Potential Ameliorative Effects of Spirulina Using Multiple Biomarkers Toward Lead Acetate Toxicity in Albino Rats

Asmaa H. A. Ahmed
Dept. of Home Economics, Faculty of Specific Education,
Menoufia University, Egypt.
Dr_moaa84@yahoo.com

كلية معتمدة

مجلة البحوث في مجالات التربية النوعية

معرف البحث الرقمي DOI: 10.21608/jedu.2021.103462.1507

المجلد السابع . العدد 37 . نوفمبر 2021

الترقيم الدولي

E- ISSN: 2735-3346   P-ISSN: 1687-3424

موقع المجلة عبر بنك المعرفة المصري https://jedu.journals.ekb.eg/

موقع المجلة http://jrfse.minia.edu.eg/Hom

العنوان: كلية التربية النوعية . جامعة المنيا . جمهورية مصر العربية

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Dr.Asmaa H. A. Ahmed

ABSTRACT

This study was carried out to investigate the potential ameliorative effects of *spirulina* toward lead acetate toxicity in albino rats. Thirty growing male albinos were divided into two main groups. The first main group was the negative group (6) rats, the second main group (24) rats was exposed to lead acetate (1.5g/L) and divided into four groups. The second was positive group fed basal diet, The third, fourth, and fifth groups fed basal diet containing (1.5%,3%,6%) *spirulina*, respectively for 30 days. Determined The body weight gain, feed intake and feed efficiency, At the end of the experimental period، Blood samples were collected for serum separation to determine the biochemical parameters. the best result found in group fed basal diet containing (6%) *spirulina* improved daily feed intake, body weight gain, feed efficiency ratio. Moreover, lead concentration was recorded the significant decreased in liver and brain also, it was improved the concentration levels of iron, copper and liver enzymes in serum of intoxicated rats, compared with positive group. The histopathology results were agreed with the results of serum parameters. These results recommend using *spirulina* as a safe and effective food supplement as well as reducing lead acetate toxicity.

Key words: *spirulina* - food supplement - serum parameters.

1. INTRODUTION.

Goto *et al.*, 2020 indicated that lead is a toxic metal that induces a wide range of behavioral, biochemical and physiological effects in humans, it is one of the heavy metals and possesses non-biodegradable nature favouring its environmental accumulation with increasing hazards. In addition to **Ning *et al.*, 2021** reported that lead is a heavy metal environmental pollutant that can cause functional damage and anemia of immune organs. **Kim *et al.*,**

2015, pointed out despite considerable efforts to identify the sources of lead pollution and to eliminate lead exposure, it is still one of the most problematic environmental pollutants, and remains a significant concern to the health and reproductive performance of various species **Wirth and Mijal, 2010** and **Basha and Reddy, 2010** mentioned that lead exposure causes cognitive, and developmental disorders, and it is suggested that some of these disorders may not be obvious until the next generation. **ATSDR, 2020** reported that many studies have shown that even very low levels of lead , resulting in lead blood concentrations <5 µg/dL, can have adverse effects in addition the adverse neurological effects during development are a major concern of lead exposure, because this may result in life-long deficits in neurological function, the mechanisms of brain injury following Pb exposure are related to cellular cytotoxicity, changes in neurotransmitter storage and release, disorders in energy metabolism, and induction of apoptosis, oxidative stress, and inflammation **Chibowska *et al.*, 2016**. Lead exposure is represented in food, air, water, paint, ceramics, cosmetics, and leaded gasoline as well as occupational sources **(Adela *et al.*, 2012; Ali *et al.*, 2020)**.

