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Effect of *Acacia arabica* gum on histochemical changes in the renal cortex of rats exposed to gamma radiation

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ABSTRACT

Objective: Lately, gum Arabic (GA) is traditionally used in Middle East countries to ameliorate renal function of patients with chronic renal failure (CRF). This action is controversial and it is still experimentally under evaluation. We aimed to shed more light on the potential effects of GA against γ -rays-induced nephrotoxicity in irradiated rats. Forty-eight male albino Sprague–Dawley rats were divided into four groups: **control group (C)**, **irradiated groups (R)** 5Gy, **gum Arabic groups (GA)** 25 mg/kg orally administrated for 3 weeks, and **GA+R groups**, rats were treated orally with 25 mg /kg GA for one week before and three weeks after irradiation (**GA+R**). The experimental rats were sacrificed after 7 and 21 days of irradiation. Histochemical examination of kidney cortex tissue of R groups showed significantly decreased PAS-positive materials, total protein content, and total DNA content, but it significantly increased amyloid β -protein content relative to the control group. While treatment with GA before and after irradiation showed a non-significant change in PAS-positive materials and the content of total protein, total DNA, and amyloid β -protein throughout the examined kidney cortex. According to the results obtained in the current study using GA as a natural agent showed a strong cytoprotective effect against the histochemical changes due to its radioprotective effect.

Keywords: Gum Arabic, Radiation, Histochemistry, Kidney, Rats.

1. Introduction

Radiation is usually defined as the emission and propagation of energy in the form of waves or particles through space or matter (Paroli and Potenza, 2017). The effects of ionizing radiation on biological systems were mainly generated from experimental studies on animals and radiation accidents. These effects depend on many factors such

as radiation type, radiation dose, and radiosensitivity of the tissue receiving the radiation, and also the volume of tissue exposed (El-Naggar, 2009). The ionizing radiation effects, either by cell death or by indirect action through ionization of water, generates relative oxygen species (ROS). ROS causes the oxidation of proteins, DNA, and lipids (Gaschler & Stockwell, 2017). Gamma rays are ionizing radiation

and thus are biologically hazardous (Gruppen *et al.*, 2005). Exposure to ionizing radiation increases the production of reactive oxygen species (ROS) such as superoxide (O_2^-), hydroxyl radical ($OH\cdot$) and hydrogen peroxide (H_2O_2) and cause lipid peroxidation in cell membrane and damage to cellular activities leading to physiological disorders and dysfunction of cells and tissues (Sarhan, 2020). The proposed mechanisms of injury from free radicals include direct attack, lipid peroxidation, DNA modification, and enzyme degradation /inactivation (Mahgoup *et al.*, 2020). Clear histochemical changes were observed after whole-body gamma irradiation in the kidney tissue of rats (Abdelhafez *et al.*, 2017). Gum Arabic is defined as an edible, water-soluble dietary fibrous heteropolysaccharide, made from the dried gummy exudate obtained and cultivated as a cash crop in agroforestry systems from the stems and branches of *Acacia senegal* or *Acacia seyal* trees (Said *et al.*, 2019). GA is rich in Ca^{2+} , Mg^{2+} , and K^+ , widely used in the pharmaceutical, cosmetic, and food industries as an emulsifier and stabilizer (Ali *et al.*, 2013). Experimentally, gum Arabic has been used in the Middle East and North Africa countries in the traditional treatment of a variety of diseases, such as renal failure, hepatic, cardiac, anemia, and diabetes mellitus, also used as an oral hygienic substance, antidiarrheal and anti-inflammatory for intestinal mucosa and inflamed skin, it improves the patients' digestive systems and improves appetite and for kidney disease patients (El-shama, 2018; Said *et al.*, 2019). In mice and rats, GA has been reported to act as a protecting agent against hepatic and renal toxicities (Nemmar *et al.*, 2019). The protective effects of GA are likely to be related to its anti-oxidant and anti-inflammatory and cytoprotective properties (Hammad *et al.*, 2019). It is a widely known safe dietary fiber that has an impact on bacterial mass and enzyme activity; the cecum's bacteria count may rise due to more dietary fiber content without altering the sorts of bacteria. The relative amounts of acetate and butyrate produced depend on the amount of GA fed (Jaafar, 2019).

2. Materials and Methods

2.1. Radiation facility

A Canadian gamma cell-40, Cesium-137 source, located at the National Center for Radiation Research and Technology (NCRRT), Cairo, Egypt, was used to conduct whole-body γ -irradiation of rats. At the time of the experiment, the dose rate was 0.6 Gy/min. Rats were exposed for 10 min to reach a single dose of 5 Gy.

2.2 . Gum Arabic (GA)

Gum Arabic is a soluble dietary fibre obtained naturally from the stems and branches of *Acacia arabica* trees (Family: *Leguminosae*). GA powder was purchased from El-Gomhouria company (Cairo, Egypt), freshly suspended in distilled water, and administered orally to the rats at a dose of 25mg/kg/day using a gastric tube for consecutive 21 days according to the method of Gamal El-din *et al.* (2003).

2.3. Experimental animals

Forty-eight male Albino Sprague–Dawley rats were used in this study.

weighing 160-180 grams were purchased from the Egyptian Holding Company for Biological Products and Vaccines, Helwan, Cairo, Egypt. The animals were kept in the laboratory for 2 weeks before the experimental work for acclimatization and they were housed in specially designed cages, 6 rats per cage, with controlled air, temperature, and relative humidity. The animals were fed standard rodent pellets. Food and water were made available ad-libitum throughout the whole experimental period.

2.4. Experimental design

Male Albino rats were randomly divided into four groups (12 rats in each group)

Group 1: Control (C)

Group 2: Whole body γ -irradiated (5Gy) animals (R).

Group 3: gum Arabic (25 mg/kg body weight) daily oral administrated by gavage for 3 weeks (GA).

Group 4: GA-irradiated group rats were treated orally with 25mg/kg body weight/day of GA for one week before and three weeks after irradiation (GA+R).

The experimental rats were sacrificed on days 7 and 21 post-irradiation.

2.5. Histochemical techniques

After 7 and 21 days, the control and all treated groups were sacrificed, and then the kidneys were quickly removed and fixed for 24 hours in 10 percent neutral formalin followed by dehydration in ascending grades of alcohol, clearing in xylene, and embedding in paraffin wax. The sections were then cut at a thickness of 5 μ using a microtome (SLEE MAINZ-Cut 4050 Microtome-Lise-Meitner-Str-1-55129-Germany) and stained with Periodic acid Schiff's technique for detection of PAS-positive materials (Drury and Wallington, 1980), mercuric bromophenol blue method for detection of total protein (Mazia *et al.*, 1953), Feulgen reaction for detection of DNA (Drury and Wallington, 1980) and Congo red technique for detection of amyloid protein (Valle, 1986).

