Biological and biochemical studies on the effect of different quercetin levels of toxic dietary acrylamide on rats

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ABSTRACT

Quercetin is a flavonoid that is present in many different foods. Quercetin has several health advantages, including improved non-communicable diseases. Acrylamide can be produced by the Maillard reaction of amino acid and reducing sugars. As a result, the effects of varying amounts of quercetin on the harmful effect of toxic dietary acrylamide were studied. Forty male albino rats (Sprague Dawley) have been split into five groups (eight rats each), and every group was fed an experimental diet for 28 days. The negative control group was given only a baseline diet, whereas the positive control group was intake both a baseline diet and 4 µg/kg body weight (BW) of acrylamide each day. Groups 2, 3, and 4 were fed a basal diet comprising of 4 µg kg/BW each day of acrylamide with 50, 100, and 200 mg of quercetin powder/kg BW/day. The results showed that treatment with acrylamide alone significantly, ($p \leq 0.05$) decreased the relative body weight; feed efficiency ratio (FER), feed intake and increased tested relative organs weight. In addition, the results revealed that the positive control group had an inhibitory impact on butyrylcholinesterase, lactate dehydrogenase activity, the immunity index, an increase in malondialdehyde activities, and the harmful effect on the histological structure of the rats' liver and brain. Whereas treatment with different levels of quercetin significantly improved all tested parameters especially, at a high dose of quercetin (200 mg). For that, adding quercetin or their dietary sources in fried meals may be significant to reduce hazardous acrylamide.

Key wards: *Quercetin -Acrylamide -liver-brain - immunity*

INTRODUCTION

Flavonoids are naturally occurring chemicals found in plants, vegetables, fruits, stems, roots, wine, barks, bulbs, and tea. Many efforts have been made to isolate some natural compounds that are well known for their health advantages. Flavonoids are increasingly recognized as a vital component in a wide range of cosmetics, pharmaceutical, and medical compositions. Quercetin (2-(3,4-dihydroxyphenyl)-3,5,7-trihydroxy-4-Hchromen-4-one) is a flavone, one of six flavonoid subcategories, and the primary polyphenolic flavonoid present in lovage, berries, capers, dill, cilantro, onions, and apples (**Anand *et al.*, 2016).** It has a yellow hue and is very soluble in alcohol and lipids. However, in cold water, it is insoluble, and in hot water, it is just slightly soluble. Additionally, it falls into the flavone category that the human body does not generate **(Lakhanpal, 2017)**. Quercetin is a significant plant compound with several pharmacological pro-perties, including antiviral, anticancer, and treatment of allergy, metabolic, and infla-mmatory diseases, as well as ocular, cardiovascular disease, and arthritis. It additionally possesses a broad spectrum of anticancer activities, with multiple studies indicating its usefulness as a cancer-prevention drug. Quercetin additionally possesses psycho-stimulant characteristics and has been shown to reduce aggregation of platelets, permeability of capillaries, and lipid peroxidation while simultaneously increasing mitochondrial biogenesis **(Dabeek and Marra, 2019)**. Furthermore, **Lesjak *et al.* (2019)** discovered that methylated quercetin metabolites (such as tamarixetin and isorhamnetin) inhibited lipid peroxidation better than quercetin. Furthermore, **Liu *et al*. (2018)** demonstrated quercetin's potential to repair ethanol-induced oxidative damage in the rats' hepatocytes, indicating that quercetin could be an acceptable hepatoprotective natural product.

Acrylamide is a common chemical having several laboratory and industrial applications. It has also created when carbohydrate and amino acid-rich foods are heated during the Maillard reaction (most commonly found in fried potato products, coffee, and bread). A variety of variables influence acrylamide levels in cooked meals, including cooking temp, cooking duration, content of moisture, and the quantity of lowered sugar and asparagine in uncooked foods

(Lukac *et al.*, 2007 and Cuda *et al.*, 2012). Following occupational exposures, neurotoxicity was discovered to be the predominant harmful impact. Acrylamide is hazardous to reproduction, development, and male germ cells in rats and mice; it is carcinogenic to various organs and genotoxic via a reactive metabolite, glycidamide. According to epidemiological research, there is no link between occupational or nutritional exposures and an increase in cancer occurrence. The general population's health hazards depend on an average exposure of 1 g/kg BW each day, escalating to 4 g/kg BW each day for heavy users. Acrylamide can occur spontaneously because of chemical reactions in some types of starchy meals during high-temperature cooking and storage practices. French fries, potato chips, grains (such as morning cereals, cookies, and toast), and coffee are examples of foods rich in acrylamide **(Stadler *et al.*, 2002 and Brem *et al.*, 2017).**

Since the finding of acrylamide in common foodstuffs, a lot of epidemiological research has looked at its possible link to malignancies of numerous organs such as the reproductive system, the gastrointestinal tract, the kidney, the lung, and the brain. The food frequency questionnaire (FFQ) was used in the majority of the epidemiological studies analyzed to assess acrylamide consumption, with a few additionally measuring biomarkers **(Lukac *et al.*, 2007; Schouten *et al.*, 2015, and Bosetti *et al.*, 2016).**

As a result, the major purpose of this research was to explore the impact of different levels of quercetin on relative body weight (RBW), feed efficiency ratio (FER), feed intake (FI), relative organ weights, and biochemical and immunological indices of rats that received acrylamide.