Spirulina platensis (SP) is a microalga belonging to the class of cyanobacteria with a special formula of active products, including minerals, vitamins and proteins, beta-carotene, tocopherols, phenolic acids. SP is also known for excreting high anti-inflammatory and antioxidant activities, so it used as a food supplement for humans and as a feed additive in many animal species, including birds and fishes**(Abdel-Daim, 2014** and **Ibrahim and Abdel-Daim 2015)**, moreover, highly active ingredient, C-phycocyanin, exhibit anti-inflammatory, immunomo-dulatory, hepato-protective, nephron-protective, neuroprotective, antidiabetic, antigenotoxic, anti-hypertensive and anticancer activities (**Abdel-Daim *et al.*,2015)**. SP products are widely promoted for their high vitamin B12 content. So far, knowledge regarding the contamination with cyanotoxins. Heavy metals, pesticides, or polycyclic aromatic hydrocarbons (PAHs) is scarce, although some studies reported high contaminant levels in spirulina products. The regular intake of spirulina, and very likely other algae products as well as a dietary supplement in the gram range demands closer monitoring of potentially harmful constituents **Grosshagauer *et al*., 2020**. Reportedly, it has protective effects against metal toxicity in various animal species. as well as histopathological changes in the brain, liver, intestine, and kidneys. Importantly, Spirulina supplementation mitigated against physiological disruption caused by $CuSO_4$ or CuO-NPs **(Soliman *et al*., 2021)**. As well as **Khalil *et al*., 2018** observed that spirulina diminished the lead content that accumulated in both the blood and the brain tissue of the exposed rats, and reduced the elevated levels of oxidative damage indices, and brain proinflammatory markers. Also, because of the Spirulina administration, the levels of the depleted biomarkers of antioxidant status and interleukin–10 in the lead-exposed rats were improved. Moreover, Spirulina protected the brain tissue (cerebrum and cerebellum) against the changes elicited by lead exposure, the study conclude that Spirulina has potential use as a food supplement in regions highly polluted with heavy metals.

Therefore, in view of the harmful effects that lead induced in humans and animals, the researcher conducted this study to find out potential ameliorative effects of spirulina toward lead acetate toxicity in albino rats.

2. Materials & methods:

2.1. Materials:

Spirulina platensis powders was purchased from the national research centre, Cairo, Egypt.

Lead acetate was obtained from a private Pharmacy, Cairo, Egypt.

Albino rats (Sprague - Dawley Strain) weighting (140 ± 10g) were purchased from the national research centre, Cairo, Egypt.

2.2. Methods:

2.2.1. Preparation of samples:

The basal diet was prepared according to **(Reeves *et al.*, 1993)** containing (1.5%,3%,6%) spirulina, these levels were selected from a preliminary study **(Gargouri *et al.*, 2012).**

Lead acetate was given 1.5 g/L daily in drinking water according to **Wang *et al.*, 2013.**

2.2.2. Experimental animals:

Thirty male albino rats (weighing 140 ± 10g) at age of 14 weeks were housed in the Animal House, Faculty of Home Economics, Minufia University in a temperature (25±1°C), humidity-controlled room and a 12-h light-dark cycle, rats were allowed free access to tap water and a standard pellet diet. One week of acclimatization, the rats were divided into two main groups, as follows: The first main group (6 rats) was fed on the basal diet and considered as negative control. The second main group (24 rats) were exposed to lead acetate at (1.5 g/L) daily drinking orally according to **Wang *et al.*, 2013**, and divided into four sub groups (6 rats for each). The first one was continued to be fed on basal diet and considered as positive control. From the second to fourth subgroups were fed on basal diet containing 1.5%, 3% and 6% Spirulina, respectively once daily for 4 weeks.

2.2.3. Biological Experiment:

During the experimental period (30 days), the diets consumed and body weights were recorded twice weekly and feed efficiency ratio according to **(Chapman *et al.*, 1959)**. using the following equations.

BWG = Final Weight-Initial weight

FER = Body weight gain (g/day) / Feed intake (g/day).

2.2.4. Biochemical determinations:

At the end of the experiment, the animals were fasting overnight (12 h), then the rats were anaesthetized and sacrificed, and blood samples were collected. Blood samples were centrifuged and the serum was separated to estimate some biochemical parameters. Lead, iron and copper concentration in serum were determined according to **Parson (1998)** and **Ramsay**

(1957). The lead residue in liver and brain was determined by **Ruhling and Tyler, 1973.** Serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST), Alkaline phosphatase (ALP) and Serum total protein were measured according to the method of **Reitman and Frankel (1957), Tietz *et al.* (1983)** and **(Lubran, 1978)**, respectively.

