Body weight Gain (B. W.G)	
			(g)	(%)
G1	182.33^{a} ± 2.483	285.80^{ab} ± 1.923	103.47^{bc} ± 1.742	56.76^{ab}± 1.550
G2	182.50^{a} ± 1.060	250.50^{d} ± 3.181	68.00^{e} ± 2.121	37.26^{d}± 0.945
G3	183.20^{a} ± 1.440	275.67^{c} ± 4.966	92.47^{d}± 3.569	50.46^{c} ± 1.569
G4	182.60^{a} ± 2.073	288.10^{a} ± 2.631	105.50^{ab} ± 2.263	57.79^{a} ± 1.554
G5	183.73^{a} ± 1.639	290.33^{a} ± 3.171	106.60^{ab} ± 2.408	58.02^{a} ± 1.305
G6	183.00^{a} ± 1.870	278.00^{c}± 5.338	95.00^{d} ± 3.741	51.90^{c} ± 1.669
G7	182.50^{a} ± 1.802	283.00^{b} ± 4.301	100.50^{c} ± 3.570	55.07^{b} ± 1.929
G8	182.25^{a} ± 3.897	289.67^{a} ± 2.857	107.42^{a} ± 1.919	58.98^{a}± 2.181

Means are an average of five determinations± SD.
In a column ; means with the same letters are not significantly different at <0.05..
G1, G2 … etc. were as in Table (A).

It was also noted that the groups (G4, G5 and G8) had more pronounced weights than the negative group (G1). These results were in the same line with (Abd El-Razek and Hassan, 2011; Ennouri *et al.*, 2014 and Hassan *et al.,* 2019), they suggested that, the improvement in growth performance of rabbits fed prickly pear is an effect of the activity of their antioxidant, antimicrobial and anti-inflammatory compounds as well as also rich in minerals, amino acids and fatty acids especially palmitic acid and Omega-6. These nutrients could accelerate metabolism and increase energy digestibility and hence improve growth performance.

3.2.2. Relative organs weight of hepatotoxic rats

The liver, kidney, and heart of rats fed on basal diet and other treatments were weighted at final of the experiment (10 weeks) and the ratio of each organ to final body weight of rats was calculated. Data offered in Table (3) appeared that the weight of liver in group 2 (control + ve) had the highest weight being (9.86g) and relative liver weight (3.94) among all examined groups. This may be due to the assemblage of fat in liver tissues, (El-Bana *et al.,* 2015).

Table 3: Effect of feeding on substituting PPP and PPS for starch on the relative organs weight in hepatotoxic rats.

Animal groups	Liver		Kidneys		Heart		Final body weight
	(g)	R.W.	(g)	R.W.	(g)	R.W.	
G1	6.41^{d} ± 0 .073	2.24	1.33^{c} ± 0.171	0.47	0.77^{d} ± 0.020	0.27	285.80^{ab} ± 1.923
G2	9.86^{a} ± 0.056	3.94	1.98^{a} ± 0.012	0.79	0.97^{a} ± 0.014	0.39	250.50^{d} ± 3.181
G3	8.60^{b} ± 0. 024	3.12	1.69^{b} ± 0.049	0.61	0.92^{b} ± 0.021	0.33	275.67^{c} ± 4.966
G4	7.71^{c} ± 0 .215	2.68	1.55^{bc} ± 0.249	0.54	0.85^{c} ± 0.040	0.30	288.10^{a} ± 2.631
G5	6.46^{d} ± 0.240	2.23	1.39^{c} ± 0.267	0.48	0.79^{d} ± 0.030	0.27	290.33^{a} ± 3.171
G6	8.55^{b} ± 0. 125	3.08	1.66^{b} ± 0.277	0.60	0.94^{ab} ± 0.034	0.34	278.00^{c}± 5.338
G7	7.54^{c} ± 0.075	2.66	1.54^{bc} ± 0.139	0.54	0.86^{c} ± 0.008	0.30	283.00^{b} ± 4.301
G8	6.55^{d} ± 0. 235	2.26	1.38^{c} ± 0.076	0.48	0.80^{d} ± 0.025	0.28	289.67^{a} ± 2.857

Means are an average of five determinations± SD.
In a column; means with the same letters are not significantly different at <0.05..
G1, G2 … etc. were as in Table (A)

For the results in the same Table, group 1 (control -ve) had the lowest value in liver weight and relative liver weight. moreover, the liver weight of rats fed with replacement with PPP and PPS for starch in the diet after hepatotoxic were lower than those of (control +ve).

The results showed that there were significant differences in both kidney and heart weights, the weights of kidney and heart in group 2 (control +ve) had the highest weight being (1.98 and 0.97g), respectively, and relatively kidney and heart weights (0.79 and0.39), respectively among all examined groups. For the results in the same Table, group 1 (control -ve) had the lowest value in kidney and heart weights and relatively kidney and heart weights. Moreover, the liver weight of rats fed with replacement with PPP and PPS for starch in the diet after hepatotoxic were lower than those of (control +ve).

3.2.3. Serum lipids parameter

Data presented in Table (4) showed that the total cholesterol content at final experiment for group 1 (control -ve) was 105.54 mg/dl, whilst the total cholesterol content of group 2 (control +ve) was 226.33 mg/dl. moreover, hepatotoxic rats group G3, G4 and G5 which feeding on basal diet substituted with (PPP) at levels 5, 10 and 15% for starch showed values of 129, 118.20, and 110.67 mg/dl respectively while, hepatotoxic rats group G6, G7 and G8 which feeding on basal diet substituted with (PPS) at levels 5, 10 and 15% for starch showed values of 122.67, 114.33 and 108 mg/dl respectively. Furthermore, hepatotoxic rats fed on PPP and PPS had a significant difference at ($P \leq 0.05$) were decreased in serum cholesterol compared with diet G2. The obtained data are consistent with Sheha and El Gezery, (2018) who reported that prickly pears are a good source of soluble fiber in the form of pectin, as well as the insoluble fibers cellulose and lignin. A diet rich in soluble fiber is due to its ability to form a gel, a characteristic it shares with some soluble fibers forms a viscous gel in the intestine, and acts as a physical barrier to absorption of cholesterol, bile acids, and glucose may help control blood cholesterol levels. Furthermore, Ennouri *et al.,* (2006) and Berraaouan *et al.,* (2014) reported that the prickly pear seeds are important sources of monounsaturated and polyunsaturated fatty acids, which may be responsible for decrease cholesterol levels. Padilla-Camberos *et al.* (2015*)* showed that aqueous extracts of *O. ficus-indica* could inhibit the enzymatic function of pancreatic lipase, preventing hypercholesterolemia, in part due to its polyphenolic compounds.