MATERIALS AND METHODS

Materials

Phytochemicals (quercetin has been acquired from Sigma) (Deisenhofer, Germany). All of the additional chemicals and solvents used in the tests and have been of analytical grade have been bought from Merck, Darmstadt, Germany. Acrylamide (99 percent pure) C3H5ON was purchased from Sigma (Deisenhofer, Germany). Diamond Diagnostics, Egypt, produced kits for (AST), (ALT), and (ALP), protein, albumin, urea, butyryl cholinesterase, malondialdehyde (MDA), and glutathione S – transferase (GST), which were acquired from Bio

diagnostic Company in Egypt. The lactate dehydrogenase (LDH) enzyme was received from Stan bio in the United States, whereas the superoxide dismutase, glutathione peroxidase, and catalase enzymes have been obtained from the Molecular Probes Company in Egypt. Interleukin 1 (IL-1) ELISA kits, (IL-6) ELISA kits, and (TNF) ELISA kits were bought from the Vitro Scient Company in Egypt.

Methods

Experimental design and animal groups

The basic diet was constructed using the following formula, as stated by **Reeves et al., (1993).**

All biological experiments were carried out at Giza's Research Institute of Ophthalmology's Medical Analysis Department. Rats (n = 40) have been placed separately in wire cages at a temperature of 25 ± 2°C and have been kept in typical healthy circumstances. For acclimatization, all rats (40 rats) had been fed a baseline diet for a week prior to the experiment. Following a week, the rats have been separated into five groups, each with eight rats, and each has been given an experimental diet for 28 days. Group (1): As a control group, this group has been given a baseline diet merely, while Group (2) has been given a baseline diet with acrylamide at 4 µg kg/BW/day as a positive control group. Groups 3, 4, and 5 have been given a baseline diet containing 4 µg/ kg BW/day and 50, 100, and 200 mg /kg body weight /day quercetin, respectively, which was added to the rat's diet.

Biological evaluation

Consumption of food has been registered daily during the experimental period (28 days), and body weight gain (BWG), feed efficiency ratio (FER), and organ weight have been calculated as per **Chapman et al. (1959)**, employing the following equations:

RBW= final weight - Initial weight / Initial weight X100

FER =BWG (g/day)/feed intake (g/day)

Relative organ weight (ROW) = organ weight (g) / final BW (g) X100

Blood sampling and organs collection

Following a 12-h fast for diet and 2 h for water, blood specimens were obtained from all of the previously described groups at the conclusion of the experiment. Blood specimens have been collected into dry, clean centrifuge tubes utilizing the retro

orbital method with a micro capillary glass, and allowed to coagulate for 30 minutes at room temperature before being centrifuged for 10 minutes at 3000 rounds per minute (r.p.m) to extract the serum. Serum has been properly extracted and transported to dry, clean Eppendorf tubes, which were then kept at -20 °C until biochemical examination (**Schemer, 1967**).

Weight and fixation of organs

The organs (brain and liver) have been removed, cleaned, and weighed after the animals have been killed by cervical dislocation. According to **Yousef and El-Demerdash's (2006)** methods, half of each brain and liver have been placed in a 10% formalin solution (for histopathological investigation).

Biochemical analysis:

Butyrylcholinesterase was determined in serum as per the approach of **Knedel and Bottger (1967).** Lactate dehydrogenase was evaluated in serum employing a test reagent kit as per the technique of **Friedman and Young (1997).** The formation of lipid peroxides (MDA) in serum has been evaluated employing the technique of **Uchiyama and Mihara (1978)**, and the activity of GST in serum has been evaluated spectrophotometrically using the technique of **Habig et al. (1974)**. While glutathione peroxidase activity in serum has been evaluated spectrophotometrically using the technique of **Ursini *et al.* (1985**), catalase in serum has been assessed spectrophotometrically using readymade kits as per the technique of **Aebi (1984)**. Superoxide Dismutase has been assessed in serum as per the technique described by **Maier and Chan (2002**). (ALT) and (AST) in serum have been determined using a colorimetric technique according to **Reitman and Frankel (1957)**. Total protein in serum has been measured as per the colorimetric technique of **Gornall *et al. (*1949)**. Albumin level has been determined in serum employing a test reagent kit based on the technique of **Doumas *et al. (*1971).** Urea content in serum has been measured calorimetrically accor-ding to the technique of **Fawcett and Soctt (1960).** Serum cytokines **(**serum IL1) were measured employing ELISA kits as per the method of **Smith (1988)**. Serum IL6 was determined using ELISA kits as per the approach described by **Van Snick (1990)**. Serum TNF has been measured employing ELISA kits

according to **Aderka et al., (1992).**

Histopathological examination

Histological investigation was done on specimens of brain and liver from all experimental groups, as per **Banchroft et al. (1996)**.