2.6-Quantitative histochemical analysis

The optical density of histochemically PAS, mercuric bromophenol blue, Feulgen, and Congo red-stained sections of a kidney of the control and treated groups was recorded using IPWIN 32 image analysis software. The mean optical density was used to compare the PAS-positive content, total protein content, total DNA content, and amyloid β -protein content of the different groups. The comparison was established as the mean of the treated group value with the control group.

2.7-Statistical analysis

Statistical analyses were performed by using analyses of variance (ANOVA) according to the method of Snedecor and Cochran (1980). The data were processed and analyzed using the SPSS software (Statistical Analysis for Social Science, Version 8). Significant differences between treatment means were determined by student t-test. Data presented as mean \pm SE and $P \leq 0.05$ were considered statistically significant.

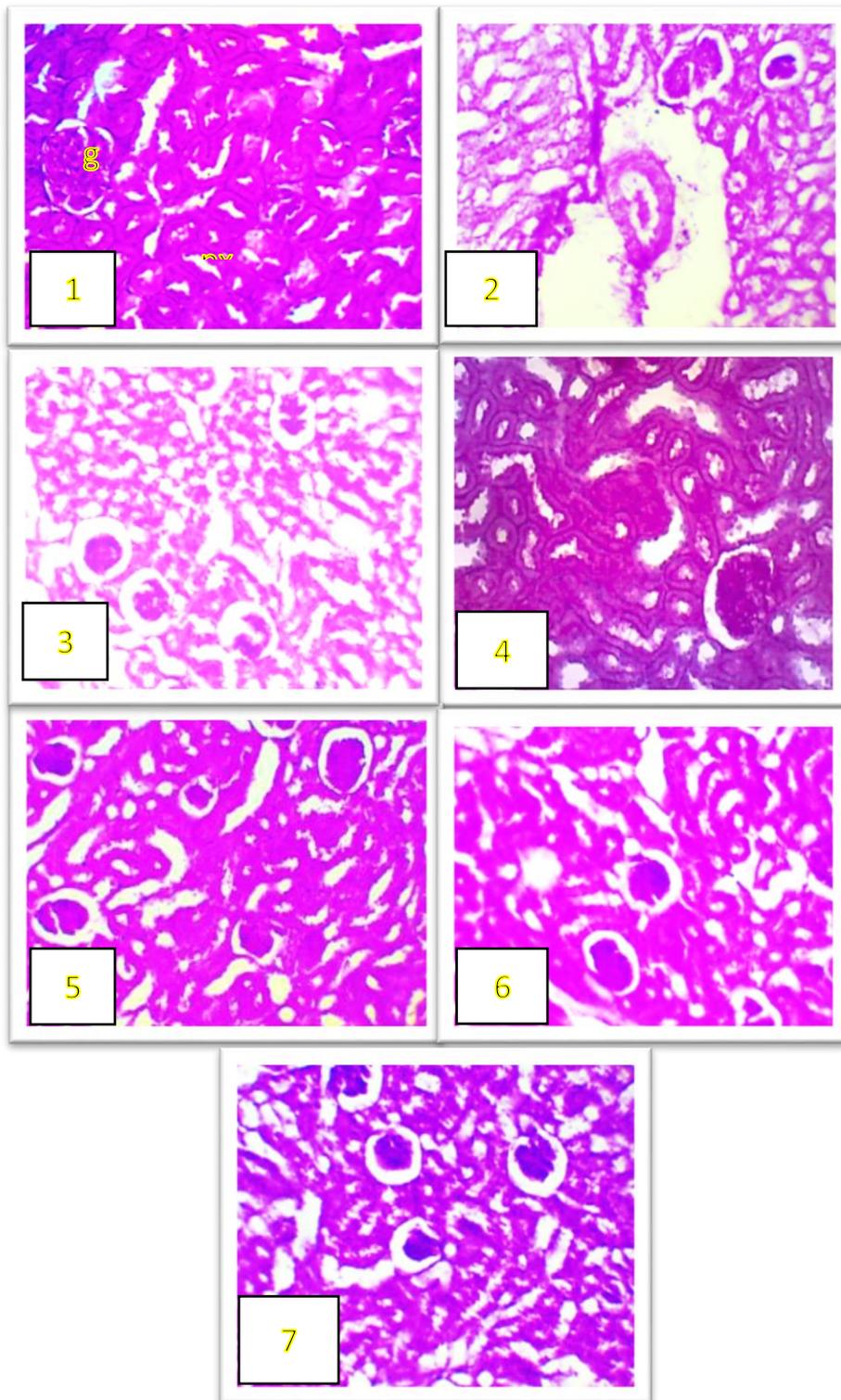
2.8-Laboratory facilities

Facilities including animal housing, histochemical and quantitative image analyses had been made available by the Zoology Department, Faculty of Science, Al-Azhar University (Girl's Branch).

3. Results

PAS-positive materials

Light microscopic examination of the kidney cortical section of the control rats showed normal distribution of polysaccharides where a strong positive reaction was seen in the glomeruli, Bowman's capsules, renal tubules, brush borders of the proximal convoluted tubules, and the basement membranes of the glomerular capillaries (Fig. 1). Exposure of rats to 5 Gy of gamma radiation showed an obvious decrease in the PAS +ve materials in both proximal and distal convoluted tubules with an intense reaction in the congested glomeruli, the brush borders of the proximal convoluted tubules, and the basement membranes of the convoluted tubules after 7 (Fig. 2) and 21 days (Fig. 3) of γ - radiation exposure. A significant decrease in the mean value which reached 0.363 and 0.372 after 7 (Fig. 2) and 21 days (Fig. 3) of γ - irradiation respectively was also depicted as compared to the control value 0.442 (table 1). Administration of gum Arabic (GA) only for 7 and 21 days respectively to normal rats showed a non-significant change in the mean value which reached 0.422 & 0.497 in the kidney cortical sections after 7 (Fig. 4) and 21 days (Fig. 5) of treatment respectively (table 1). Sections of rats exposed to gamma radiation following gum Arabic administration showed more or less normal appearance of the PAS +ve materials throughout the examined kidney cortex with a non-significant decrease in the mean value which reached 0.409 and 0.415 after 7 (Fig. 6) and 21 days (Fig. 7) of γ -irradiation process respectively (Table 1).



