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تحية طيبة وبعد،،،

يسر **معامل التأثير والاستشهادات المرجعية للمجلات العلمية العربية (ارسيف – ARCIF)**، أحد مبادرات قاعدة بيانات **"معرفة"** للإنتاج والمحتوى العلمي، إعلامكم بأنه قد **أطلق التقرير السنوي الثامن للمجلات للعام 2023.**

ويسرنا تهنئتكم وإعلامكم بأن **المجلة المصرية للدراسات المتخصصة** الصادرة عن **جامعة عين شمس، كلية التربية النوعية، القاهرة، مصر، قد نجحت في تحقيق معايير اعتماد معامل "ارسيف Arcif"** المتوافقة مع المعايير العالمية، والتي يبلغ عددها **(32) معياراً**، وللاطلاع على هذه المعايير يمكنكم الدخول إلى الرابط التالي:

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وبإمكانكم الإعلان عن هذه النتيجة سواء على موقعكم الإلكتروني، أو على مواقع التواصل الاجتماعي، وكذلك الإشارة في النسخة الورقية لمجلتكم إلى معامل **"ارسيف Arcif"** الخاص بمجلتكم.

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* **بحوث علمية محكمة باللغة العربية:**

* بحوث علمية محكمة باللغة الإنجليزية :

Dietary Importance of Spirulina and its Efficacy Against sodium arsenite Toxicity in Rats

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Dietary Importance of Spirulina and its Efficacy Against sodium arsenite Toxicity in Rats

Dr. Sara A. A. Mahmod

Abstract

This research examined the value of spirulina (sp) in diets and how well it protected rats from the damaging effects of arsenic. Thirty albino Sprague-Dawley strain rats weighing roughly 150±5 gm were randomly assigned into five main groups, six of each When equated with the +ve control group, the groups who were fed SP experienced greater gains in body weight than did the +ve group. When equated with the group serving as the positive control, levels of liver enzymes which include AST, ALT, as well as urea nitrogen and creatinine, reduced significantly in groups three, four and five, respectively. As a result, the spirulina powder had a positive influence on the toxic effects of sodium arsenite toxicity in rats.

Keywords: Spirulina, sodium arsinate toxicity, Antioxidant enzyme, liver and kidney function

ملخص:

العنوان : أهمية المتناول من الاسبيرولينا وفاعليته ضد التسمم بالزئبق فى الفئران

المؤلفون : سارة عاطف على محمود

يهدف هذا البحث إلى معرفة قيمة السبيرولينا في النظام الغذائي وتأثيره على حماية الفئران من الآثار الضارة للزرنيخ. تم استخدام ثلاثون فار من سلالة سبراجو داولى يبلغ وزنها حوالي (150±5 جم) تم تقسيمها عشوائيًا إلى خمس مجموعات رئيسية، ستة فئران فى كل منها أظهرت النتائج زيادة في زيادة وزن الجسم في المجموعات التي تم تغذيتها على السبيرولينا مقارنة مع المجموعة الضابطة الموجبة. إنزيمات الكبد مثل (ALT, AST) بالإضافة إلى نيتروجين اليوريا والكرياتينين انخفضت بشكل ملحوظ في المجموعات (3، 4، 5) على التوالي مقارنة مع المجموعة الضابطة الموجبة ، توصلت هذه الدراسة إلى استنتاج أن مسحوق السبيرولينا له تأثير إيجابي على الصحة من خلال تقليل التأثيرات السامة للمعادن الثقيلة، وخاصة الزرنيخ.

الكلمات الدالة : سبيرولينا، سمية أرسينات الصوديوم، إنزيم مضادات الأكسدة، وظائف الكبد والكلى.

Introduction

Arsenic has the potential to spread widely throughout the plant and animal kingdoms by entering the food chain. Arsenic is a naturally and element that is not vital to life that has a glossy, grey appearance. The most poisonous types of arsenic are those that are inorganic **(FAO and WHO, 1983).** One of the most ubiquitous and dangerous metalloids in the environment is arsenic. Arsenic in its inorganic form poses a danger to millions of people throughout the world who consume tainted food and water. Metalloid arsenic (As) can be found in water and soil in both organic and inorganic forms (**Khatun *et al*., 2020 and Silbergeld *et al*., 2008)**. A major public health issue involving millions of individuals is arsenic toxicity. Arsenic is distributed widely in the environment and comes from both natural and artificial sources (**Amalendu *et al*., 2014 & Erbanova *et al*., 2008).**