Statistical analysis

Using a student (t) test, the findings have been reported as mean ± SD. ANOVA (one-way analysis of variance) has been employed (SAS, 1985) described by **Gomez and Gomez, (1984)**.

Results and Discussion

The impacts of giving acrylamide in the basal diet (4 µg kg/ BW/ day) daily for 28 days alone or together with quercetin by 50, 100, and 200 mg on RBW, (FER) and (FI) are shown **in table (1)**. The present data illustrated that treatment of acrylamide alone significantly, ($p \leq 0.05$) decreased the percent of BW, FER, and feed intake of rats when compared with the normal control group and corresponding values in managed groups, which were nearly to the normal values, especially treatments with acrylamide combined with 200mg quercetin. The percent of body weight and FER of rats significantly increased compared to the positive control group, but still significantly less than the negative control group. For RBW, there were significant differences between all of the tested groups and both of the control groups. There have been no significant differences in FER between G2 and G3, but all treatment groups were significantly greater than the control group. There have been no significant differences among groups with acrylamide together with 50 and 100 mg of quercetin for feed intake. The decrease in relative body weight obtained in the present work is in agreement with the observation of **Bosetti *et al.* (2016)**, who found that the body weight of acrylamide-treated rats was significantly lower than that of normal control animals. Also **Biedermann *et al.* (2003)** indicated that body weights of rats received acrylamide by 50 mg per 35 day decreased significantly as compared with negative control. The obtained findings also agree with **Liu *et al.* (2018) who** indicated that values of RBW of animals given quercetin improved when compared to values in control group. In addition, **Lekic *et al.* (2013)** indicated that quercetin had positive effects on body weight, feed consumption and effective-

eness by treating rats which had toxic material ($p \leq 0.05$).

Table (2) shows the effect of giving acrylamide alone or in combination with different levels of quercetin on the internal relative weights of organs as compared to the negative control group. Rats given acrylamide alone by 4 µg kg/BW/day had a significant ($p \leq 0.05$) increase in the brain and liver's relative organ weight, while rats given acrylamide combined with all tested groups and quercetin had a significant reduction in the relative organ weight of the brain and liver by increasing the level of quercetin. However, no significant differe-nces in liver weight have been found between the acrylamide-treated groups and quercetin at different levels, except at the level of 200 mg. Such findings were in parallel with the results of **Biedermann *et al.* (2003), who** indicated that acrylamide by 2 µg kg/BW/day for 35 days significantly increased relative brain weight. **Boots *et al.* (2018)** found that quercetin powder treatment decreased organ weight in male rats when compared to the toxic group.

The results **in table (3)** demonstrated the inhibitory impact of acrylamide alone on butyrylcholinesterase and lactate dehydrogenase activity in rat serum compared to the negative control values. The inhabitation of enzyme activity decreased with the constant increase in the concentration of quercetin combined with acrylamide (4 µg kg/ body weight / day). Opposite result was obtained in serum, malondialdehyde content (MDA), in which its concentration was greatly increased by acrylamide alone and decreased by adding levels of quercetin. On the other hand, acrylamide combined with quercetin were found to have an ameliorative impact on enzyme activity. Acrylamide's impact on cholinesterase, an enzyme present in blood serum that is synthesized via the liver and hydrolyzes acetylcholine. Acetylcholine is a compound that is produced at nerve endings and is involved in the transmission of nerve impulses to muscle fibers (**Ashwood et al., 1996).** Acrylamide is well-known neurotoxic chemical that causes distal axonopathy in both the central and peripheral nervous systems**.** They investigated whether the neurological malfunction (skeletal muscle weakening) linked to acrylamide poisoning was caused by decreased neurotransmission at central and peripheral synapses (acetylcholine deficiency). Acrylamide inhibited the action of

lactate dehydrogenase in brain and serum. Studies by **Sharmila *et al.* (2014)** indicated that administration of quercetin at a level of 100 mg inhibited an elevation in the activity of glucose metabolic pathway enzymes such as hexokinase, LDH, and SDH, inhibited lipid peroxidation, and decreased MDA.

At the conclusion of the experiment, the activity of glutathione-S-transferase and glutathione peroxidase in serum decreased due to acrylamide treatment alone by 4 µg /kg BW/day for 28 days, as shown **in table (4)**. The effect of feeding acrylamide with quercetin at the levels 50, 100 and 200 mg on serum GST and serum glutathione peroxidase which was found to have an ameliorative impact on enzyme activity , but the activity was still higher than the positive control value and lower than the negative control group.