Figs. 1-7- Photomicrographs in the kidney cortical sections of the control and treated groups showing the distribution of PAS +ve materials. (PAS stain X 200) **Fig. 1-** The control group showing densely stained PAS + materials in the glomeruli (g), basement membranes, convoluted tubules, and brush borders of the proximal tubules (px). **Figs. 2&3-** Showing a decrease in the PAS +ve materials in the glomeruli and some epithelial cells of the convoluted tubules after 7 (**Fig. 2**) and 21 days (**Fig. 3**) of exposure to gamma radiation. **Figs. 4&5-** Showing moderately stained PAS +ve materials in sections of the kidney cortical tissue of GA groups after 7 (**Fig. 4**) and 21 days (**Fig. 5**) of treatment respectively. **Figs. 6&7-** Showing somewhat normal appearance of PAS +ve materials in sections of the kidney cortex of GA+R groups after 7 (**Fig. 6**) or 21 days (**Fig. 158**) following γ - radiation exposure.

Parameter Time Groups	PAS-positive materials			
	Seven days		Twenty-one days	
	Mean ± S.D	% Change	Mean ± S.D	% Change
Control	0.442±0.145	0.0%	0.442±0.145	0.0%
Radiation	0.363±0.021*	-17.87 %	0.372±0.052*	-15.84%
Gum Arabic (GA)	0.422±0.061	-4.52%	0.497±0.03	12.44%
GA + R	0.409±0.018	-7.47%	0.415±0.062	-6.11%

Table 1-Showing PAS-positive materials in kidney cortex tissue of the control and all the treated groups of adult male Albino rats-Each value represents the mean ± standard deviation (SD)-* Significant difference from the control at $P \leq 0.05$

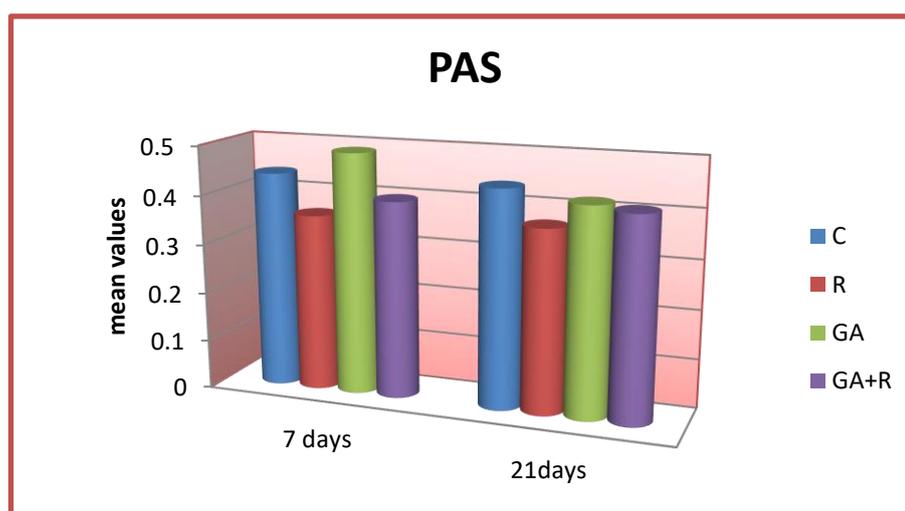
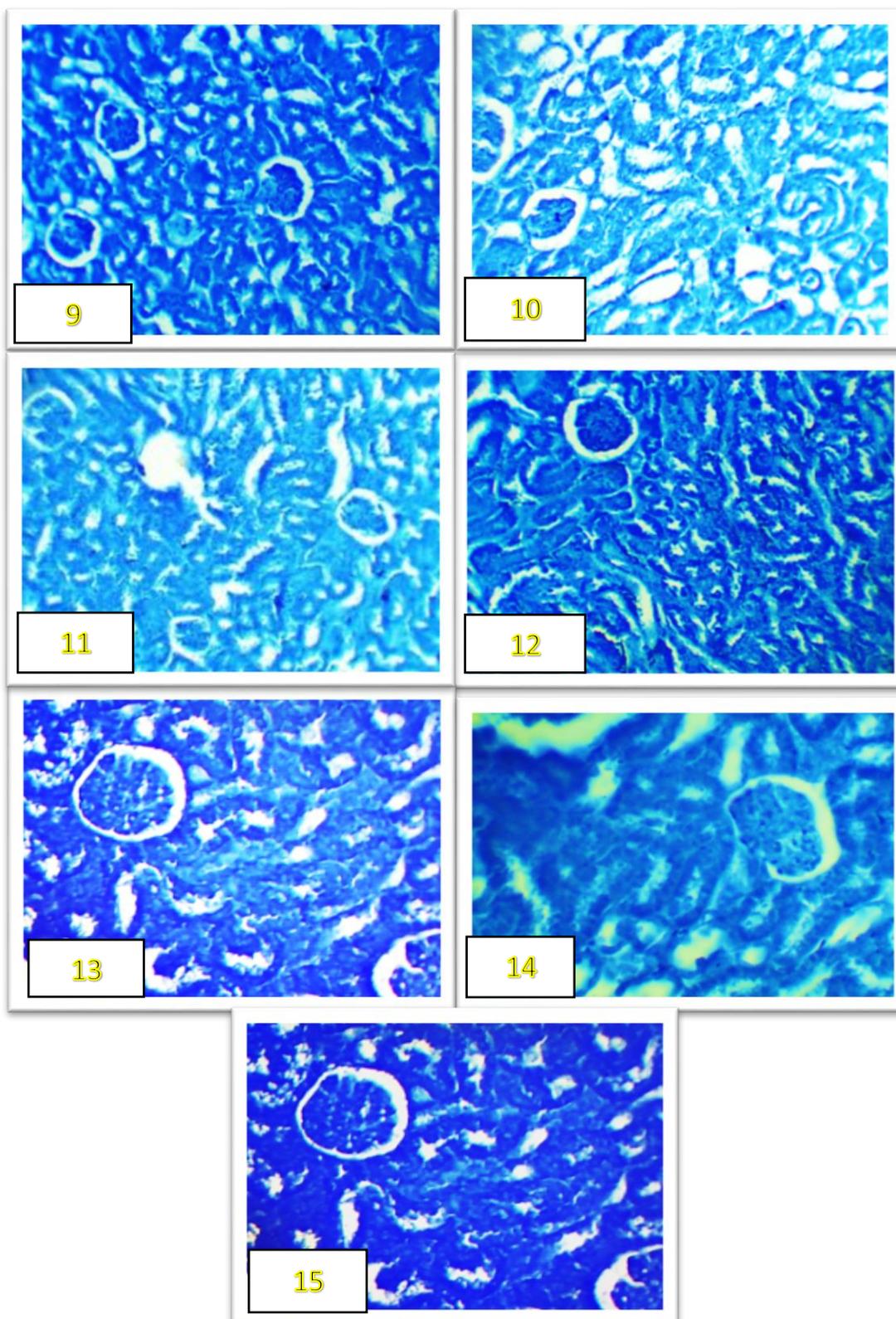


Fig. 8- Showing the mean values of PAS-positive materials relative to the control value.