2.2.5. Statistical methods and evaluation:

The statistical analyses of the data were conducted using Microsoft Excel, results expressed are average data values plus or minus standard deviation (SD). The groups were compared using a one-way analysis of variance (ANOVA). was performed followed by Schefft post hoc comparisons for the source of statistically significant difference. Differences in mean values were accepted as being statistically significant ($P \leq 0.05$).

2.2.6. Histopathological analysis:

Tissue samples were taken from the liver and brain in different groups and used for histopathological examination using H& E stain according to **Bancroft *et al.*, 1996**.

3. Results and Discussion:

3.1. Biological parameters:

Data in Table (1) showed the effect of feeding *Spirulina platensis* supplementation on body weight (BWG), feed intake (FI), and feed efficiency ratio (FER) on rat intoxicated with lead acetate. The results indicated that the positive control group had the lowest values ($P \leq 0.05$) of these parameters (19.96±1.31, 16.31±1.99and 0.032±0.013) compared to the health control (57.97±1.38, 22.50±1.80 and 0.092±0.008), respectively. Treated groups of *S. platensis* (1.5%3%and 6%) increased BWG, FI and FER compared with control positive group, best treated group was containing 6% SP. These results were in line with those of **Yousefi *et al.*, 2019** that reported Spirulina can be possibly administered as a safe and efficient supplementation in the case of metabolic syndrome components. while **Zeinalian *et al.*,2017** discussed as an efficient supplementation for weight management. and found that *S. platensis* (1 g/day) effective for reducing body weight and BMI. also, **Szulinska *et al.*, 2017** *S. platensis* supplementation at a dose of (2 g/day) in hypertensive and overweight patients also resulted in a significant decrease in weight and body mass index.in addition **Mazokopakis *et al.*, 2014** summarised that SP is rich in phenylalanine, a potent releaser of cholecystokinin that affects the brain's appetite centre, which in turn acts as a body weight suppressant.

Table (1). Effect of *Spirulina platensis* supplementation on body weight gain (%), feed intake (g /day) and food efficiency ratio (g) in lead acetate-intoxicated rats.

Parameters / Groups	BWG (%)	Feed Intake (g/day)	FER (g)
G1 control (-)	57.97^{a}±1.38	22.50^{a}±1.80	0.092^{a}±0.008
G2 control (+)	19.96^{e}±1.31	16.31^{c}±1.99	0.032^{d}±0.013
G3 (1.5%SP)	32.90^{d}±2.46	19.60^{b}±1.69	0.060^{c}±0.009
G4 (3 %SP)	40.60^{c}±1.51	20.10^{a}±1.04	0.071^{b}±0.006
G5 (6%SP)	52.48^{b}±1.93	21.43^{a}±1.90	0.087^{a}±0.006

Values are expressed as means ±SD; mean in the same column with different superscript letters are significantly different at $P \leq 0.05$.

3.2. Biochemical parameters:

Data in the table (2) reported that *Spirulina platensis* supplementation on the removal of lead acetate in serum, liver and brain. The effect of activated Spirulina on serum, liver and Brain in lead acetate- infected male albino rats is shown in Table 2. There were a significant ($p \leq 0.05$) decrease in serum, liver and brain in rats treated with Spirulina supplementation groups (3,4&5) compared to rats in the control positive group2. These three parameters increased significantly reduction ($p \leq 0.05$) in group 5 animals given Spirulina (6%) after lead acetate treatment.

These results were in harmony with those of **Grosshagauer *et al.*, 2020** indicted that SP has high contents in protein, essential amino acids, vitamins, and minerals., although some studies reported high contaminant levels in spirulina products. on other hand **Kosnett *et al.*, 2007** recommend that individuals be removed from occupational lead exposure if a single blood lead concentration exceeds 30 µg /dL or if two successive blood lead concentrations measured over a 4-week interval are ≥ 20 µg/dL. **Gargouri *et al.*, 2016** recommend the utilization of *S. platensis* biomass for heavy metal removal from aqueous solutions. **Soliman *et al.*, 2021** found that Spirulina reportedly has protective effects against metal toxicity in various animal species. as well as histopathological changes in the brain, liver, intestine, and kidneys. Importantly, Spirulina supplementation mitigated against physiological disruption caused by CuSO4.