Spirulina (SP) is a non-toxic species of cyanobacteria and blue-green algae. It is a dietary supplement that includes important fatty acids, vitamins, and minerals. In alkaline waters in tropical regions, the Spirulina (SP) family naturally grows as microalgae and the nation's manufacturing output is always expanding. It is an excellent source of nourishment and has a high percentage of protein, vitamins (B6, A, B2, Vitamin B12 and E), enzymes, minerals (Ca, Fe, Mg, P, Cu, Zn, Mn, K, Na, Cr, and Se), essential amino acids, essential fatty acids, & other nutrients. It was selected as ((generally recognized) product by the FDA in 2011(**Guldas *et al*., 2022; Gutierrez-Salme *et al*., 2015 and Kent *et al*., 2015).**

The Pacific Ocean in Japan and Hawaii, as well as sizable freshwater lakes in Africa, Mexico, South America and North America, are habitats where spirulina grows extensively. Spirulina (SP) maxima and Spirulina platensis are the two varieties of Spirulina that are most frequently utilised in dietary supplements **(Ghaeni , & Roomiani , 2016; Khan *et al*., 2005).** Free-floating filamentous cyanobacteria known as SP are

originate in tropical also subtropical lakes in Asia, Africa, Central America and South in addition Europe. They are distinguished by their Central America, and South America, in addition to Europe composed of several cells arranged in a left-handed open helix (**El-Sheekh *et al*., 2014; Vonshak 1997**). Spirulina has a number of therapeutic benefits, including lowering blood cholesterol, preventing some cancers, increasing intestinal lactobacilli, boosting the immune system, protecting against radiation, lowering hyperlipidemia, reducing nephrotoxicity from drugs and heavy metals, and reducing obesity **(Ghaeni *et al*., 2014; Jimenez *et al*., 2003).** The research aimed to determine the nutritional value of SP in the diet and its effectiveness in protecting rats from arsenic toxicity.

Materials and methods

Materials:

El-Gomhoria Company in Cairo, Egypt provided the minerals, cellulose, and arsenic that were purchased. The Imtenan Company sold spirulina, which was purchased. At the Helwan Farm for Experimental Animals in Cairo, Egypt, a total of thirty albino Sprague-Dawley strain rats that weighed approximately 150± 5 grammes each were acquired for the purpose of conducting experiments. Kits for conducting biochemical analysis were available for purchase from the Biodiagnostic Company for Pharmaceuticals and Chemicals in Dokki, Egypt. In Cairo,

Egypt, at the Morgan Chemical Factory, vitamins, casein, cellulose, minerals, flour and choline were purchased.

Experimental Animal Design:

After an adaptation period, thirty Sprague-Dawley albino rats, weighing 150±5 grams, were randomly assigned into two main groups (6 rats). The 1st group being kept on the basal diet as the negative control (-ve), and the 2nd group24 rats being subjected to sodium arsenite exposure (10 mg/kg) daily in intake water for 6 weeks and divided into 4 groups. The first group was used as a positive control (+ve), while the other 3 were given basal diet with dried SP added at levels of 25, 50, and 75 mg/kg respectively for a period of six weeks.

The animals were housed in the Animal House of the Agricultural Research Center, Giza, Egypt, under hygienic conditions at a temperature of 25±2°C with a moderate humidity of 56%. Ad libitum access to basic diet and water was provided.

The Basal Diet Preparation:

The basal diet was made in accordance with **Reeves *et al*., (1993)**. Twenty percent protein, 10 % sucrose, 4.7 % maize oil, 2 % choline chloride, 3.5 % mixture of salts, 1 % mixture of vitamins, and 5 % fibers makes up the ingredient list. Corn starch made up the remaining 1% to the full 100%.

Gain in overall body mass was computed at the conclusion of the trial (6 weeks). All rats were given a brief ether anaesthesia while they fasted overnight. Blood was drawn into a dry, plastic centrifuge tubes. After centrifuging blood samples, serum was extracted and kept at -20°C in a clean, well-sealed vial until analysis.

Biochemical Analysis:

Alanine (ALT) amino transeferase enzyme was identified in serum to the technique of ***Sherwin (1984).*** Aspartate amino transeferase(AST) was identified as the enzyme along with ***Young (1990).*** The serum alkaline phosphatase (ALP) level was

measured consistent with the process designated by **Roy (1970).** The level of serum urea nitrogen was measured by the technique of ***Fossati et al., (1980)***. Creatinine was evaluated consistent with the technique designated by ***Henry (1974)***. The concentration of serum arsnic was measured by the method of **Gora *et al.*, (2014).** Malondialdehyde (MDA) levels in the blood were measured according of ***Draper & Hadly (1990).*** The serum Catalase CAT activity in tissue homogenate was evaluated consistent with ***Aebi (1984).*** Superoxide Dismutase (SOD) was dignified as stated by ***Nishikimi et al., (1972)***.