Also, results showed that total triglycerides (TG) for Group1 (control -ve) was 105.33 mg /dl after 10 weeks. Increased to 158.67mg/dl in hepatotoxic rats which fed on basal diet in (G2) while, total triglycerides contents for hepatotoxic rat groups (G3, G4 and, G5) which fed on basal diet in replacement with (PPP) at levels (5,10 and 15%) for starch showed values of 118.00, 111.50 and 108.67 mg/dl respectively. While, the total triglycerides contents for hepatotoxic rat groups G6, G7, and G8 fed on basal diet replacement with PPS at levels (5, 10, and, 15%) for starch showed values of 115.73, 110.67 and106.33 mg/dl respectively. The data in the current Table illustrated that the replacement of feeding basal diet with PPP and PPS led to enhancement HDL-C for hepatotoxic rat groups. In addition, hepatotoxic rats were fed a diet with PPP and PPS replacement at 15%. As well as, it was closer than HDL-C to group 1 (control-ve). These means were significantly different in comparing with those means listed in group 2 (control +ve). As shown in Table (4) the values of LDL-C from group1 (control -ve) was 36.09 mg/dl, whilst the value of hepatotoxic Group2 (control +ve) was 183.27 mg/dl. Furthermore, LDL-C of hepatotoxic rats fed on basal diet replaced with PPP at the ratio of 5, 10, and 15% (G3, G4 and G5) being 72.07, 56.90, and 43.61 mg/dl, respectively. Whilst, LDL-C of hepatotoxic rats fed on basal diet substitution with replacement with PPS at the ratio 5, 10 ,and 15% (G6, G7, and G8) being 63.85, 51.53, and 40.86 mg/dl, respectively (Díaz *et al.,* 2017 and Salem *et al.,* 2019), indicates that some soluble fibers have the ability to bind bile acids or cholesterol during the formation of micelles. Reducing the output in the cholesterol content of the liver cells regulates the next LDL receptor by increasing LDL cholesterol removal. In addition, mechanisms include inhibition of the synthesis of hepatic fatty acids by fermentation products such as acetate, butter, and propionate. Chougui *et al.,* (2013) mentioned that the high content of polyunsaturated fatty acids in the oil of prickly pear seeds makes this oil potentially beneficial for health because these fatty acids play a preventive role in cardiovascular diseases. This type of fatty acid is described as having activities to reduce total cholesterol and low-density lipoproteins cholesterol.

Table 4: Effect of feeding on replacing PPP and PPS for starch on serum lipids of hepatotoxic rats.

Lipid profile	T. Cholesterol mg/dl		Triglyceride mg/dl		HDL –C mg/dl		LDL – C mg/dl		vLDL – C mg/dl	
Animal groups	Zero	Final	Zero	Final	Zero	Final	Zero	Final	Zero	Final
G1	94.75^{f} ± 0.829	105.54^{g} ± 1.120	83.25^{f} ± 1.299	105.33^{d} ± 2.483	49.00^{a} ± 0.707	48.38^{a} ± 1.192	29.10^{f} ±0.574	36.09^{g} ± 0.546	16.65^{f} ± 0.259	21.07^{d} ± 0.496
G2	164.33^{b} ± 2.857	226.33^{a} ± 3.188	145.33^{e} ± 1.080	158.67^{a} ± 2.677	12.33^{c} ± 0.735	11.33^{g} ± 0.735	122.93^{a} ± 3.364	183.27^{a} ± 2.315	29.07^{e} ± 0.216	31.73^{a} ± 0.535
G3	152.67^{e} ± 1.080	129.00^{b} ± 0.707	145.67^{e} ± 1.471	118.00^{b} ± 1.414	11.82^{c} ± 0.460	33.33^{f} ±0.540	111.71^{c} ± 0.790	72.07^{b} ± 1.105	29.13^{e} ± 0.294	23.60^{b} ± 0.282
G4	156.00^{d} ± 1.870	118.20^{d} ± 2.489	167.50^{c} ± 1.060	111.50^{c} ± 1.767	13.44^{b} ± 0.498	39.00^{d} ± 0.707	109.06^{c} ±2.038	56.90^{d} ± 3.290	33.50^{c} ± 0.212	22.30^{c} ± 0.353
G5	168.20^{a} ± 1.303	110.67^{f} ± 2.273	164.33^{d} ± 1.080	108.67^{cd} ± 2.857	13.23^{b} ± 0.686	45.33^{b} ± 1.080	122.10^{ab} ± 1.352	43.61^{f} ± 0.979	32.87^{d} ± 0.216	21.73^{cd} ± 0.571
G6	159.20^{c} ± 2.167	122.67^{c} ± 2.160	183.00^{a} ± 2.549	115.73^{b} ± 4.431	12.30^{c} ± 0.796	35.67^{e} ± 0.540	110.30^{c} ± 1.151	63.85^{c} ± 3.310	36.60^{a} ± 0.509	23.15^{b} ± 0.886
G7	154.33^{de} ± 1.080	114.33^{e} ± 2.273	179.00^{b} ± 2.549	110.67^{c} ± 1.471	12.40^{c} ± 0.424	40.67^{c} ±0.408	106.13^{d} ± 1.373	51.53^{e} ± 2.342	35.80^{b} ± 0.509	22.13^{c} ± 0.294
G8	167.00^{a} ± 2.121	108.00^{fg} ± 2.121	165.67^{cd} ± 2.160	106.33^{d} ± 1.779	13.70^{b} ± 0.696	45.87^{b} ± 0.848	120.17^{b} ± 3.218	40.86^{f} ± 1.474	33.13^{cd} ± 0.432	21.27^{d} ± 0.355

Means are an average of five determinations± SD.
In a column ;means with the same letters are not significantly different at <0.05..
G1, G2 … etc. were as in Table (A).