Such findings were in parallel with those of **Hatem *et al.* (2010),** who discovered that acrylamide decreased GSH-Px activity. When taken orally for 10 days after or before paracetamol administration, it tends to bring the glutathione peroxidase level to near normal. Since it is capable of scavenging reactive oxygen species, quercetin has been shown to have antioxidant properties. Quercetin has been employed to inhibit cancer through controlling oxidative stress factors and antioxidant enzymes, which helps to stop the progression of cancers like prostate, lung, breast, liver, colon, and cervical cancer. The in vivo study measured histology and oxidative stress indicators like (GSH), (LPO), and (H2O2) in rats to see how quercetin compared to carcinogens and testosterone in terms of antioxidant activity. In comparison to quercetin-treated rats, carcinogen and testosterone-treated animals exhibited greater LPO and H2O2 levels and lower GSH levels **(Boots *et al.*, 2014**). In rats afflicted with prostate cancer, **Sharmila et al. (2014)** found that quercetin boosted the concentrations of apoptosis proteins and antioxidant enzymes. They also found that quercetin modulated the expression of androgen receptors (AR), protein kinase B (AKT), and insulin-like growth factor receptor 1 (IGFIR), as well as cell growth and anti-apoptotic proteins, all of which are elevated in cancer. Furthermore, quercetin was shown to decrease MDA concentration while enhancing catalase and (SOD) activities to regulate the anti-inflammatory and anti-apoptosis mechanisms, thereby

protecting the heart from secondary heart malfunction caused by oxidative stress and inflammation. Quercetin also decreases trauma-induced overproduction of reactive oxygen species (ROS), increases TNF-α, and inhibits Ca2+ overload-induced myocardial cell damage. As a result, quercetin may efficiently protect against oxidative stress-related damage. Quercetin was discovered to be a potent anti-inflammatory agent with a long-lasting anti-inflammatory effect. In a variety of in vitro investigations, quercetin has been demonstrated to suppress the generation of LPS-mediated tumor necrosis factor (TNF-α) in macrophages and IL-8 induced LPS in lung A549 cells.

The activity of (ALT) and (AST) have been determined in rat serum to evaluate the role of acrylamide alone or combined with quercetin on liver functions. Results **in table (5)** indicated that feeding rats on a basal diet containing acrylamide alone by 4 µg kg/BW/day significantly elevated serum ALT and AST when compared to the negative control and the other treated groups. From the other hand, rats fed a basal diet comprising acrylamide at 4 µg kg/ body weight/day combined with 200 mg of quercetin showed the best treatment, followed by the level of 100 mg. In vivo studies showed that quercetin increased heme oxygenase 1 activity in D-galactosamine- and LPS-treated animals by decreasing plasma ALT levels and increasing its hepatotoxic and hepatoprotective effects (**Lekic *et al.*, 2013**).

The changes in protein, albumin, and serum urea of rats given acrylamide alone or combined with quercetin were investigated. The results are summarized **in table (6**). When compared to the negative control group and treatment group, there has been a significant decrement in overall protein and albumin concentrations in the acrylamide group. There has been no significant difference between (G2 and G3) for urea. However, there were significant increment in serum urea activity on acrylamide group (G2) as comparing with G4 and G5. These findings agree with those of Asha et al. (2008), who found that larger dosages of ACR led to steady declines in hepatic protein levels, which could be due to a delay in protein synthesis, a change in protein metabolism, or the leaking of protein reserves from hepatocytes. The conjugated double bond and the amide group that could conjugate with the-SH group of a sulfur-containing amino acid

and the α-NH2 group of a free amino acid, are the two reactive locations of the ACR molecule. On the other hand, **Lesjak *et al. (*2019**) showed that quercetin decreased levels of serum creatinine and blood urea (BUN), which had been elevated in gentamicin-treated rats. Quercetin also decreased serum urea, creatinine, and uric acid concentrations.

As indicated in **table (7),** acrylamide alone greatly increased the activity of serum interleukin (IL1, IL6 and TNF-a) when compared with the negative control group and other quercetin-treated groups. It could be found that activities of pervious parameters level decreased with the increase in the concentration of quercetin combined with acrylamide, but the activity was still lower than the positive control value and higher than the negative control group. **Pan et al. (2018)** indicated that acrylamide induced cytokine enzymes like (TNFα), (IL)-1b, (IL)-6, and (IL)-10. Quercetin exerts inhibitory effects on pro-inflammatory cytokine expression. Interleukin (IL) is a group of proinflammatory cytokines that modulate adhesion molecules, metalloproteinases, and proangio-genic factors involved in tumor invasion. Furthermore, quercetin has been shown to lower TNF-α and IL-1α concentrations in LPS-induced mRNA, resulting in less apoptotic neuronal cell death induced by microglial stimulation. Quercetin inhibits inflammatory enzyme production (such as lipoxygenase (LOX) and cyclo-oxygenase (COX)). It suppresses LPS-induced inflammation in RAW 264.7 cells by suppressing Src and Syk-mediated PI3K-(p85) tyrosine phosphorylation and subsequent complex formation of Toll-like Receptor 4 (TLR4)/MyD88/PI3K, limiting downstream signaling pathway stimulation. It also might suppress the production of pro-inflammatory cytokines, tryptase, and histamine from mast cells generated from human umbilical cord blood; this suppression is thought to include calcium influx and phospho-protein kinase C (PKC) inhibition. Because of its chemoprotective activity against tumor cell lines via metastasis and apoptosis, quercetin is believed to be a promising anticancer option **(Boots *et al.*, 2018).**