Table (2). Effect of *Spirulina platensis* supplementation on the removal of lead acetate in serum, liver and brain.

Parameters / Groups	Serum µg/dL	Liver µg/dL	Brain µg/Dl
G1 control (-)	3.23[e]±0.25	0.63[e]±0.15	0.30[e]±0.10
G2 control (+)	61.10[a]±1.8	25.50[a]±1.51	7.00[a]±0.50
G3 (1.5%SP)	43.83[b]±1.38	15.76[b]±1.71	5.16[b]±1.04
G4 (3 %SP)	21.50[c]±1.40	9.66[c]±1.52	3.00[c]±0.50
G5 (6%SP)	11.00[d]±2.00	5.00[d]±1.99	1.46[d]±0.45

Values are expressed as means ±SD; mean in the same column with different superscript letters are significantly different at $P \leq 0.05$.

3.2.1 Liver function activities:

In the case of liver function, the parameters including serum AST, ALT, ALP activities and total protein levels are used to check liver function in the intoxicated animals relative to the health normal rats, lead acetate toxicity caused a significant increase in serum AST, ALT, ALP activities and decrease in total protein in control positive groups (87.76±2.25 ,77.20±2.19, 73.00±2.00 & 5.00±0.50IU/L) as compared to healthy controls, $P \leq 0.05$ (27.46±1.41,45.03±2.11, 38.13±2.15 & 9.10±0.55 IU/L), respectively. Results observed that (SP) groups ingestion significantly stimulated the activity of AST and ALT and elevation in total protein value, best of them (*SP*) at a dose (6%) as compared to lead treated animals.

These observations are in agreement with a previous study which reported that **Ali *et al.*, 2016** indicated that pretreatment with middle-dose SP (200 mg per kg BW) can effectively prevent liver cell damage induced by chronic alcohol exposure. These results were similar to **FU *et al.*, 2018** resulted in the liver function index (ALT, AST) increased after the liver was damaged, with pathological changes of different degrees, Spirulina reduced the liver function index and played a role in the mitigation of alcohol pathological liver injury. These suggests a protective effect in chronic alcoholic liver injury, these data strongly indicated that pre-treatment with middle-dose SP can effectively prevent liver cell damage induced by chronic alcohol exposure. (**Bin-Jumah *et al.*, 2021**) indicated that their results show that SP has a powerful protective effect on serum biochemistry and liver, kidney, and brain antioxidant machinery in AA-intoxicated rats. **Khalil *et al.*, 2020** displayed that oral SP administration, particularly in the protective/therapeutic co-treated group, markedly supressed the serum levels of the tissue injury biomarkers, diminished the inflammatory response, and restored the perturbed morphology of the hepatic and renal tissues. These data are in harmony with an earlier study which mentioned that **Mohamed *et al.*, 2021** concluded that SP prevented liver damage in CCl_4-treated rats via augmentation of antioxidant defense mechanisms and inhibition of inflammatory cytokines mediators and antiproliferative effects.

Table (3). Effect of *Spirulina platensis* supplementation on in serum ALT, AST, ALP activities and Total protein in lead acetate-intoxicated rats.

Parameters / Groups	AST (IU⁄L)	ALT (IU⁄L)	ALP (IU⁄L)	Total protein (mg/dl)
G1 control (-)	27.46^{e}±1.41	45.03^{e}±2.11	38.13^{d}±2.15	9.10^{a}±0.55
G2 control (+)	87.76^{a}±2.25	77.20^{a}±2.19	73.00^{a}±2.00	5.00^{d}±0.50
G3 (1.5%SP)	65.26^{b}±2.15	65.26^{b}±1.86	58.00^{b}±2.00	6.00^{c}±0.50
G4 (3 %SP)	46.00^{c}±2.29	59.00^{c}±2.00	42.33^{c}±2.08	7.90^{b}±0.40
G5 (6%SP)	32.60^{d}±2.39	52.00^{d}±1.09	34.56e±2.31	8.73^{a}±0.67

Values are expressed as means ±SD; mean in the same column with different superscript letters are significantly different at P≤ 0.05.