From obtained data in Table (4), the mean values of v.LDL-C of (control -ve) being 21.07 mg/dl, whilst the value of group 2 (control +ve) being 31.73mg/dl. Meanwhile, v.LDLC of hepatotoxic rats which fed on basal diet replaced with PPP 5, 10 and 15% groups (G3, G4, and G5) were 23.60, 22.30 and 21.73 mg/dl, respectively. While, the v.LDL-C of rats fed on hepatotoxic basal diet replaced with PPS 5, 10, and 15% (G6, G7, and G8) being 23.15, 22.13, and 21.27 mg/dl, respectively (Lee and Lim, 2000; Louacini *et al.,* 2012; Zeedan *et al.,* 2015 and Nazareno, 2017) they reported that the prickly pear contains pectin, which interferes with cholesterol and lipids synthesis, through binding cholesterol to bile acids and then when the concentrations of these compounds increase, they accelerate the catabolism of cholesterol. Moreover, the interaction among flavonoids, betalains, and vitamin E seems to be responsible for the hypolipidemic activity of prickly pear. It could be noticed that hepatotoxic rats fed on diet replaced the PPP and PPS at the ratio of 5, 10, and 15% to basal diets had a significantly decreased T.C., T.G., LDL-C, and VLDL-C compared with hepatotoxic Group 2 (control +ve). But, these groups had high-level HDL-C at ($P \leq 0.05$). The obtained data are consistent with (Milán-Noris *et al.,* 2016; Al-Kubaisy *et al.,* 2016 and Sheha and El Gezery, 2018).

3.2.4. Liver function activities (ALT), (AST) and (ALP)

The effect of feeding on PPP and PPS for starch at the level of, alanine aminotransferase (ALT), aspartate aminotransferase (AST), and (ALP) enzymes in serum of hepatotoxic rats during experiment shown in Table (5). At the end of the experiment, the level of ALT of the hepatotoxic (control +ve) increased significantly compared with group 1 (control -ve) was 195.67 and 68.33 U/L respectively. Meanwhile, the hepatotoxic rats feeding on diets replaced with PPP (G3, G4 ,and G5) led to a more lowering at level 5,10 and15% were 118.50, 96.33, and 83.67 U/L, respectively the same trend was found when replacement with PPS at the same ratio (G6, G7, and G8). Regarding the results of serum AST of the hepatotoxic CCL4 caused a significant increase ($P<0.05$) in the hepatotoxic group 2 (control +ve) was 248.67 U/L comparative to (control -ve) group1 was 109.50 U/L .

Table 5: Effect of feeding on replacing prickly pear peels and seeds for starch on liver function activities (ALT), (AST), and (ALP) in hepatotoxic rats.

Animal groups	ALT (U/L)		AST (U/L)		ALP (U/L)	
	Zero	Final	Zero	Final	Zero	Final
G1	$31.50^{f} \pm 1.118$	$68.33^{h} \pm 1.471$	$77.00^{e} \pm 2.236$	$109.50^{g} \pm 1.767$	$141.25^{e} \pm 2.384$	$182.33^{f} \pm 2.160$
G2	$150.67^{ab} \pm 1.471$	$195.67^{a} \pm 1.779$	$188.33^{a} \pm 1.471$	$248.67^{a} \pm 1.471$	$356.50^{ab} \pm 1.060$	$441.33^{a} \pm 1.779$
G3	$148.00^{cd} \pm 1.414$	$118.50^{c} \pm 1.060$	$171.67^{c} \pm 1.779$	$149.33^{c} \pm 1.080$	$354.33^{bcd} \pm 1.779$	$226.67^{c} \pm 1.080$
G4	$145.00^{e} \pm 1.414$	$96.33^{f} \pm 1.080$	$172.42^{c} \pm 1.873$	$120.83^{e} \pm 1.136$	$356.00^{abc} \pm 1.870$	$208.50^{d} \pm 1.060$
G5	$149.00^{bc} \pm 2.121$	$83.67^{g} \pm 2.160$	$180.00^{b} \pm 1.870$	$111.50^{f} \pm 1.541$	$357.67^{a} \pm 1.779$	$189.67^{e} \pm 1.080$
G6	$149.33^{bc} \pm 1.779$	$128.00^{b} \pm 1.870$	$165.73^{d} \pm 1.790$	$154.50^{b} \pm 1.060$	$353.00^{d} \pm 1.870$	$235.83^{b} \pm 1.814$
G7	$146.00^{de} \pm 1.870$	$112.33^{d} \pm 1.779$	$171.00^{c} \pm 1.870$	$147.83^{c} \pm 0.889$	$356.17^{abc} \pm 1.947$	$224.73^{c} \pm 1.098$
G8	$152.27^{a} \pm 1.845$	$101.45^{e} \pm 1.666$	$166.77^{d} \pm 1.797$	$133.75^{d} \pm 1.794$	$353.67^{cd} \pm 1.471$	$210.33^{d} \pm 2.160$

Means are an average of five determinations± SD.
In a column; means with the same letters are not significantly different at <0.05.
G1, G2 … etc. were as in Table (A).

Whilst, the hepatotoxic rats feeding on basal diets replaced with PPP for starch at 5,10 and 15% were 149.33, 120.83 and 111.50 U/L respectively for (G3, G4, and G5), Also, feeding on diets replacing with PPS at 5,10 and 15% were 154.50, 147.83 and 133.75 U/L respectively for (G6 , G7, and G8). These data were in a line with Mohamed *et al.,* (2005) and El-Nashar, (2007) who found that the treatment with flavonoids was able to suppress the elevation of AST and ALT, reduce the damage of

hepatocytes in vitro and exhibited strong antioxidant activity against reactive oxygen species (ROS). Also Djerrou *et al.* (2015) concluded that *opuntia ficus-indica* aqueous extract at a dose of 2 mL/kg exerted a hepatoprotective effect against carbon tetrachloride-induced toxicity in rats at least by decreasing AST activity.