Histopathological results of brain

Microscopically brain of acrylamide group rat, which fed on basal diet containing (4 µg kg/ body weight / day for 28 day

revealed congestion of meningeal blood vessels (photo.3). This result agree with that of **Nail (2010)** who found a great damage in brain of rats orally administered acrylamide and 100 mg quercetin daily for 35days. Brain of rat from group 2 which were given acrylamide(4 µg kg/ body weight / day) combined with 50 mg daily quercetin for/ 28 day, revealed necrosis of some neurons neuronophagia of pyknotic neurons and focal gliosis (photo 4). Some examined sections of brain from, group3 and group 4, which given acrylamide (4 µg kg/ body weight / day combined with quercetin 100 and 200 mg daily showed no histopathological changes (Photos 5 and 6). **Dabeek and Marra (2019)** found dietary supplementation of quercetin at 10 % along with salt toxicity reduced the damages in the brain and liver**.** Quercetin has been shown to protect diabetic rats' brains and sciatic tissues from oxidative damage, according to **Lakhanpal (2017).**

Histopathological results of liver

The liver of a rat from group 1 showed kupffer cell activation and focal hepatic and focal hepatic hemorrhage (photo 5) were observed in this group. (H and E X 400). This result is in line with **El-Bohi et al. (2011)**, who stated that the ACR-treated animals' livers were given a daily dose of 4 µg kg1 BW. Cells had minor reversible degeneration alterations defined by hazy swelling or hydropic degeneration of certain liver cells, hypotrophied Kupffer's cells, dilated and congested blood vessels and liver sinusoids, as well as many bile ductules. The liver of a rat from group 2 showed kupffer cell activation (photo 6), slight congestion of central veins and small vacuoles in the cytoplasm of hepatocytes, while examined sections of liver from group 3 and 4 showed no histopathological changes (photos 7 and 8). Such results are consistent with those of **Lesjak *et al.* (2019**) who discovered that liver of rats treated with ethanoic extract of quercetin showed normal histology.

CONCLUSION

In conclusion, the study revealed that acrylamide induces toxicity by decreasing the tested biological parameters and inhibition of the levels of butyryl cholinesterase, lactate dehydrogenase activity, the immunity index and the harmful effect on histological structure of the rats' liver and brain. While treatment with different levels of

quercetin significantly increased the biological parameters and improved the other tested parameters especially at high dose of quercetin (200 mg). As a result, more research is required to determine the exact mechanisms through which quercetin protects against acrylamide toxicity.

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Table (1): The influence of different quercetin levels on RBW, FER, and feed intake of rats that received toxic acrylamide (Mean± SD)

Groups / Parameters	Negative control group (G1)	Positive control group (2) Acrylamide group	Group (3) Acrylamide + 50 quercetin	Group (4) Acrylamide + 100 quercetin	Group (5) Acrylamide +200 quercetin	L.S.D.
Relative body weight gain (RBW) (%)	27.86 ^{a} ±0.03	-19.52^{e} ±0.03	4.26^{d} ± 0.59	10.23 ^{c} ± 1.04	19.50^{b} ± 2.01	3.39
Feed efficiency ratio(FER)	0.097 ^{a} ±0.05	-0.108^{d} ± 0.006	0.030^{c} ± 0.031	0.042^{c} ± 0.028	0.066^{b} ± 0.021	0.021
Feed intake (gm / day)	14.9^{a} ±2.55	4.07^{c} ± 1.32	6.53^{b} ± 0.65	9.05^{b} ±1.23	12.60 ^{a} ± 1.89	2.96

Every value indicates the mean of eight rats' ± SD. When compared to the control group, the P ≤ 0.05 values were substantially different. Same letter means non-significant.

Table (2): Effects of various quercetin levels on the relative liver and brain weight of rats that received toxic acrylamide (Mean± SD)

Groups / Parameters	Negative control group (G1)	Positive control group (2) Acrylamide group	Group (3) Acrylamide + 50 quercetin	Group (4) Acrylamide + 100 quercetin	Group (5) Acrylamide +200 quercetin	L.S.D.
Brain	0.63^{e} ±0.001	1.13^{a} ±0.058	0.78^{b} ±0.057	0.73^{c} ±0.048	0.66^{d} ±0.020	0.020
Liver	2.73^{c} ±0.12	3.44 ^{a} ±0.12	3.37 ^{a} ±0.22	3.27^{a} ±0.08	3.06^{b} ±0.01	0.17

Every value indicates the mean of eight rats' ± SD. When compared to the control group, the P ≤ 0.05 values were substantially different. Same letter means non-significant.