Total proteins

Total protein content was demonstrated in a section of the kidney cortex of the control group as a homogenous moderately blue-stained throughout both nuclei and cytoplasm of cuboidal cells of the proximal, distal convoluted tubules and glomerulus. Moderately stained proteinic materials were realized in the brush border of the PCT (Fig. 9). Exposure of rats to 5 Gy of gamma radiation showed a marked decrease in total protein content with a significant decrease in the mean value of total protein which reached 0.289 & 0.323 after 7 (Fig. 10) and 21 days (Fig. 11) of gamma irradiation respectively as

compared to the control value which reached 0.547 (Table 2). Oral administration of GA only to normal rats showed a nearly normal distribution of the total protein content with a non-significant decrease in the mean value of total protein content which reached 0.451 & 0.489 after 7 (Fig. 12) and 21 days (Fig. 13) following gum Arabic administration respectively. Treatment of experimental animals with GA before and after exposure to a single dose 5 Gy of γ -radiation showed a non-significant decrease in the mean value of the total protein which reached 0.42 & 0.43 after 7 (Fig. 14) and 21 days (Fig. 15) of γ -radiation exposure process respectively.



Figs. 9-15- Photomicrographs of the kidney cortical sections of rats of the control and treated groups showing the distribution of the total protein. (Bromophenol blue X 250)

Fig. 9- Showing moderately stained total protein in the glomerular capillaries and convoluted tubules of rats of the control group. **Figs. 10&11-** Showing weak staining affinity of total protein in sections of the kidney cortex of rats which were exposed to γ - radiation especially in the lobulated glomeruli, but some epithelial cells of the convoluted tubules acquired densely staining affinity after 7 (**Fig. 10**) and 21 days (**Fig. 11**) of γ - irradiation respectively. **Figs. 12&13-** Showing moderately stained total protein in the glomeruli and convoluted tubules of kidney cortex of rats of groups GA after 7 (**Fig. 12**) and 21 days (**Fig. 13**) of treatment respectively. **Figs. 14&15-** Showing somewhat normal appearance of total protein in sections of the kidney cortex of GA+R groups after 7 (**Fig. 14**) or 21 days (**Fig. 15**) of γ - irradiation.

Parameter	Total protein content			
Time Groups	Seven days		Twenty one days	
	Mean \pm S.D	% Change	Mean \pm S.D	% Change
Control	0.547 \pm 0.111	0.0%	0.547 \pm 0.111	0.0%
Radiation	0.289 \pm 0.002*	-47.17 %	0.323 \pm 0.041*	-40.95%
Gum Arabic (GA)	0.451 \pm 0.021	-17.55%	0.489 \pm 0.064	-10.6%
GA + R	0.421 \pm 0.028	-23.03%	0.435 \pm 0.023	-20.48%

Table 2–Showing total protein content in kidney cortex of the control and all the treated groups of adult male Albino rats -Each value represents the mean \pm standard deviation (SD) -* Significant difference from the control at $P \leq 0.05$

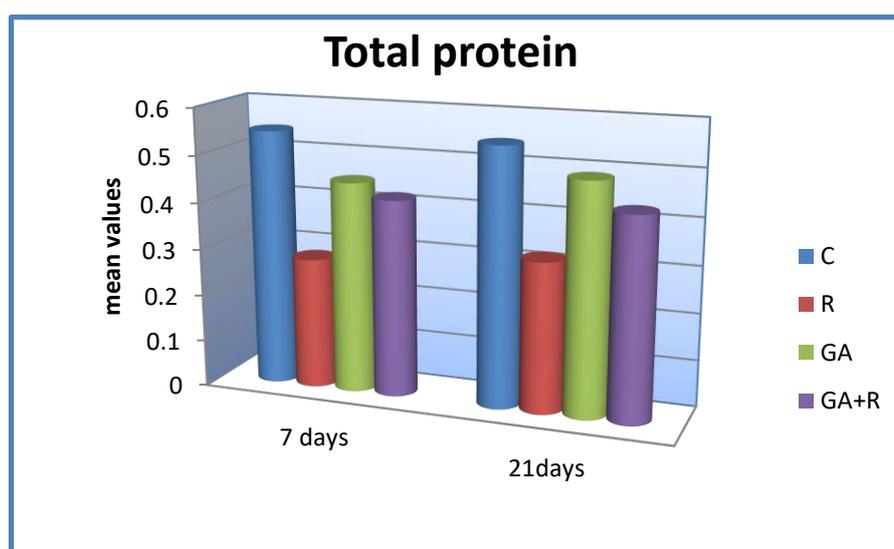
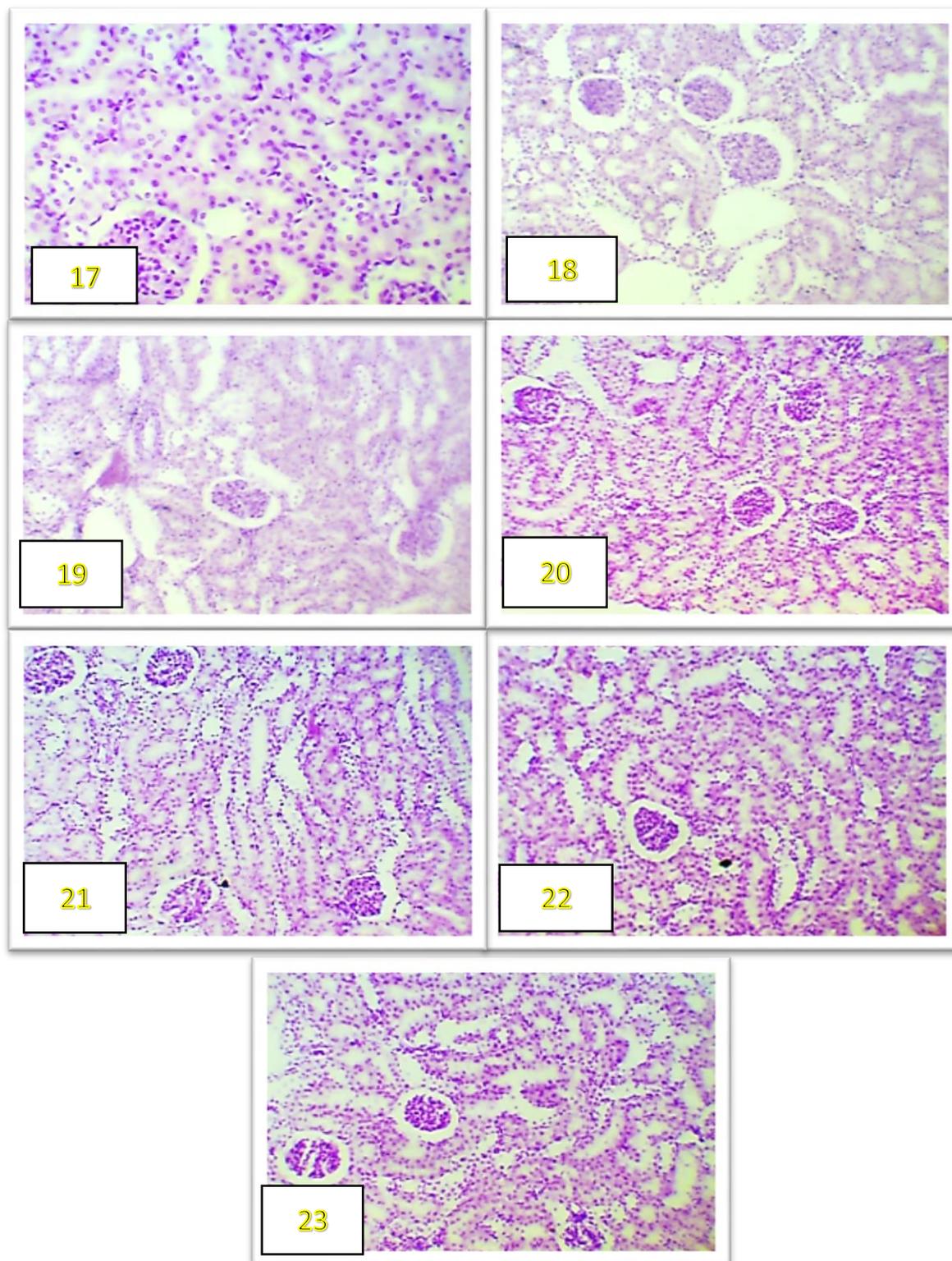