On another side, Alkaline phosphatase levels (ALP) of group1 (control -ve) was 182.33U/L. while (ALP) levels of hepatotoxic (control +ve) group 2 was 441.33 U/L. Meanwhile, hepatotoxic rats fed on PPP and PPS which were replaced with 5, 10 and 15% for starch showed significantly lowered compared with the hepatotoxic (control +ve) group 2. Results correspond with, Singab *et al.,* (2005) and Al-Kubaisy *et al.* (2016) who reported that flavones glycosides in prickly pear peels were reduced the elevated levels of the serum enzymes: GOT, GPT and ALP.

3.2.5. Kidney functions (urea, uric acid, and creatinine)

Table (6) shows the mean values of urea, uric acid, and creatinine in the blood of Group 1 (control-ve), hepatotoxic group 2 (control +ve), and all other groups that fed on a basal diet that was replaced with PPP and PPS at 5, 10, and 15% for starch at the end of the experiment. Data showed that the urea content of hepatotoxic group 2 (control +ve) was 86.50 mg/dl in the blood, while hepatotoxic rats which fed on a diet that was replaced with PPP at levels of 5, 10 and 15% for starch at groups (G3, G4 and G5) were 75.50, 53.50 and 50.50 mg/dl respectively, whilst replacement with PPS at the ratio of 5, 10 and 15% for starch at groups (G6, G7 and G8) was 63.67, 61.50 and 49.17 mg/dl respectively.

Table 6: Effect of feeding on substituting PPP and PPS for starch on kidney function activities (Urea, Uric acid, and Creatinine) in hepatotoxic rats.

Animal groups	Urea mg/dl		Uric acid mg/dl		Creatinine mg/dl	
	Zero	Final	Zero	Final	Zero	Final
G1	$33.00^{c} \pm 1.274$	$44.00^{g} \pm 1.581$	$0.65^{d} \pm 0.065$	$1.18^{ef} \pm 0.129$	$0.76^{d} \pm 0.019$	$0.80^{bc} \pm 0.010$
G2	$45.50^{ab} \pm 1.060$	$86.50^{a} \pm 0.353$	$1.57^{c} \pm 0.021$	$2.06^{a} \pm 0.010$	$1.74^{ab} \pm 0.007$	$1.26^{a} \pm 0.047$
G3	$46.75^{a} \pm 0.176$	$75.50^{b} \pm 1.767$	$1.89^{a} \pm 0.103$	$1.45^{bc} \pm 0.104$	$1.67^{bc} \pm 0.095$	$0.84^{bc} \pm 0.017$
G4	$45.00^{b} \pm 1.060$	$53.50^{e} \pm 1.764$	$1.71^{b} \pm 0.148$	$1.36^{cd} \pm 0.056$	$1.61^{c} \pm 0.120$	$0.82^{bc} \pm 0.049$
G5	$45.00^{b} \pm 1.414$	$50.50^{f} \pm 1.060$	$1.93^{a} \pm 0.049$	$1.11^{f} \pm 0.040$	$1.73^{abc} \pm 0.109$	$0.79^{c} \pm 0.081$
G6	$44.80^{b} \pm 0.565$	$63.67^{c} \pm 1.471$	$1.59^{bc} \pm 0.134$	$1.51^{b} \pm 0.088$	$1.77^{ab} \pm 0.134$	$0.85^{b} \pm 0.031$
G7	$46.70^{a} \pm 0.833$	$61.50^{d} \pm 1.766$	$1.65^{bc} \pm 0.046$	$1.39^{bcd} \pm 0.091$	$1.60^{c} \pm 0.125$	$0.83^{bc} \pm 0.024$
G8	$45.03^{b} \pm 1.944$	$49.17^{f} \pm 1.594$	$1.92^{a} \pm 0.138$	$1.28^{de} \pm 0.148$	$1.82^{a} \pm 0.042$	$0.80^{bc} \pm 0.024$

Means are an average of five determinations± SD.
In a column; means with the same letters are not significantly different at <0.05..
G1, G2 … etc. were as in Table (A).

Data showed that the urea level was reduced in hepatotoxic rats fed on diets replaced with PPP and PPS at 5, 10 and 15% for starch (G3, G4, G5, G6, G,7 and G8) compared to hepatotoxic group 2 (control +ve). The obtained data in Table (6) showed that uric acid levels were reduced in hepatotoxic rats fed on diets replaced with PPP and PPS at 5,10 and 15% for starch (G3, G4, G5, G6, G7, and G8) compared to the hepatotoxic control group (G2).

The obtained data showed that the creatinine content of Group 1 (control -ve) was 0.80 mg/dl after 10 weeks. The same table showed that the creatinine content of hepatotoxic Group 2 (control +ve) was 1.26 mg/dl. While hepatotoxic rats fed on diets (G3, G4 and G5) fed on PPP at levels of 5, 10, and 15% were 0.84, 0.82, and 0.79 mg/dl, respectively. Furthermore, hepatotoxic rats fed on diets (G6, G7, and G8) fed on PPS at 5, 10, and 15% for starch were 0.85, 0.83, and 0.80 mg/dl, respectively. The observed decrease in urea and creatinine levels in the current study supports the findings of Korkmaz and Kolankaya, (2009) and El-said *et al.,* (2011). It is posited that a significant decrease in blood urea and plasma concentrations in these rats might be attributed to the high ascorbic acid present in prickly pear (Opuntia fruit) peel. From the data in Table (6), it is evident that hepatotoxic rats which fed on PPP and PPS at (5, 10, and 15%) for starch had significantly reduced levels of creatinine, uric acid, and urea in their blood compared with those of hepatotoxic group 2

(control +ve). whereas group1 (control -ve) which fed on the basal diet had a significantly reduced level of urea, uric acid, and creatinine. These results were in agreement with (Ennouri *et al.,* 2007; Oguondo *et al.,* 2010 and Sheha and El Gezery, 2018).

3.2.6. Serum total protein (TP) and albumin

The effect of feeding on PPP and PPS for starch level on serum total protein (TP), albumin of hepatotoxic rats during the experiment is shown in Table (7). At the end of the experiment, the level of total protein of the hepatotoxic (control +ve) decreased significantly compared with group 1 (control -ve) was 5.34 and 8.27, respectively. Whilst, the hepatotoxic rats feeding on diets replaced with PPP (G_3, G_4 and G_5) led to increasing at levels 5, 10 and 15% were 6.53, 7.17 and 8.08 g/dl respectively, the same trend was found when replacement with PPS at the same ratio were 5.92, 6.43 and 7.68 g/dl respectively for (G6 , G7 and G8). The obtained data is consistent with Abd El-Razek and Hassan, (2011).