Statistical Analysis:

Mean and standard error were used to represent the results (SE). The Dunk'test multiple range post-hoc test was used to conduct the statistical analysis using SPSS, PC statistical software (Verion 18.0 SPSS Inc., Chicago, USA). One-way analysis of alteration was functioned to analyse the data (ANOVA). At P under 0.05, the values were considered substantially different **(*Snedecor & Cochran, 1980*)**.

Results and Discussion

Table (1): Chemical Composition of 100 gm Spirulina

	Nutrients (100 g)	
Nutrients (g)	Energy	25kcal
	Protein	6 g
	Fat	0.45 g
	Carbohydrate	3.5 g
Minerals (mg**)**	Calcium	11 mg
	Iron	2.99 mg
	Sodium	100 mg
Vitamins (mg)	Vitamin C	1mg
	Vitamin A	60 IU

As shown in Table 1, aspirin contains 25 kcal of energy, 6g of protein, 3.5g of carbohydrate, 0.45 g of lipids, 11mg of calcium, 2.99mg of iron, 100 mg of sodium, 1 mg of vitamin C, and 60 IU of vitamin A. Based on the outcomes of the research performed by **Ali , (2017)**, the lipids as well as the ash content of SP platensis were, respectively, 5.3 percent & 6.9 percent, which

were fewer than our findings. On the other hand, the protein and fibers content were, respectively, 61.8 & 9.5%, which were greater than our outcomes. In our research, Spirulina platensis revealed a higher percentage of protein in comparison to SP platensis obtained in Nomayos & Chad, which respectively accounting for 37.55% & 50.24% of the total protein content. According to the findings of our tests, the concentration of protein was much lower in comparison to that which was harvested in Switzerland & Burkina Faso, where it stretch to 65 as well as 61.3% respectively **(Branger *et al*., 2003)**. This divergence raises the possibility that SP platensis' protein content shifts during the course of a cultivation cycle in response to the amount of photons (sunlight) available to the plant. **(AFAA, 1982)**. The trial that create this variation was published in 1982. The amounts, quantity, in addition accessibility of the protein's amino acids are what determine the quality of the protein, which is why it is necessary to evaluate the quality of the protein in addition to the quantity.

Table (2): Effect of A spirulina on feed intake, body weight gain% and feed efficiency ratio of rats treated with sodium arsenite

Parameters / Groups	Body weight Gain (%)	Feed Intake (g)	Feed Efficiency Ratio
Control (-Ve)	120.60±4.037c	15.06±0.321b	8.02±0.164c
Control (+Ve)	113.60±5.413d	12.40±1.056c	9.20±0.980a
Spirulina (25mg/kg) + sodium arsenite	127.00±2.121b	16.00±0.400b	7.96 ±0.297c
Spirulina (50mg/kg) + sodium arsenite	145.00±1.871a	16.44±0.699a	8.80±0.418b
Spirulina (75mg/kg) + sodium arsenite	149.20±8.167a	16.14±0.924a,b	9.26±0.747a

The data were presented as mean ± S.E.
(* *) = highly significant at p< 0.01, (*) = significan a p≤0.05, (-) = Non significant p>0.05.
Acco ding o “D ncan” he mean val es we e a anged in a descending o de f om “a”: “d”

Results in table (2) showed that body weight gain % (BWG), feed consumption was significantly decreased for the +ve

group as compared to with the -ve control group but feed Efficiency ratio was significantly rise for +ve group Compared to the –ve control group. Furthermore, body weight gain, (FI) for rats in groups three, four, besides five presented significant increase in body weight gain, FI when equated with the +ve control rats. The influence of the taste, odour, and deliciousness of the rats' food may be the cause of the increases in BWG and feed intake along with an upsurge in the levels of dehydrated SP.

During the whole study period, the treated rats did not exhibit any clinical symptoms or lesions, however most of the groups did notice a minor rise in body weight. When compared to rats given arsenic with spirulina (T2), animals in the arsenic-treated group (T1) had lower body weights, but these differences were not very significant. In light of this, it may be concluded that feeding rats NaAsO2 (4 mg/kg BW) will not result in chronic arsenic toxicity, however it may take longer or involve a larger dose of As for symptoms to appearing **(Hasan *et al., 2015*).**

Table (3): Protective effect of aspirulina on weight of some organs in rats treated with sodium arsnic.