Table (3): The influence of different quercetin levels on serum butyryl cholinesterase, lactate dehydrogenase, and malondialdehyde levels of rats received toxic acrylamide (Mean± SD)

Groups / Parameters	Negative control group (G1)	Positive control group (2) Acrylamide group	Group (3) Acrylamide + 50 quercetin	Group (4) Acrylamide + 100 quercetin	Group (5) Acrylamide +200 quercetin	L.S.D.
***ButyrylCholinesterase* (U / L)**	356.03^{a} ±11.33	161.93^{e} ±7.09	200.73^{d} ±8.54	216.53^{c} ±3.43	232.53^{b} ±9.69	9.743
Lactate dehydrogenase (U/L)	208.00^{a} ±9.04	97.43^{e} ±5.85	117.00^{d} ±7.07	122.43^{c} ±7.57	130.00^{b} ±8.76	4.82
Malondialdehyde (nmol/mg)	0.89^{e} ±0.002	5.33^{a} ±1.170	2.34^{b} ±0.03	1.38.^{c} ±0.08	1.19^{d} ±0.080	0.17

Every value indicates the mean of eight rats' ± SD. When compared to the control group, the P ≤ 0.05 values were substantially different. Same letter means non-significant.

Table (4): The influence of different quercetin levels on serum GST, GPX, SOD, and catalase of rats received toxic acrylamide (Mean± SD)

Groups / Parameters	Negative control group (G1)	Positive control group (2) Acrylamide group	Group (3) Acrylamide + 50 quercetin	Group (4) Acrylamide + 100 quercetin	Group (5) Acrylamide +200 quercetin	L.S.D.
Glutathion -S-transferase(U/L)	120.78 ^{a} ±7.53	50.26^{e} ±5.49	66.38^{d} ±7.26	71.68^{c} ±6.31	88.81^{b} ±1.963	6.47
Glutathion peroxidase (nmol/min/ml)	194.44^{a} ±8.03	71.97^{c} ±2.27	115.92^{b} ±6.91	121.67^{b} ±6.58	128.07^{a} ±1.33	4.64
Superoxide dismutase (IU/ml)	0.584^{a} ±0.005	0.094^{e} ± 0.013	0.134^{d} ±0.002	0.174^{c} ±0.008	0.284^{b} ±0.005	0.029
Catalase (IU/ml)	67.93^{e} ±0.58	175.85^{a} ±1.36	155.85^{b} ±1.36	138.05^{c} ±0.94	110.62^{d} ±0.66	3.872

Every value indicates the mean of eight rats' ± SD. When compared to the control group, the P ≤ 0.05 values were substantially different. Same letter means non-significant.

Table (5): The influence of different quercetin levels on serum ALT and AST of rats received toxic acrylamide (Mean± SD)

Groups / Parameters	Negative control group (G1)	Positive control group (2) Acrylamide group	Group (3) Acrylamide + 50 quercetin	Group (4) Acrylamide + 100 quercetin	Group (5) Acrylamide +200 quercetin	L.S.D.
(ALT)) (U/L)	30.02^{e} ±3.08	59.6 ^{a} ±6.74	52.6^{b} ±1.82	47.5^{c} ±2.26	39.8^{d} ±2.38	3.46
(AST) (U/L)	31.9 ^{e} ±2.12	58.43^{a} ±3.09	51.33^{b} ± 4.87	46.00^{c} ±5.60	37.00^{d} ±3.90	4.87

Every value indicates the mean of eight rats' ± SD. When compared to the control group, the P ≤ 0.05 values were substantially different. Same letter means non-significant.

Table (6): The influence of different quercetin levels on protein, albumin, and serum urea of rats received toxic acrylamide (Mean± SD)

Groups / Parameters	Negative control group (G1)	Positive control group (2) Acrylamide group	Group (3) Acrylamide + 50 quercetin	Group (4) Acrylamide + 100 quercetin	Group (5) Acrylamide +200 quercetin	L.S.D.
Protein (gm/dl)	7.01 ^{a} ±0.71	3.7^{e} ±0.10	4.21^{d} ±0.59	4.97^{c} ±0.56	5.90 ^{b} ±0.31	0.307
Albumin (gm/dl)	4.97^{a} ±0.09	1.57^{e} ±0.05	2.33^{d} ± 1.94	3.23 ^{c} ±0.153	3.87^{b} ±0.28	0.228
Urea (mg/dl)	25.33^{d} ±6.02	50.17 ^{a} ±2.84	48.67 ^{a} ±1.53	37.78^{b} ±4.58	30.33^{c} ±1.52	4.12

Each value represents the mean of eight rats' ± SD. When compared to the control group, the P ≤ 0.05 values were substantially different.. Same letter means non-significant.