3.2.2 Iron and Copper levels.

In the table (4), the result indicated that Lead acetate caused a significant decrease in serum iron level intoxicated male rats (26.00±1.00g/dl), on other hands in the groups treated with spirulina recorded significant increase level iron values (32.00±2.00, 40.50±1.51& 44.16±1.56g/dl), respectively compared to the positive control group, especially group 5 treated with spirulina at a dose of 6% was found that iron level to natural level. Regarding Lead acetate toxicity caused a significant decrease in Cupper level when compared to positive controls, $P \leq 0.05$. mean values were (100.67±8.02& 144.33±5.51g/dl), respectively. it was found improvement between spirulina and cupper level, the best-treated group (6%SP).

These results agree with **Ramesh *et al.*, 2021** that related to the safety and side effects of Spirulina. Potential health benefits of Spirulina are mainly due to its chemical composition, which includes proteins, carbohydrates, essential amino acids, minerals especially iron, essential fatty acids, vitamins, and pigments. As confirmed by **(WHO, 2016)** that Lead exposure also causes anemia, immunotoxicity and toxicity to the reproductive organs. Cupper is one of the necessary minerals for the human body.so **(Soliman, 2015)** concluded that Copper deficiency causes anaemia and osteoporosis. it plays an important function as a cofactor in various enzymes; however, it is toxic to cells when present at elevated concentrations **(Zhang *et al.*, 2020)**. However, the use of microalgae or plant extracts may be mitigated against CuO-NP toxicity **(Arafa *et al.*, 2017; Eid *et al.*, 2018)**.

Table (4). Effect of *Spirulina platensis* supplementation on Iron and Copper in lead acetate-intoxicated rats.

Parameters / Groups	Iron g/dl	Copper g/dl
G1 control (-)	47.67^{a}±2.51	144.33^{c}±5.51
G2 control (+)	26.00^{e}±1.00	100.67^{e}±8.02
G3 (1.5%SP)	32.00^{d}±2.00	127.33^{d}±5.69
G4 (3 %SP)	40.50^{c}±1.51	147.67^{b}±4.16
G5 (6%SP)	44.16^{b}±1.56	155.67^{a}±4.51

Values are expressed as means ±SD; mean in the same column with different superscript letters are significantly different at $P \leq 0.05$.

4. Histopathological result:

4.1. Liver:

Microscopic examination of livers of control rats (group 1) showed normal central vein and hepatic parenchymal cells (photo1). While, liver of control positive (group 2) rats revealed marked histological alterations. Livers of those rats showed diffuse vascular degeneration, necrosis and nuclear pyknosis of the hepatic cells, The portal areas in livers of control positive rats showed proliferation of the bile duct epithelium with many newly formed bile ductules, mild inflammatory cells infiltration, edema and congested portal vessels (photo 2). Regarding the treated groups, livers of control positive rats that was treated with SP 1.5% (group 3) showed mild to moderate degree of hepatocellular vacuolar degeneration and scattered necrosis with some activated Kupffer cells (photo 3). Liver of control positive rats that treated with SP 3% (group 4) showed a mild degree of hepatocellular degeneration and scattered necrotic cells and Some livers showed a moderate degree of degeneration and necrosis of the hepatic cells with the good restoration of the hepatic cells. (Photo 4). Concerning, livers of control positive rats that treated with SP 6% (group 5) showed a good degree of protection of the hepatic parenchyma with only very few degenerated and rare necrotic hepatic cells (photo 5).