Table 7: Effect of feeding on replacing PPP and PPS for starch on serum total protein (TP) and albumin in hepatotoxic rats.

Parameters / Animal groups	TP (g/dl)		Albumin (g/dl)	
	Zero	Final	Zero	Final
G1	$6.58^{a} \pm 0.132$	$8.27^{a} \pm 0.177$	$3.86^{a} \pm 0.213$	$3.97^{a} \pm 0.148$
G2	$3.61^{b} \pm 0.109$	$5.34^{g} \pm 0.139$	$1.75^{b} \pm 0.132$	$1.19^{f} \pm 0.084$
G3	$3.15^{d} \pm 0.014$	$6.53^{e} \pm 0.147$	$1.65^{bc} \pm 0.116$	$3.11^{d} \pm 0.056$
G4	$3.07^{d} \pm 0.007$	$7.17^{d} \pm 0.108$	$1.49^{cd} \pm 0.118$	$3.52^{c} \pm 0.045$
G5	$3.48^{b} \pm 0.145$	$8.08^{b} \pm 0.113$	$1.46^{d} \pm 0.081$	$3.82^{b} \pm 0.120$
G6	$3.60^{b} \pm 0.107$	$5.92^{f} \pm 0.056$	$1.46^{d} \pm 0.124$	$2.92^{e} \pm 0.049$
G7	$3.30^{c} \pm 0.114$	$6.43^{e} \pm 0.147$	$1.62^{bcd} \pm 0.064$	$3.16^{d} \pm 0.081$
G8	$3.32^{c} \pm 0.147$	$7.68^{c} \pm 0.163$	$1.44^{d} \pm 0.124$	$3.78^{b} \pm 0.113$

Means are an average of five determinations± SD.
In a column; means with the same letters are not significantly different at <0.05..
G1, G2 … etc. were as in Table (A)

Regarding the results of albumin content, of Group 1 (control -ve) was 3.97 g/dl after 10 weeks the same Table showed that albumin content of hepatotoxic Group 2 (control +ve) was 1.19 g/dl. While, hepatotoxic rats fed on basal diets (G3, G4 and G5) fed on PPP at levels of 5, 10 and 15% for starch were 3.11, 3.52 and 3.82 g/dl, respectively. Furthermore, hepatotoxic rats fed on basal diets (G6, G7 and G8) fed on PPS at 5, 10 and 15% starch were 2.92, 3.15 and 3.78 g/dl, respectively. The results correspond with (Al-Kubaisy *et al.,* 2013 and Al-Kubaisy *et al.*, 2016).

3.2.7. Serum antioxidants (GPX), (SOD) and (CAT) enzymes

According to results given in Table (8), shows that CCI4 injected rats had significantly lower levels of glutathione peroxidase (GPX), superoxide dismutase (SOD) and catalase (CAT) antioxidant enzymes activity in comparison to the negative control group. Substitution of PPP and PPS at levels 5,10 and 15% for starch at 5,10 and 15% in the diet of CCl4 -Intoxicated rats increased the activity levels of GPX, SOD and CAT antioxidant enzymes in comparison with hepatotoxic group 2 (control +ve) .

Aforementioned results coincide with those obtained by Al-Kubaisy *et al.* (2013); Al-Kubaisy *et al.,* (2016); Osuna-Martínez *et al.,* (2014) and Attanzio *et al.,* (2018) they reported that the *Opuntia ficus-indica* exhibits diverse pharmacological actions through its antioxidant activity: protects cells against oxidative damage, acts as radical scavengers, reduces lipid peroxidation and an increase in anti-inflammatory factor.

Table 8: Effect of feeding on substituting PPP and PPS for starch on (GPX), (SOD) and (CAT) enzymes in hepatotoxic rats.

Parameters / Animal groups	GPX (u/ml)	CAT (u/ml)	SOD (u/ml)
G1	$25.45^{a} \pm 0.095$	$63.14^{a} \pm 0.853$	$23.80^{a} \pm 0.107$
G2	$15.34^{h} \pm 0.208$	$45.99^{f} \pm 0.175$	$13.24^{g} \pm 0.771$
G3	$20.33^{g} \pm 0.130$	$50.41^{e} \pm 0.586$	$17.29^{f} \pm 0.469$
G4	$23.46^{e} \pm 0.323$	$54.43^{d} \pm 2.238$	$19.61^{d} \pm 0.716$
G5	$24.34^{c} \pm 0.135$	$61.08^{b} \pm 0.675$	$21.59^{b} \pm 0.107$
G6	$22.46^{f} \pm 0.316$	$58.11^{c} \pm 1.368$	$18.55^{e} \pm 0.471$
G7	$23.88^{d} \pm 0.044$	$60.89^{b} \pm 0.451$	$19.66^{d} \pm 0.660$
G8	$24.64^{b} \pm 0.075$	$62.20^{ab} \pm 0.764$	$20.56^{c} \pm 0.316$

Means are an average of five determinations± SD.
In a column ;means with the same letters are not significantly different at <0.05..
G1, G2 … etc. were as in Table (A).

3.3. Histopathological changes

The influence of prickly pear peels and prickly pear seeds on the liver and kidney tissues of male albino rats was studied, and the detected histopathological alterations were shown in table (9) and slides (NO.1 to NO.20) of the examined organs in various treatments.

Table 9: Histopathological changes in the liver and kidney tissues of rats fed on substituting prickly pear peels and prickly pear seeds for starch in hepatotoxic rats.