Fig. 16-Showing mean values of total protein content relative to the control value

Total DNA content

Moderately stained DNA content was detected in nuclei of the glomeruli, proximal and distal convoluted tubules of the kidney cortex tissue of a control rat (**Fig. 17**). Exposure of rats to 5 Gy of gamma radiation showed a reduction in the DNA content indicated by faint staining affinity in the proximal and distal convoluted tubules, cellular infiltration area exhibited densely staining affinity with a significant decrease in the mean value of DNA content which recorded 0.321 and 0.328 after 7 (**Fig. 18**) and 21 days (**Fig. 19**) of

γ - irradiation as compared to the control value which reached 0.375 (**Table 3**). Gum Arabic administration only showed moderately stained DNA materials with a non-significant decrease in the mean value which reached 0.361 and 0.364 after 7 (**Fig. 20**) and 21 days (**Fig. 21**) of oral administration respectively. Rats exposed to a single dose of gamma radiation and treated with GA showed a sign of improvement indicated by moderately stained DNA which exhibited a non-significant decrease in the mean value of DNA content which reached 0.354 and 0.357 after 7 (**Fig. 22**) and 21 days (**Fig. 23**) of γ - radiation exposure respectively.



Figs. 17-23- Photomicrographs in the kidney cortical sections of rats of the control and treated groups showing DNA content.

Fig. 17- The control group showing moderately stained DNA in nuclei of the glomerulus, Bowman's capsules, and convoluted tubules indicated by magenta color. (**Feulgen stain X 400**). **Figs. 18&19-** Showing highly reduced staining affinity of nuclei of cells of the convoluted tubules and glomeruli in sections of the kidney cortex of R groups after 7 (**Fig. 18**) and 21 days (**Fig. 19**) of γ - irradiation. (**Feulgen stain X 250**). **Figs. 20&21-** Showing moderately stained DNA distributed throughout the nucleoplasm of the glomerular capillaries and convoluted tubules of rats of groups GA in both groups after 7 (**Fig. 20**) and 21 days (**Fig. 21**) of treatment. (**Feulgen stain X 250**). **Figs. 22&23-** Showing somewhat normal appearance of DNA content in the kidney cortex of rats of groups GA+R in both groups after 7 (**Fig. 22**) and 21 days (**Fig. 23**) of γ -irradiation. (**Feulgen stain X 250**).

Parameter Time Groups	Total DNA			
	Seven days		Twenty-one days	
	Mean ± S.D	% Change	Mean ± S.D	% Change
Control	0.375±0.0001	0.0%	0.375±0.0001	0.0%
Radiation	0.321±0.006*	-14.4 %	0.328±0.008*	-12.53%
Gum Arabic (GA)	0.361±0.0002	-3.73%	0.364±0.0002	-2.93%
GA + R	0.354±0.001	-5.6%	0.357±0.0003	-4.8%

Table 3-Showing total DNA content in the kidney cortex of the control and all the treated groups of adult male Albino rats-Each value represents the mean ± standard deviation (SD)-* Significant difference from the control at $P \leq 0.05$