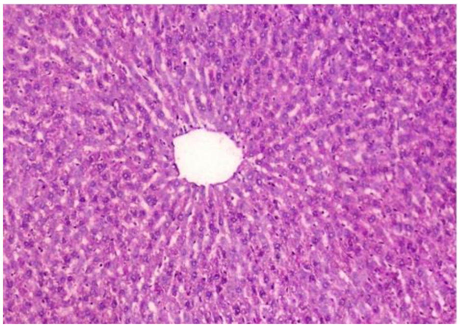

Photo. 1. Liver of control rat (group 1) showing normal central vein (CV) and hepatic parenchymal cells (HCs). **(H&E, X200).**

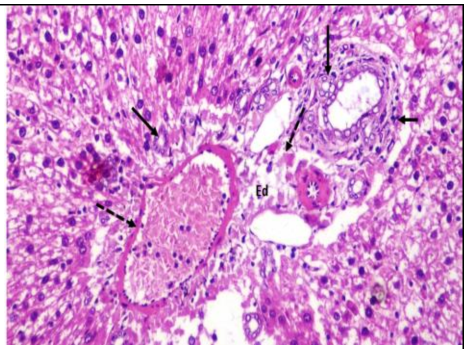

Photo. 2. liver of control positive (group 2) rats revealed marked histolo-gical alterations. Livers of those rats showed diffuse vascular degene-ration, necrosis and nuclear pyknosis of the hepatic cells, The portal areas in livers of control positive rats showed proliferation of the bile duct epithelium with many newly formed bile ductules, mild inflam-matory cells infiltration,

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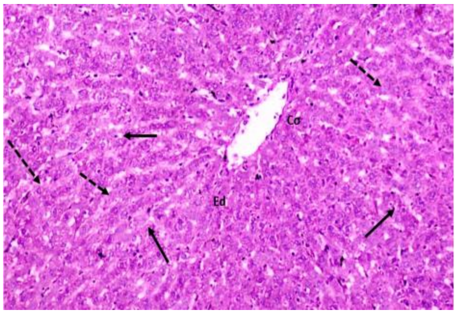
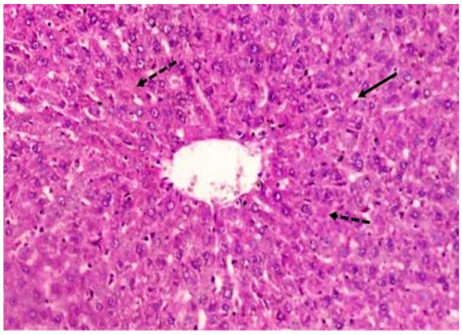
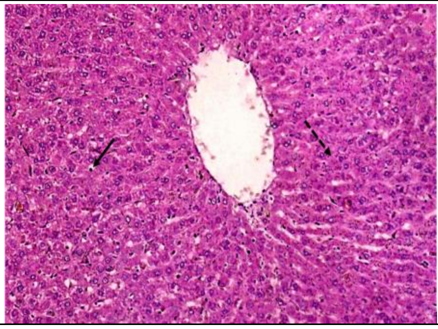
<tr><td></td><td></td></tr>
<tr><td>Photo. 3. livers of control positive rats that treated with SP 1.5% (group 3) showed mild to mode-rate degree of hepato-cellular vacuolar dege-neration and scattered necrosis with some activated Kupffer cells. (H&E, X200).</td><td>Photo. 4. Liver of control positive rats that treated with SP 3% (group 4) showed mild degree of hepatocellular degen-eration and scattered necrotic cells and Some livers showed moderate degree of degeneration and necrosis of the hepatic cells with good restoration of the hepatic cells. (H&E, X200).</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Photo. 5. livers of control positive rats that treated with SP 6% (group 5) showed good degree of protection of the hepatic parenchyma with only very few degenerated and rare necrotic hepatic cells. (H&E, X200).</td></tr>
</table>

4.2. Brain:

Microscopic examination of the brain of control rats showed normal rats (group1) showing normal histological structure **(**photo 1**)**. Brain (cerebral cortex) of control positive (group 2) rat showing neuronal cell vacuolar degeneration (arrow), pyknosis (dashed arrow) and necrosis (short arrow) with pericellular edema (arrow head) and marked neuronal necrosis (arrow) and neuronophagia (short arrow) with mild vacuolation of the neuropil (photo 2). Brain (cerebral cortex) of control positive rat which treated with SP 1.5% (group 3) showing the moderate degree of neuronal cells degeneration and necrosis (arrow) with scattered neuronophagia (dashed arrow) with perivascular edema **(**photo 3). Brain (cerebral cortex) of control positive rat which treated with SP 3% (group 4) showing neuronal cells pyknosis, mild necrobiotic changes of scattered neurons, neuronophagia (arrow) of the necrotic neurons**,** neuronoral cells vacuolation (short arrow), shrinkage (arrow) neuronophagia of necrotic neurons (photo 4)**.** Brain (cerebral cortex) of control positive rat which treated with SP 6% (group 5) showing good protection of the brain tissue with near to normal appearance of the neurons and only mild degenerated ones (photo 5).