Table (7): The influence of different quercetin levels on interleukin 1, interleukin 6 and tumor necrosis factors of rats received toxic acrylamide (Mean± SD)

Groups / Parameters	Negative control group (G1)	Positive control group (2) Acrylamide group	Group (3) Acrylamide + 50 quercetin	Group (4) Acrylamide + 100 quercetin	Group (5) Acrylamide +200 quercetin	L.S.D.
Interleukin 1 IL1(pg/ml)	6.99^{e} ±5.08	12.74^{a} ±4.657	10.48^{b} ±0.76	9.06^{c} ±0.622	7.39^{d} ±5.08	0.12
Interleukin 6 IL6(pg/ml)	43.99^{e} ±5.08	126.83^{a} ±7.866	117.57^{b} ±1.181	99.86^{c} ±1.283	79.70^{d} ±2.37	3..969
Tumor necrosis factors TNF (pg/ml)	73.99^{e} ±5.08	168.86^{a} ±5.41	133.33^{b} ±0.66	113.17^{c} ±1.16	92.82^{d} ±0.74	7.654

Every value indicates the mean of eight rats ± SD. When compared to the control group, the P ≤ 0.05 values were substantially different. Same letter means non-significant.

Histopathological results of brain

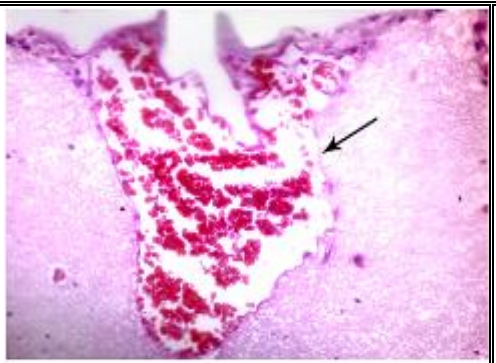

Photo (1): Brain rat of group (1) showing congestion of meningeal blood vessels. (H and E X 400).

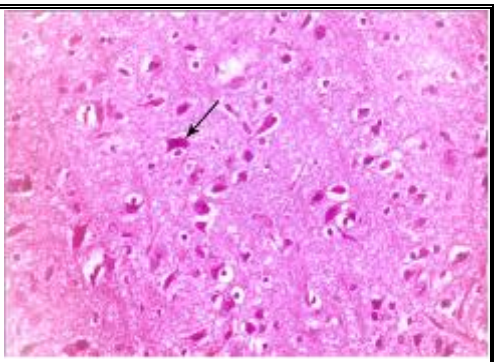

Photo (2): Necrosis of some neurons was discovered in the brain of a rat from Group 2. (H and E X 400)

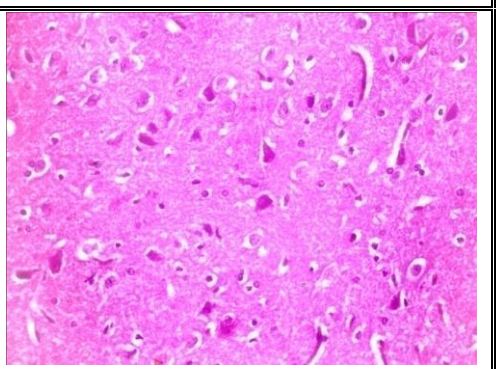

Photo (3): No histopathological changes were found in the brains of rats in group 3 (H and E X 400)

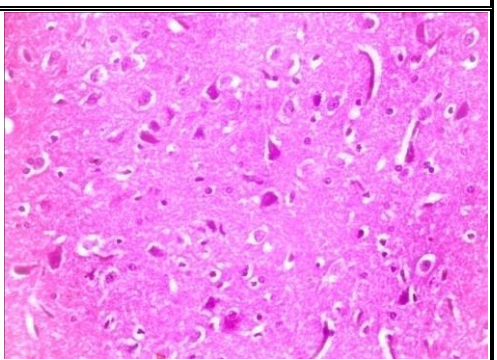

Photo (4): Brain of rat from group 4 showed no histopathological changes (H and E X 400).

Histopathological results of liver

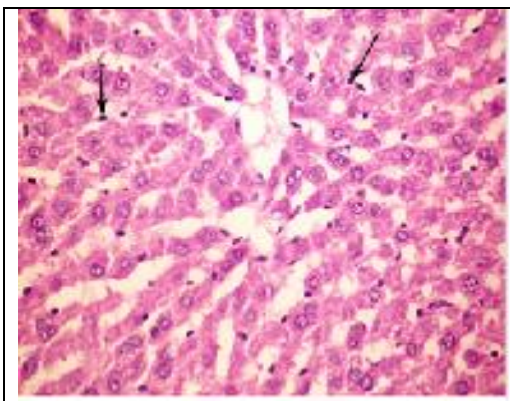

Photo (5): Kupffer cell activation and focal hepatic in the liver of a rat from group one (H and E X 400).