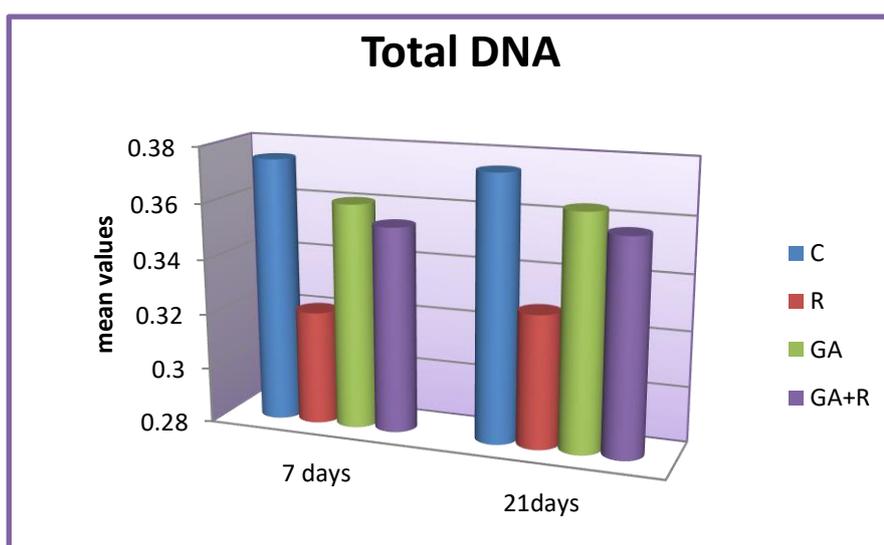
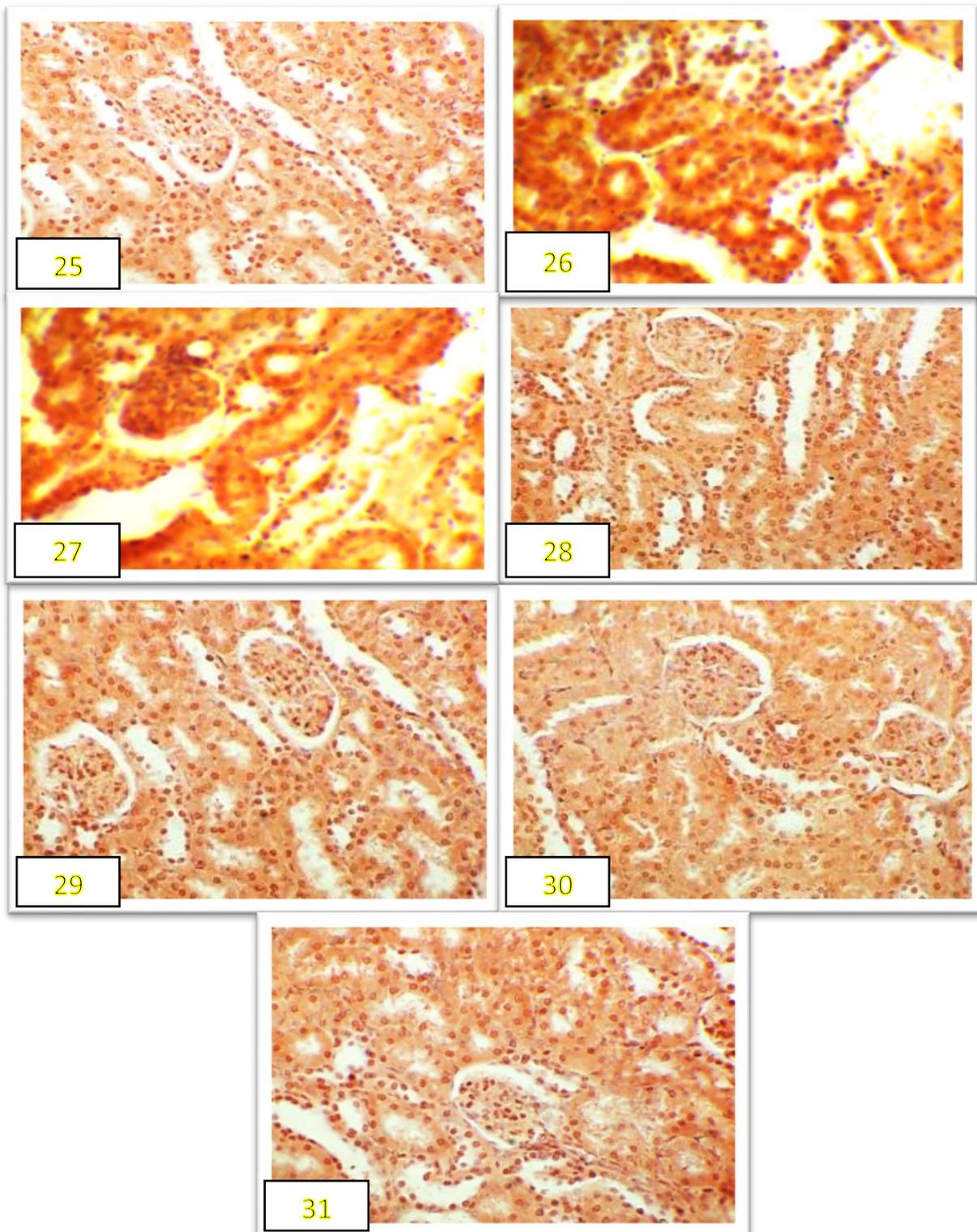


Fig. 24-Showing the mean values of total DNA content relative to the control value.

Amyloid β - protein content

Faintly stained amyloid β - protein was demonstrated in the kidney cortex of the control rats (**Fig.25**) while, rats exposed to a single dose 5 Gy of gamma radiation showed an intense staining affinity in the proximal and distal convoluted tubules with a significant increase in the mean value which reached 1.36 and 1.231 after 7 (**Fig. 26**) and 21 days (**Fig. 27**) of γ - radiation exposure respectively as compared to the control rats value which reached 0.437 (**Table 4**). Treatment with GA alone showed a weak staining affinity throughout the kidney cortex

with a non-significant change in the mean value of the amyloid β -protein which reached 0.415 & 0.439 after 7 (**Fig. 28**) and 21 days (**Fig. 29**) of treatment respectively. Experimental animals which administrated GA and exposed to γ -radiation exhibited weak staining affinity of β -amyloid protein and represented a non-significant increase in the mean value of the amyloid β - protein content which reached 0.575 and 0.542 after 7 (**Fig. 30**) and 21 days (**Fig. 31**) of γ - radiation exposure.



Figs. 25-31- Photomicrographs in the kidney cortical sections of rats of the control and treated groups showing the distribution of amyloid β -protein content. (Congo red stain X 400).

Fig. 25- Showing faintly stained amyloid- β protein in sections of the kidney cortex of the control rats. **Figs. 26&27-** Showing highly increased amyloid- β protein in the glomerular capillaries and basement membranes of some convoluted tubules of R groups after 7 (**Fig.26**) and 21 days (**Fig.27**) of γ - radiation exposure. **Figs. 28&29-** Showing normal distribution of amyloid - β protein in sections of the kidney cortex of GA groups after 7 (**Fig.28**) and 21 days (**Fig. 29**) of treatment. **Figs. 30&31-** Showing somewhat normal distribution of amyloid- β protein in sections of the kidney cortex of GA+R groups after 7 (**Fig.30**) and 21 days (**Fig.31**) of γ - radiation exposure.