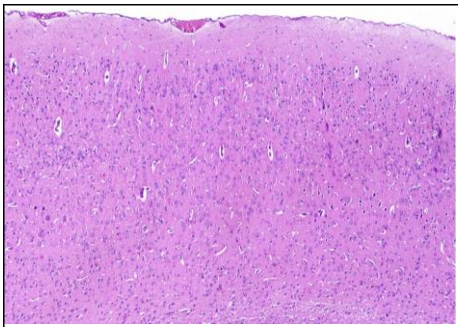
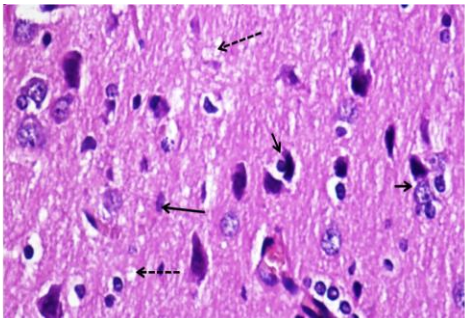
	

Photo. 1. Brain (cerebral cortex) of control rat showing normal histological structure. **(H&E, X100).**	**Photo. 2.** Brain (cerebral cortex) of control positive (group2) rat showing neur-onal cell vacuo-lar degeneration (arrow), pyk-nosis (dashed arrow) and nec-rosis (short arrow) with pericellu-lar edema (arrow head) and marked neuronal necrosis (arrow) and neuronophagia (short arrow) with mild vacuolation of the neuropil (dashed arrow). **(H&E, X400).**

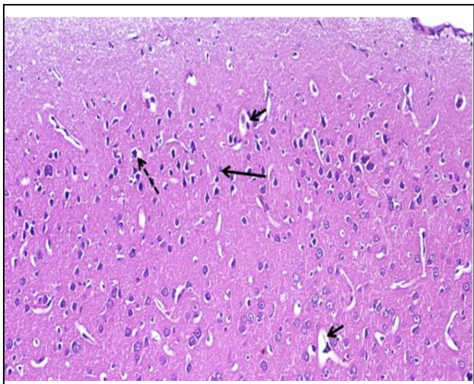
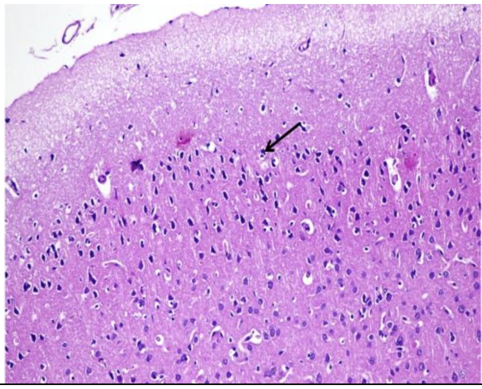
	

Photo. 3. Brain (cerebral cortex) of control positive rat which treated with SP 1.5% (group 3) showing moderate degree of neuronal cells degeneration and necrosis (arrow) with scattered neuronophagia (dashed arrow) with perivascular edema (short arrow). **(H&E, X200).**	**Photo. 4.** Brain (cerebral cortex) of control positive rat which treated with SP 3% (group 4) showing neuronal cells pyknosis, mild necrobiotic changes of scattered neurons, neuronophagia (arrow) of the necrotic neurons**,** neuronoral cells vacuolation (short arrow), shrinkage (arrow) neuronophagia of necrotic neurons. **(H&E, X200).**