Parameters / Groups	Liver (%)	Kidney (%)
Control (-Ve)	8.24 ±0.207c	7.96 ±.451b
Control (+Ve)	9.26±0.611a	8.88±.597a
aspirulina (25mg/kg) + sodium arsenite	9.18±0.192a	8.10±.158a
aspirulina (50mg/kg) + sodium arsenite	8.96±0.391b	8.24±.114a
aspirulina (75mg/kg) + sodium arsenite	8.80±0.339b	7.96±.358b

The data were presented as mean ± S.E.
(* *) = highly significant at p< 0.01, (*) = significan a p≤0.05, (-) = Non significant p>0.05.
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Outcomes in table (3) presented that organs weight/ body weight %(liver & kidney) was significantly enlarged for the +ve control group equated with the -ve control one. Additionally, organs weight (liver & kidney) for rats in groups 3,4,5 respectively exposed significant decreased in liver, kidney when compared with the positive control rats.

When contrasted with the normal control group, the arsenic control group demonstrated a statistically significant and apparently decreased end body weight alongside an increased liver weight. When compared to the arsenic control group, the SP platensis- treated group indicated a significant increase in both the final body weight and liver weight. This was because arsenic toxicity was not present in the Spirulina platensis- treated group. When compared to those of the arsenic control group, the ultimate body and liver weights of the SP platensis/arsenic-treated group did not significantly vary from those of the arsenic group. In this study, the exposure to arsenic had no impact on the weight of the kidneys. When compared to the arsenic control group, the SP platensis- treated group demonstrated a significant increase in both the final body weight & liver weight. This was caused by the absence of any adverse effects from arsenic. However, the final body besides liver masses were unaffected. In contrast, there was no alteration between the SP platensis/arsenic-treated group & the arsenic control group in terms of the ultimate weights of the body and liver. Arsenic exposure in this experiment had no effect on kidney weight. (**Bashandy *et al*., 2018)**.

Table (4): Protective effect of aspirulina on liver enzymes in rats treated with sodium arsnic.

Parameters / Groups	ALT	AST	ALP
	(U/L)		
Control (-Ve)	39.40a±1.673d	49.40a±2.881d	843.60±0.817c
Control (+Ve)	72.00±2.121a	109.00±5.390a	861.20±2.683a
Spirulina (25mg/kg) + sodium arsenite	57.40±1.817b	60.20±2.864b	853.80±2.588b
Spirulina (50mg/kg) + sodium arsenite	53.40±1.140b	55.40±1.140c	849.20±1.789b
Spirulina (75mg/kg) + sodium arsenite	44.60±1.140c	53.80±1.304c	847.80±1.304b,c

The data were presented as mean ± S.E.
(* *) = highly significant at p< 0.01, (*) = significan a p≤0.05, (-) = Non significant p>0.05.
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Table 4 shows the impact of SP powder on serum Alanine Aminotransferase serum activity. The +ve group exposed to

Arsnic toxicity had higher ALT activity, as compared to the negative control group (72.00±2.121 vs. 39.40±1.673 u/l) while the Spirulina-fed groups showed significant reductions, as compared to the positive control group. Group 5 rats fed SP powder had the lowest ALT activity with a mean value of 44.60±1.140 u/l.

Table (3) also indicated the impact of *Spirulina* powder on the activity of AST. The serum levels of Aspartate Aminotransferase in the group of rats subjected to Arsnic toxicity (positive control group) were considerably higher (109.00±5.390 u/l) than those in the group of rats not exposed to Arsnic toxicity (49.40±2.881 u/l). When compared to the positive control group, the outcomes established that the serum activity of Aspartate Aminotransferase was decreased in the rats fed a diet containing *SP* powder, regardless of the amount consumed. Serum AST activity was observed to be 53.80±1.304u/I lower in the group of rats administered Spirulina powder (group 5).

Also, Table (4) presented the influence of Spirulina powder on Alkaline Phosphatase. When rats were subjected to arsnic toxicity, the activity of ALP in serum elevated considerably, with a mean value of 861.20±2.683 u/L in comparison to the negative control group's value of 843.60±1.817 u/L. The distinction was statistically When contrasted with the positive control (861.20±2.683U/L), the results demonstrated that the mean value of Alkaline Phosphatase in serum decreased significantly in a group of mice nurtured on SP powder at three levels in diet as mean value 853.80±2.588U/L, 849.20±1.789 U/L, & 847.80±1.304 U/L, respectively. These values were found to be significantly lesser than the positive control's value.