Animal groups	Liver	Kidney
G1	Normal	Normal
G2	Showing small focal hepatocellular necrosis, apoptosis associated with inflammatory cells infiltration, hepatocellular vacuolar degeneration (steatosis) and fibroplasia in the portal triad	Showing cytoplasmic vacuolization of epithelial lining renal tubules, congestion of renal blood vessel and focal necrosis of renal tubules associated with inflammatory cells infiltration.
G3	Showing congestion of central vein and slight Kupffer cells activation	Congestion of renal blood vessel and glomerular tuft.
G4	Showing slight Kupffer cells activation	Cytoplasmic vacuolization of epithelial lining some renal tubules
G5	Showing slight Kupffer cells activation and slight fibroplasia in the portal triad	Normal
G6	Showing small focal hepatocellular necrosis associated with inflammatory cells infiltration and slight Kupffer cells activation	Showing cytoplasmic vacuolization of epithelial lining some renal tubules
G7	Showing slight Kupffer cells activation and steatosis of sporadic hepatocytes	Normal
G8	Showing slight Kupffer cells activation	Normal

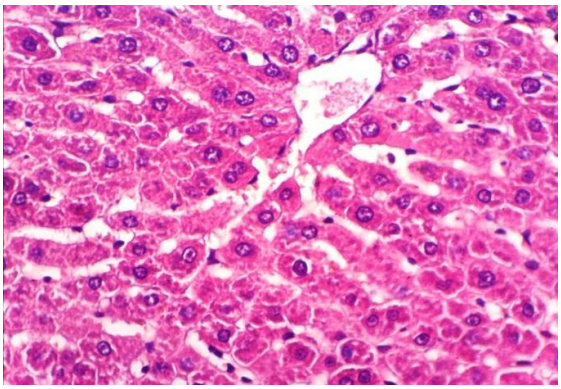

Fig. 1: Liver of rat from group 1 showing the normal histological structure of hepatic lobule (H & E X 400).

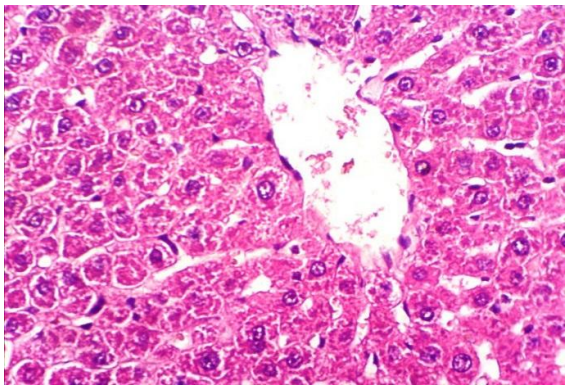

Fig. 2: Liver of rat from group 1 showing the normal histological structure of hepatic lobule (H & E X 400).

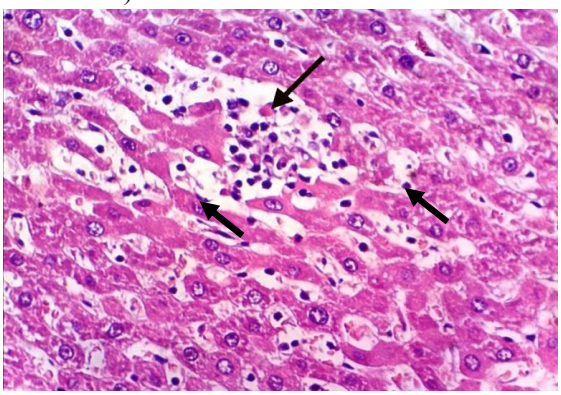

Fig. 3: Liver of rat from group 2 showing small focal hepatocellular necrosis and apoptosis associated with inflammatory cells infiltration (H & E X 400).

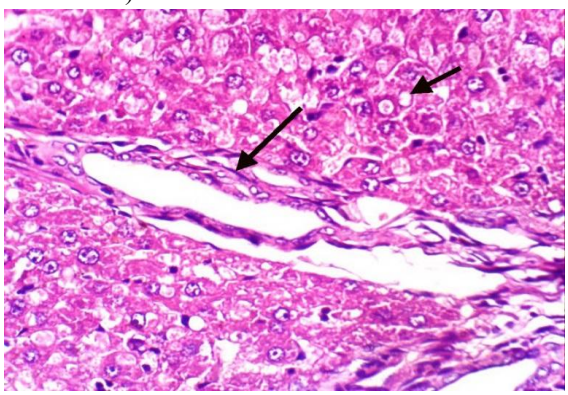

Fig. 4: Liver of rat from group 2 showing hepatocellular vacuolar degeneration (steatosis) and fibroplasia in the portal triad (H & E X 400).

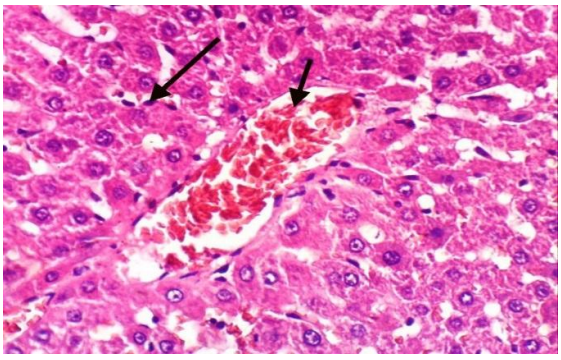

Fig. 5: Liver of rat from group 3 showing congestion of central vein and slight Kupffer cells activation (H & E X 400).

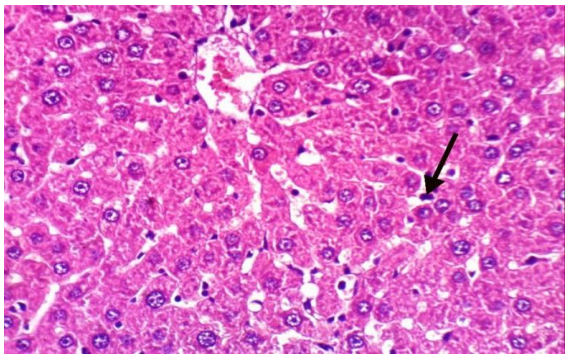

Fig. 6: Liver of rat from group 4 showing slight Kupffer cells activation (H & E X 400).

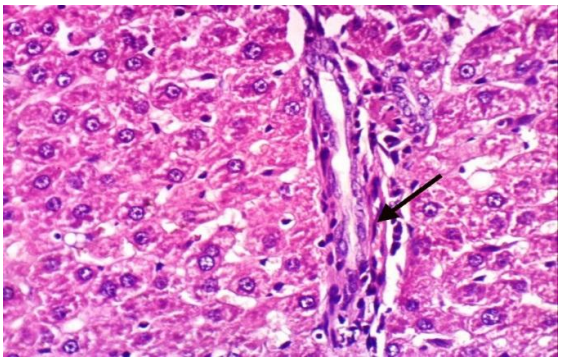

Fig. 7: Liver of rat from group 5 showing slight Kupffer cells activation and slight fibroplasia in the portal triad (H & E X 400).