Parameter	Amyloid content			
Time Groups	Seven days		Twenty-one days	
	Mean ± S.D	% Change	Mean ± S.D	% Change
Control	0.437±0.0002	0.0%	0.437±0.0002	0.0%
Radiation	1.36±0.007*	211.21 %	1.231±0.052*	181.69%
Gum Arabic (GA)	0.415±0.007	-5.03%	0.439±0.08	0.46%
GA + R	0.575±0.004	31.58%	0.542±0.04	24.02%

Table 4- Showing amyloid-β protein content in kidney cortex of the control and all the treated groups of adult male Albino rats -Each value represents the mean ± standard deviation (SD)-* Significant difference from the control at P ≤ 0.05

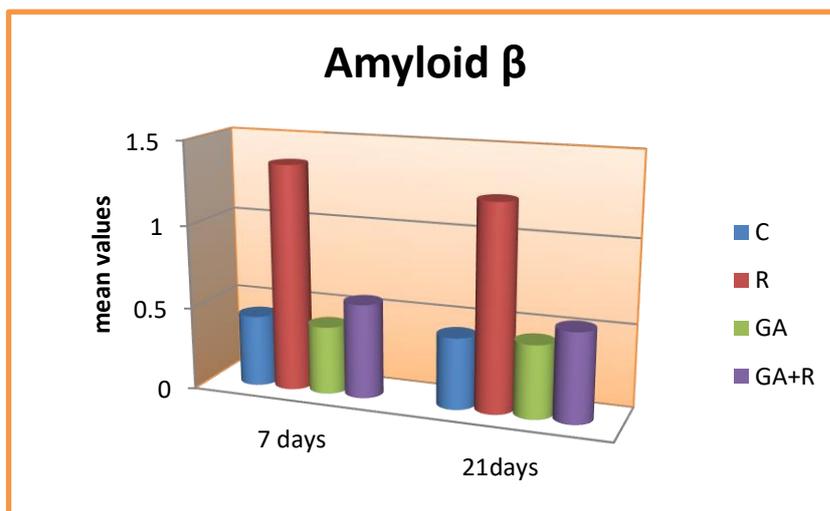


Fig. 32- Showing the mean values of amyloid β- protein relative to the control value

**4-Discussion
Polysaccharides**

Concerning the histochemical observations in the current work, sections of the kidney cortex of rats exposed to 5 Gy of γ-radiation showed a reduction of polysaccharides. According to **Zaghloul and Salem (2001)** and **Koyu et al. (2005)**, these changes in polysaccharides may be due to failure of Golgi apparatus to synthesize carbohydrate or due to lytic enzymes released from ruptured lysosomes or due to hypoxia. These findings are in agreement with **Eid**

and Al-Dossary (2007) who reported that highly reduced polysaccharides in fetal kidney cortex post-irradiation may be due to degeneration and vacuolation observed in most cells of proximal and distal convoluted tubules and renal Malpighian corpuscles or may be due to failure of Golgi apparatus to synthesize polysaccharides. Reduced staining affinity of PAS +ve materials was detected in kidney tissue of the irradiated rats at dose 2Gy (**Emam et al., 2013**). Present results showed that male rats that received GA had a normal appearance

of PAS +ve materials, it is known that GA contains a high percentage of polysaccharides. **Yu et al. (2018)** investigated the bioactivity of polysaccharides from natural resources, including its diverse pharmacological applications, such as immunoregulatory, anti-tumor, anti-virus, antioxidation, and hypoglycemic activity. The present results were also noticed by **El-shama et al. (2014)** who elucidated that male rats that received GA have a normal appearance of PAS +ve materials. Non-significant decrease in the mean value of PAS +ve materials as illustrated in the current investigation in the kidney cortex tissue of the GA+R group after 7 and 21 days of γ - irradiation. Similar results were obtained by **Tavafi et al. (2012)** and **El-shama et al. (2014)** who found that GA is a nephroprotective agent against acute kidney failure. **Helal et al. (2014)** noticed that diabetic rats treated with flavonoids showed that the mucopolysaccharide content more or less was similar to the control level. *Acacia* species is one of the richest resources of bioactive flavonoids, alkaloids, phenolics, saponins, polysaccharides, tannins, and terpenoids (**Pal et al., 2019**). Improvement in polysaccharides content observed in this study in group GA+R may be due to the antioxidant activity of gum Arabic (**Al-Doaiss and Al-Shehri, 2020**).

Total protein

The present results showed that exposure of rats to 5 Gy of gamma radiation represented a significant decrease in the mean value of total protein in kidney cortex tissue 7 and 21 days following the γ -irradiation process. This finding was considerably supported by the results of **Curran (2000)** who reported that radiation-induced a clear inhibition of protein contents in the kidney (cortex and medulla) this may be due to the release of glucocorticoid which breakdown protein in the tissue. In more detail, **Kempner (2001)** explained that this decrease in protein level may be due to gamma-irradiation which can damage or inactivate proteins by two different mechanisms. First, it can rupture the covalent bonds in the target protein molecules as a direct result of a

photon depositing energy into the molecule. Second, it can act indirectly, link with a water molecule, producing free radicals and other non-radical reactive oxygen species that are in turn responsible for most (99.9%) of the protein damage. Similar findings were obtained by **Abdelhafez et al. (2017)** who stated that a single dose of total body gamma irradiation (6 Gy) to rats induced a detectable decrease in total protein. This reduction in protein content may be due to the decreased ability of the tissue to produce proteins (**Al Gahtani, 2006**). Similarly, **Ali et al. (2007)** revealed that rats exposed to whole-body gamma radiation at 7.5Gy showed a decline in total protein compared to the control group. A noticeable decrease in the total proteins was observed in proximal and distal convoluted tubules and glomeruli post-exposure to radiation, but increased stainability was detected in RBCs (**Eid and Al-Dossary, 2007**). Moreover, **Sanaa et al. (2012)** reported that tissue total proteins and total lipids, decreased significantly at different sampling times post-radiation exposure(5.7 Gy) at a dose rate of 2.67 rad/sec. **Abdel-Meguid et al. (2012)** stated that the decrease in protein could be attributed to the disruption of lysosomal membranes under the effects of various toxicants; thus, led to the liberation of their hydrolytic enzymes in the cytoplasm. Additionally, the presence of hydrolytic enzymes may cause the lysis and dissolution of the target material within the cytoplasm. Decreased total protein in the glomeruli, Malpighian's corpuscles, walls of the convoluted tubules with negatively stained degenerated areas were noticed in the kidney cortex of irradiated (2Gy) pregnant rats (**Bakhit, 2013**). Irradiation of animals at 900-1800MHz resulted in a marked reduction in the total protein content giving weak to moderate reactions in some hippocampal areas (**Mohammed, 2014**). According to **Eid et al. (2014)**, this decrease may be due to the decrease in ribosomal granules of the rough endoplasmic reticulum or due to the decrease in DNA content. **Antebi et al. (2016)** also concluded that ionizing radiation at high doses (50 kGy) caused significant reduction (between 35% and 52%) in the

concentrations of total protein. **Eid et al. (2018)** revealed highly decreased total protein content in the heart tissue of the irradiated group (4Gy) after 5 and 21 days. Reactive oxygen species directly impair mitochondrial function, protein synthesis and structure, DNA synthesis, and cellular repair mechanisms (**Perazella and Moeckel, 2010**). Oxidative stress is already found in the early stages of renal disease and increases with declining kidney function (**Zhou et al., 2019**). In the present study, rats in groups GA or GA+R showed a non-significant decrease in the mean value of total protein compared to the control group in sections of the kidney cortex tissue. The improvement in protein content in GA and GA+R may be due to the presence of polysaccharides and flavonoids. The previous studies have indicated that polysaccharides, alkaloids, coumarins, flavonoids, saponins, and other compounds possess anti-radiation effects (**Shi et al., 2013; Eid et al., 2018; Boojar, 2020**). They declared that the mechanism of this effect may be attributed to protecting DNA, inhibiting immune injury, protecting the hematopoietic system, and scavenging free radical activities of GA.