The data in this table revealed that the mean values of AST, ALT and ALP increased in the positive control group compared to the negative control group, while treating rats with spirulina at the three levels improved liver enzymes.

When rats received both SP and arsenic, these metrics improved. This rise is a sign of cellular absence & a breakdown in the integrity of liver cell membranes' functional integrity. The liver is a significant target organ of toxicity owing to its distinct metabolic processes. This toxicity is known to be linked with oxidative stress. **(Korany *et al*., 2019; Chowdhury *et al*., 2016).**

The biochemical analysis in our trial revealed a considerable increase in liver enzymes (AST & Alanine Aminotransferase), & these findings were comparable with those of previous research **(Ahmed *et al*., 2019; Flora *et al*., 1997; Sayed *et al*., 2015).** The precise process causing the increase of these enzymes is still unknown. According to several researchers, this impact could be brought on by cellular injury or improved plasma membrane absorbency. In addition, other variables could be at play, like elevated synthesis or diminished enzyme degradation **(Ahmed *et al*., 2019; Sayed *et al*., 2015).** In contrast, the co-administration of Sp in the current study considerably reduced the levels of aspartate aminotransferase and ALT to levels that were close to control levels. This study also shown that A- treatment caused a noticeable rise in serum creatinine levels, indicating impaired renal function.

Table (5): Protective Effect of Spirulina on Serum Kidney Functions of Rats with sodium arsenite

Parameters / Groups	Urea	Creatinine	Uric acid
	mg/dl		
Control (-Ve)	44.80±1.483c	0.78±0.110c	4.02±0.110c
Control (+Ve)	54.00±2.915a	1.54 ±0.134a	5.54±0.114a
Spirulina (25mg/kg) + sodium arsenite	52.40± 2.074a	1.32±0.130a	4.18 ±0.084b
Spirulina (50mg/kg) + sodium arsenite	49.00±0.707b	1.16±0.055b	4.38±0.084b
Spirulina (75mg/kg) + sodium arsenite	45.80±0.837c	1.12±0.084b	4.14±0.261b, c

The data were presented as mean ± S.E.
(* *) = highly significant at p< 0.01, (*) = significan a p≤0.05, (-) = Non significant p>0.05.
Acco ding o “D ncan” he mean val es we e a anged in a descending o de f om “a”: “d”

Table (5) demonstrated the impact that Spirulina powder has on kidney functioning as measured by serum concentrations of creatinine, urea nitrogen, and uric acid. The concentration of

serum levels of urea nitrogen was dramatically raised with a mean value of 54.00±2.915 mg/dl when rodents were subjected to arsnic toxicity. This was in comparison to the -ve control group, which had levels that were 44.80±1.483 mg/dl. When compared to the positive control group, which had a serum level of urea nitrogen that was 54.00±2.915 mg/dl, groups 3, 4, and 5 had concentrations of urea nitrogen in the serum that ranged from 52.40±2.074 mg/dl to 45.80±0.837 mg/dl, respectively.

Table (5) Relative to the negative control group, which had a creatinine concentration that was 0.78±0.110 mg/dl on average, the +ve group, which had been exposed to arsenic toxicity, had a concentration of creatinine that was 1.54±1.34 mg/dl higher than the negative control group. When compared with the positive control group, the groups of rats who were fed Spirulina powder at whatever amount of intake demonstrated a lower concentration of creatinine in their serum. The optimal level was determined in group 5, with a mean value of 1.12±0.84 mg/dl; this group is considered to be superior to the negative control group.

In addition, table (5) exhibited the reduction of uric acid by SP powder. Rats supplementing their diet with spirulina powder had lower serum uric acid activity compared to the positive control group at all doses. Group 5 rats administered SP powder had the lowest serum uric acid activity, with a mean value of 4.14±0.261mg/dl.

Similarly, arsnic-treated rats showed considerably increased levels of oxidative stress and kidney arsenic buildup; however, resveratrol pretreatment prevented these alterations from occurring. Additionally, creatinine, the blood urea nitrogen, in addition to renal tubular epithelial cell necrosis levels were lower before starting resveratrol therapy. The reactivity of arsenic, which results in the production of ROS and compounds containing sulfur, is connected to its toxicity. (**Zhang *et al*., 2014; Hughes *et al*., 2011; Lu *et al*., 2012).** ROS, which are implicated in the pathogenic mechanisms of diseases, are particularly prone to causing harm to the kidney **(Zhang *et al*., 2014; Rodrigo and**

Rivera, 2002). Our investigation also confirmed that arsenic-induced kidney oxidative damage was caused by ROS.