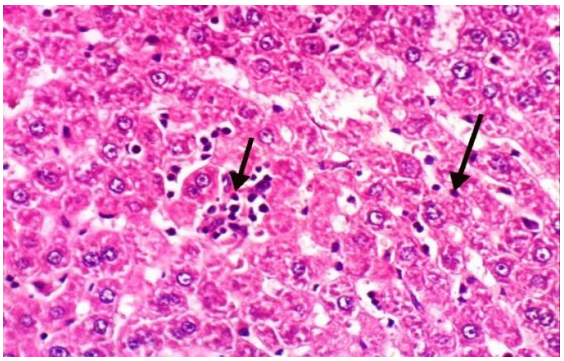

Fig. 8: Liver of rat from group 6 showing small focal hepatocellular necrosis associated with inflammatory cells infiltration and slight Kupffer cells activation (H & E X 400).

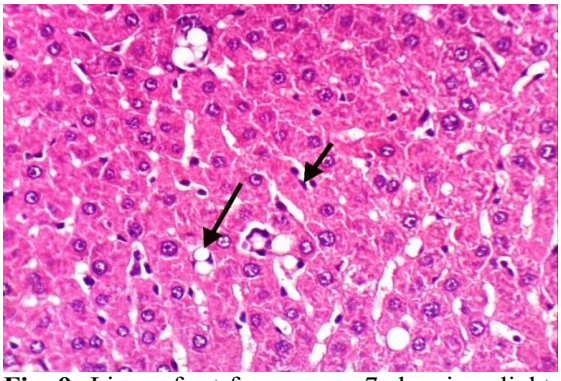

Fig. 9: Liver of rat from group 7 showing slight Kupffer cells activation and steatosis of sporadic hepatocytes (H & E X 400).

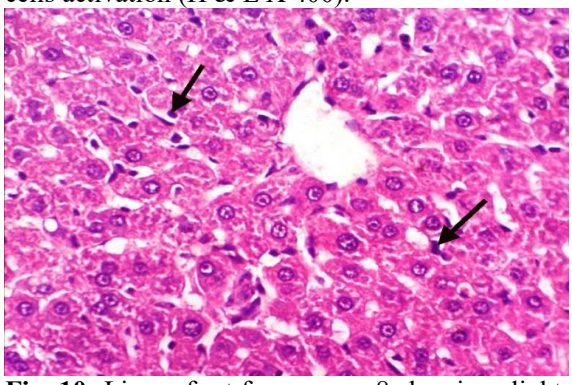

Fig. 10: Liver of rat from group 8 showing slight Kupffer cells activation (H & E X 400).

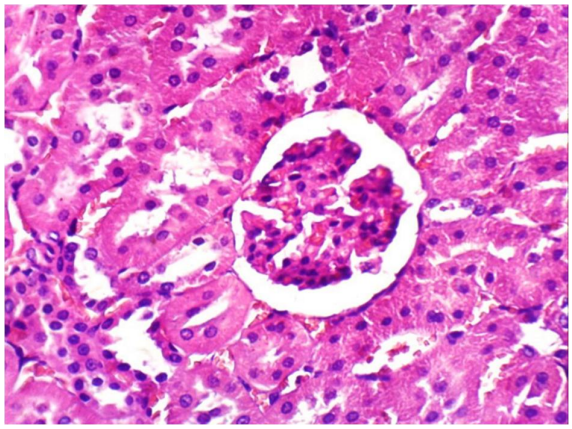

Fig. 11: Kidney of rat from group 1 showing the normal histological structure of renal parenchyma (H & E X 400).

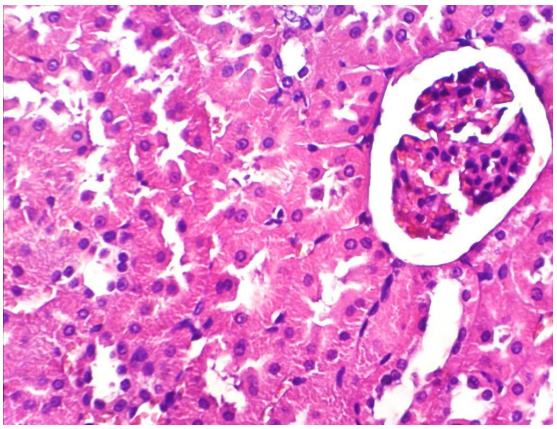

Fig. 12: Kidney of rat from group 1 showing the normal histological structure of renal parenchyma (H & E X 400).

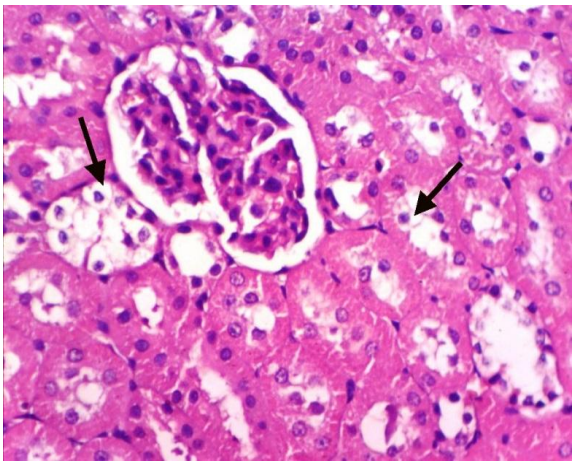

Fig. 13: Kidney of rat from group 2 showing cytoplasmic vacuolization of epithelial lining renal tubules (H & E X 400).