Gum Arabic has antioxidant action, by testing whether treatment with gum Arabic has any effect on the concentrations of some free radical scavengers [reduced glutathione (GSH), ascorbic acid (AA), lipid peroxidation (LP), and superoxide dismutase (SOD)] in the kidneys and liver of healthy rats given gum Arabic in the drinking water at a concentration of 2.5, 5.0 or 10.0% for eight consecutive days. The results indicated that the gum Arabic, at the three doses used, did not significantly affect any of the variables measured. It seems highly unlikely that gum Arabic has a palliative effect on renal failure through an antioxidant mechanism (**Ali, 2004**).

DNA content:

In the present study exposure of rats to 5 Gy of gamma radiation illustrated a significant decrease in the mean value of DNA materials. Ionizing radiation exerts adverse biological effects through direct and

indirect processes breaks in DNA strands and the production of oxygen free radicals. These oxygen free radicals in turn damage and mutate cellular DNA, leading to an increased rate of malignancy with radiation exposure. In addition, free radicals destroy supporting cellular structures, including organelles and cell membranes, resulting in programmed cell death (**Robbins and Zhao, 2004**).

Increased mutation and decreased DNA content in nuclei of the cells post-irradiation may be due to the production of active oxygen which leads to oxygen pressure and increased free radicals which affect chains of DNA that lead to cancer (**Mahmod, 2006**).

Similarly, **Purohit et al. (2007)** noticed that in the irradiated animals, the values of glycogen, protein, and DNA decreased in kidney tissue continuously up to day 7 and increased thereafter up the day 28. The decrease in both DNA and total protein was attributed to arrested metabolism or to use it to build up new cells or enzymes to reduce the radiation stress and also disruption of lysosomal membranes under the effect of various toxicants leading to liberating their hydrolytic enzymes in the cytoplasm and resulted in marked lysis and dissolution of the target materials (**Sakr and Shalaby, 2011**). **Abdelhafez et al. (2017)** illustrated that the decrease of DNA content was associated with a decrease in protein content in kidney cells of the rats exposed to 6Gy of γ -radiation. **Eid et al. (2018)** noticed a decrease in the staining affinity of DNA content in the heart tissue of rats following exposure to 4Gy of γ -radiation. **Zhou et al. (2019)** demonstrated that oxidative stress, characterized by the generation of reactive oxygen and nitrogen species, produces permanent genomic alterations and cellular DNA damage. Results of the present study showed a non-significant decrease in total DNA content in the kidney cortex in the groups treated with GA alone or GA+R in comparison with the control. This improvement may be due to the anti-inflammatory and antioxidant properties of GA that protects against DNA damage initiated by free radicals (**Mohamed et al., 2015**). They added that the antioxidative capacity of GA could prevent the

formation of superoxide completely and the oxidative stress-induced DNA double-strand breaks to a certain extent. DNA double-strand breaks are serious lesions, initiating genomic instability, inducing cell death, or even mutations. A lowered amount of superoxide anions and a lowered incidence of double-strand breaks could in part explain the positive effect of GA on the progression of kidney disease. This positive effect can also be ascribed to the ability of GA to lower the blood pressure in the adenine-treated rats (Ali *et al.*, 2011; Jaafar, 2019), other authors showed an increase of ROS in animals with hypertension (Welch, 2006; Schupp *et al.*, 2011).

Amyloid- β protein

The results of the current study recorded a significant increase in the amyloid- β protein content in the kidney cortex tissue, in the glomerular capillaries, especially in the basement membrane of some convoluted tubules, and in the hemorrhagic areas of the irradiated animals throughout the experimental periods.

Amyloid- β peptide (A β) is still best known as a molecule to cause Alzheimer's disease (AD) through accumulation and deposition within the frontal cortex and hippocampus in the brain. Thus, strategies for developing AD drugs have been focused on the reduction of A β in the brain (Sang-Sun and Sangmee, 2012). Amyloid β - is produced by both brain and peripheral cells and can pass through the blood-brain barrier (Davanipour *et al.*, 2007). Mohammed (2014) showed that whole-body microwave exposure of 1h / day for 140 days revealed a slight deposition of amyloid β -protein in the nuclei of hippocampus cells. The application of Congo red stain recorded slightly increased amyloid β deposits inside some of the granular cells of the hippocampus of the irradiated mice, but those neurons which underwent apoptosis in most of the hippocampal areas exhibited a high strong amyloid β reaction. In the same direction, Eid *et al.* (2018) showed that exposure of rats to gamma radiation increased amyloid β -proteins in the heart tissues after 5 or 21 days of γ - radiation exposure. In addition,

Abdelhafez *et al.* (2017) found a significant increase in the amyloid- β protein content in the kidney cortex tissue of rats after exposure to 6 Gy gamma radiation. The present finding showed a weak staining affinity and a non-significant change in the mean value of amyloid β - protein (A β) content in GA and GA+R groups after 7 and 21 days of treatment in the kidney cortex tissues.

Ono *et al.* (2006) proved that there are several antioxidant compounds with anti-amyloidogenic effects. Ameliorated results in different organs of the irradiated rats treated with GA observed in this study may be due to antioxidant and anti-inflammatory effects (Ali *et al.*, 2018; Al-Doaiss and Al-Shehri, 2020). The use of antioxidant compounds may also have a role in reducing A β amyloid-induce toxicity. These substances include blueberries, flavonoids, polyphenols, resveratrol, epicatechin, and melatonin (Massaad, 2011). Anti-oxidant treatments in the early stages of pathogenesis were able to alleviate the functional impairment (Hsiao *et al.*, 2012) and to reduce brain A β in Alzheimer's disease mouse models (Chu, 2012; Cheng *et al.*, 2014). Grossi *et al.* (2013) concluded that dietary supplementation of GA may prevent or delay the occurrence of Alzheimer's diseases and may reduce the severity of its symptoms such as amyloid deposition.

5-References

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