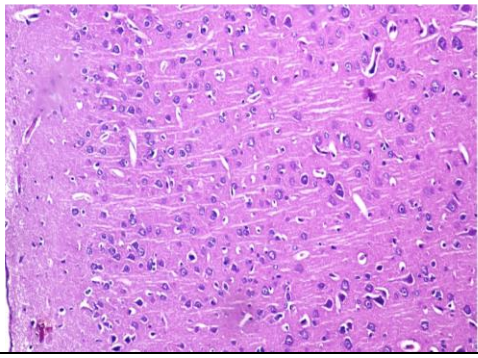


Photo. 5. Brain (cerebral cortex) of control positive rat which treated with drug 3 showing good protection of the brain tissue with near to normal appearance of the neurons and only mild degenerated ones. **(H&E, X200).**

The result similar to **Soliman *et al*., 2021** reported that Spirulina reportedly has protective effects against metal toxicity in various animal species. as well as histopathological changes in the brain, liver, intestine, and kidneys. Importantly, Spirulina supplementation mitigated against physiological disruption caused by CuSO4 or CuO-NPs. Also, **Khalil *et al*., 2018** observed that Spirulina diminished the lead content that accumulated in both the blood and the brain tissue of the exposed rats, and reduced the elevated levels of oxidative damage indices, and brain proinflammatory markers. Also, because of the Spirulina administration, the levels of the depleted biomarkers of antioxidant status and interleukin–10 in the lead-exposed rats were improved. Moreover, Spirulina protected the brain tissue (cerebrum and cerebellum) against the changes elicited by lead exposure. Spirulina has potential use as a food supplement in regions highly polluted with heavy metals.

5. Conclusions:

The obtained results assured that *Spirulina* ameliorated the harmful effect of lead acetate on both liver and brain concentration was decreased in liver and brain also, it was improved the concentration levels of iron, copper in serum of intoxicated rats, liver enzymes compared with positive group. The histopathology results were agreed with the results of serum parameters. Nutrition Education Programs are needed to illustrate the importance of *spirulina* in reducing lead toxicity.

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التأثيرات التحسينية المحتملة للسبيرولينا باستخدام مؤشرات حيوية متعددة تجاه سمية خلات الرصاص في الفئران البيضاء

أسماء حسن عبد العظيم أحمد

قسم الاقتصاد المنزلي – كلية التربية النوعية – جامعة المنوفية – مصر.

المخلص العربي

تهدف هذه الدراسة لمعرفة التأثيرات المحتملة للسيبرولينا تجاه سمية خلات الرصاص في ذكور الفئران البيضاء، تم إجراء الدراسة على عدد (30 فأر) وتم تقسيمهم إلى مجموعتين رئيسيتين ، المجموعة الأولى (الضابطة السالبة= 6 فئران) أما المجموعة الثانية (فأر24) قد تعرضت للتسمم بخلات الرصاص(1.5 جم/لتر) وقسمت إلى 4 مجموعات كلا منها (6 فئران) حيث تغذت المجموعة الأولي على الغذاء الأساسي (المجموعة الضابطة الموجبة) والمجموعات الثالثة والرابعة والخامسة تغذت على الغذاء الرئيسي يحتوي على 1.5%، 3%، 6% للسيبرولينا على التوالي لمدة 30 يوما" تم حساب كلا من معدل الزيادة في وزن الجسم ،كمية الطعام المتناول وكذلك معدل كفاءة الغذاء وبنهاية التجربة تم تجميع عينات الدم وتقدير نشاط إنزيمات الكبد ،البروتين الكلي ،الحديد والنحاس في السيرم وتقدير الرصاص في كلا من الكبد والمخ .أظهرت النتائج أن الفئران التي تناولت السيبرولينا بنسبة 6% أفضل النتائج في معدل الزيادة في الوزن والطعام المتناول ومعدل كفاءة الطعام علاوة على ذلك سجل تركيز الرصاص انخفاضاً معنوياً في الكبد والمخ مقارنة بالمجموعة الضابطة الموجبة وأكدت نتائج الفحص الهستوباثولوجي نفس النتائج السابقة ،لذلك توصي الدراسة باستخدام السيبرولينا كمكملات آمنة وفعالة لخفض خطر التسمم بخلات الرصاص.

الكلمات المفتاحية: السيبرولينا – مكمل غذائي– مؤشرات السيرم