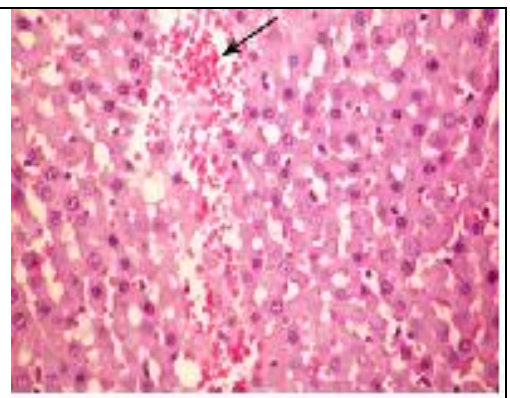

Photo (6): A rat's liver from group 2 has a focal hepatic hemorrhage (H and E X 400).

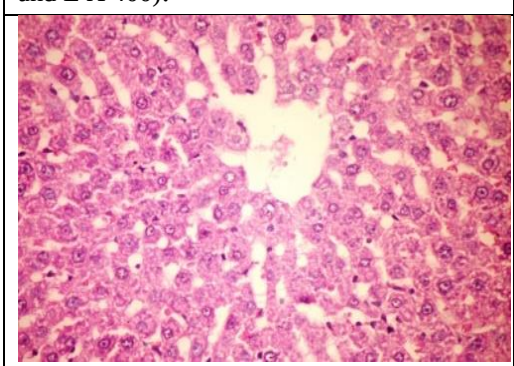

Photo (7): The liver of control group rat 3 displays the normal histopathological structure of the hepatic lobule (H and E X 400).

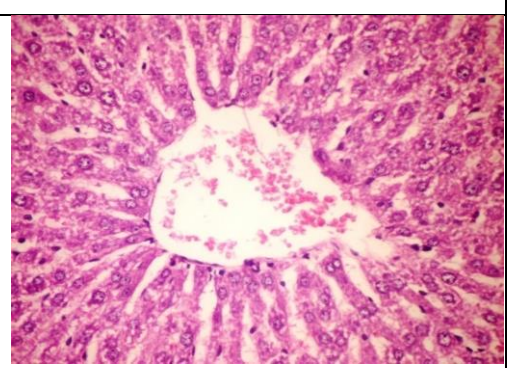

Photo (8): The liver of a rat in group 4 exhibited no histopathological changes.

دراسات بيولوجية وبيوكيميائية لتأثير المستويات المختلفة من الكيرسيتين على مادة الأكريلاميد الغذائية السامة فى الجرذان.

هدى مسعود الجزيرى١ – هنادى جابر شيحة٢

١. قسم الدراسات والبحوث الميدانية - المعهد القومى للتغذية – القاهرة – مصر
٢. قسم التغذية الاكلينيكية -- المعهد القومى للتغذية – القاهرة – مصر

الملخص العربى

الكرسيتين هو عبارة عن فلافونيد يوجد في العديد من الأطعمة ويعمل على تحسين الامراض غير المعدية وله خصائص مضادة للالتهابات. تتكون مادة الأكريلاميد في الاطعمة نتيجة تفاعل الأحماض الأمينية مع الجلوكوز. نتجة لذلك تمت دراسة آثار كميات مختلفة من الكرسيتين على التأثير الضار لمادة الأكريلاميد الغذائية السامة. تم استخدام أربعين جرذ من ذكور ألألبينو. تم تقسيم الجرذان إلى خمس مجموعات كل مجموعة تتكون من ثمانية جرذان ، وتغذت جميع المجموعات على نظام غذائي لمدة ٢٨ يومًا ، تغذت المجموعة الضابطة ***(السالبة)*** *على نظام غذائي أساسي فقط ، بينما تم تغذية المجموعة الضابطة* ***(الموجبة)*** *على النظام الغذائي الأساسي مضاف الية ٤ ميكروغرام لكل كجم من وزن الجسم يوميًا من مادة الأكريلاميد. تم تغذية المجموعات* ***٣ و ٤ و ٥*** *على نظام غذائي أساسي مضاف اليه ٤ ميكروغرام لكل كجم من وزن الجسم يوميًا أكريلاميد مع ٥٠ و ١٠٠ و ٢٠٠ ملجم من مسحوق الكرسيتين. أظهرت النتائج أن المعاملة بالأكريلاميد وحدها أدت إلى انخفاض نسبى فى وزن الجسم (p≤ 0.05) ، ومعدل كفاءة الغذاء ، وزيادة فى وزن الأعضاء المختبرة.* ***كما أوضحت النتائج*** *التأثير المثبط لانزيم butyrylcholinesterase , lactate dehydrogenase وتأثيره فى تقليل المناعة وزيادة نشاط malondialdehyde وتأثيره الضار على التركيب النسيجي للمخ و الكبد للجرذان فى المجموعة الضابطة الموجبة. في حين أن العلاج بمستويات مختلفة من الكرسيتين أدى إلى تحسن تلك. لذلك ,فان اضافة الكرسيتين او مصادرة الغذائية كمكون طبيعى فى الوجبات المقلية قد يكون مهما لتقليل الاثار الضارة من المواد السامة التى تنتج اثناء القلى مثل مادة الاكريلاميد.*

الكلمات المفتاحية: *الكرسيتين- الاكريلاميد- الكبد – المخ- المناعة*