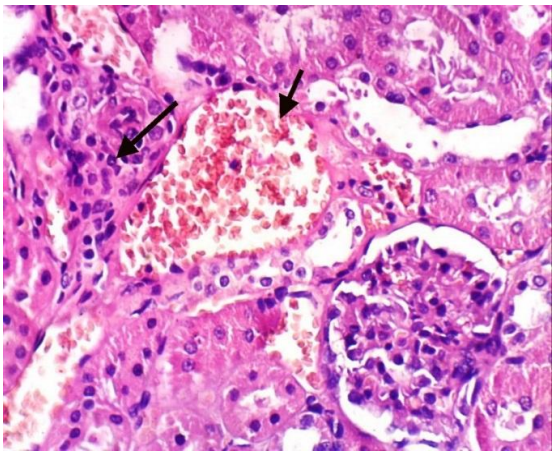

Fig. 14: Kidney of rat from group 2 showing congestion of renal blood vessel and focal necrosis of renal tubules associated with inflammatory cells infiltration (H & E X 400).

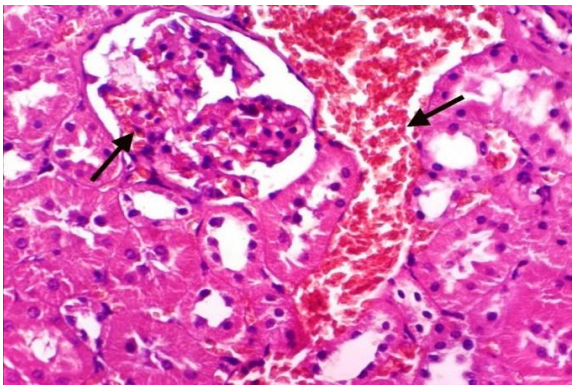

Fig. 15: Kidney of rat from group 3 congestion of renal blood vessel and glomerular tuft (H & E X 400).

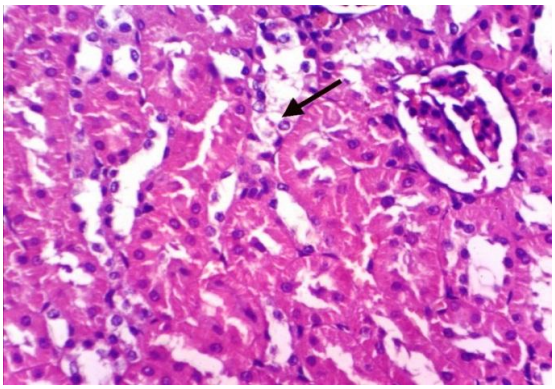

Fig. 16: Kidney of rat from group 4 showing cytoplasmic vacuolization of epithelial lining some renal tubules (H & E X 400).

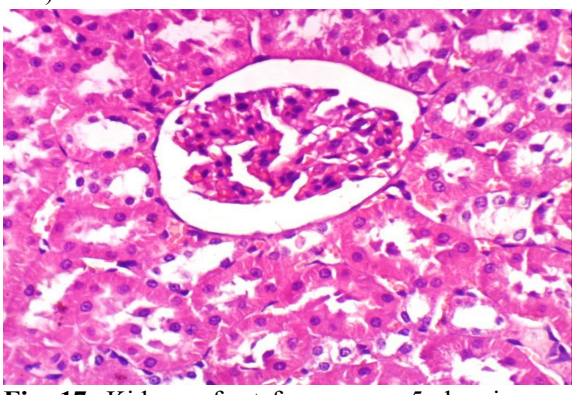

Fig. 17: Kidney of rat from group 5 showing no histopathological changes (H & E X 400).

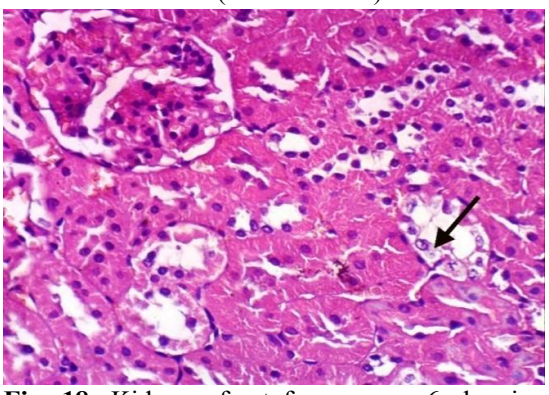

Fig. 18: Kidney of rat from group 6 showing cytoplasmic vacuolization of epithelial lining some renal tubules (H & E X 400).

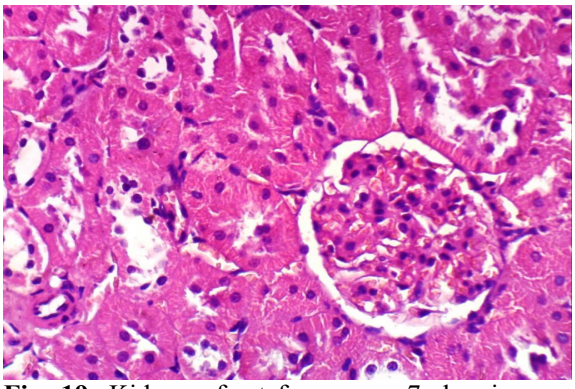

Fig. 19: Kidney of rat from group7 showing no histopathological changes (H & E X 400).

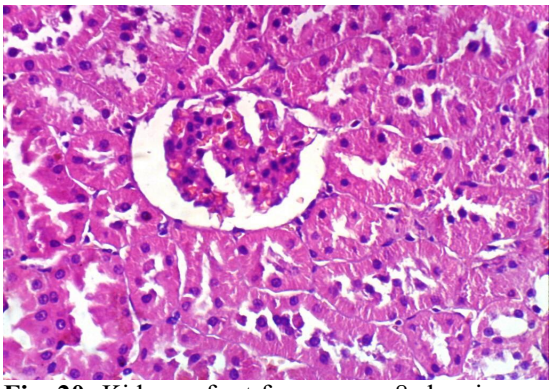

Fig. 20: Kidney of rat from group 8 showing no histopathological changes (H & E X 400).

From these results, it was suggested that prickly pear peels and prickly pear seeds could protect the liver cells from CCl4-induced liver damage, perhaps by their antioxidative effect on hepatocytes, hence eliminating the deleterious effects of toxic metabolites from CCl4. As a result of their hepatoprotective and hypolipidemic activities, prickly pear peels and prickly pear seeds were recommended in this study for patients suffering from liver diseases. Further studies are required in this field.

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