Spirulina platensis indicated a significant positive improvement in both kidney & liver functions through its modulation of the oxidative stress parameters in addition to the inflammatory cytokines, regardless of whether it was given alone (to ascertain any problems) or in combination with sodium arsenite intoxicated rats. This improvement appeared through its modulation of the oxidative stress parameters as well as the inflammatory cytokines. The purpose of our experimental investigation is to enhance atherosclerotic indices, & this improvement in the previously indicated parameters, in particular the levels of uric acid and IL-6, reflected in the much lower level of MCP-1. SP may be employed as an inexpensive, safe, and natural adjuvant therapy for atherosclerosis in the future rather than expensive, traditional medication therapy with several adverse effects. **(Bashandy et al., 2018; Jensen *et al.*, 2016).**

Table (6): Influence of Spirulina on Serum Lipid Profile of Rats with sodium arsenite

Parameters / Groups	TC	TG	HDL-c	LDL-c	VLDL-c
	(mg/dl)				
Control (-Ve)	141.60±8.678d	106.80±1.789d	38.40±1.517c	81.84±9.910b	21.36±0.358c
Control (+Ve)	254.20±7.855a	193.80±1.789a	53.00±2.828a	162.44±8.764a	38.76±0.358a
Spirulina (25mg/kg) + sodium arsenite	151.20±1.643b	139.80±1.483b	48.60±1.517b	74.64±2.613c	27.96±0.297b
Spirulina (50mg/kg) + sodium arsenite	146.20±1.643c	134.60±2.702b	45.80±0.837b	73.48±2.492c	26.92±0.540b
Spirulina (75mg/kg) + sodium arsenite	144.20±4.438c	113.60±3.362c	40.80±0.837c	80.68±4.793b	22.72±0.672c

The data were presented as mean ± S.E.
(* *) = highly significant at p< 0.01, (*) = significan a p≤0.05, (-) = Non significant p>0.05.
Acco ding o "D ncan" he mean val es we e a anged in a descending o de f om "a": "d"

As stated in table (6), the levels of total cholesterol, total fat, very low-density lipoprotein cholesterol, in addition to low density lipoprotein cholesterol all amplified significantly in the positive control group, with P values more than 0.05. However, as compared to the group serving as a positive control, the HDL-C serum level was statistically significantly reduced (P above 0.05).

The mean values of the serum lipid profile exhibited a statistically significant drop (P over 0.05) after SP treatment. On the other hand, when compared to the control group with the negative result, the serum HDL-C level enlarged significantly (P above 0.05). As opposed to the positive control group, the lipid profile of the arsnic-toxic rats that were administered spirulina displayed significant improvement. These alterations point to the significance of consuming a diet rich in SP either for the treatment of arsnic toxicity or the prevention of its occurrence.

Spirulina's hypolipemic effects were also demonstrated in mice that had been given alloxan (250 mg/kg body weight), which was used to experimentally cause diabetes. Hepatic triacylglycerols decreased after receiving 5% SP. Improvement in blood HDL levels and decreases in serum LDL and VLDL were also seen. Li et al discovered that when fed a high-fat diet, spirulina for 8 weeks increased HDL-C and decreased LDL-C, TG, and TC levels **(DiNicolantonio *et al*., 2020 and Li *et al*., 2018).** Similar to prior trials, it was also demonstrated to normalise hepatic steatosis with enhancements in liver function tests, including free fatty acids, transaminases & total lipid profile.

The outcomes were distinguished by a marked decrease in TC during the first four weeks of SP supplementation, which recovered to baseline once it was stopped. These TC alterations were proportionate to the levels of serum and dietary TC. No adjustments were made to TG, HDL, or body weight **(DiNicolantonio *et al*., 2020; Nakaya *et al*., 1988).** Spirulina supplementation at a dose of 2 to 8 grammes per day has been shown to enhance lipid profiles, especially by lowering TG, TC, & LDL-c in addition to raising HDL-c; increasing apolipoprotein A1 and decreasing apolipoprotein B; and promoting weight reduction and lowering BMI.

Table (7): Protective Effect of Spirulina on Serum Malondialdehyde and Glutathione of Rats with sodium arsenite

Parameters / Groups	Malondialdehyde (ng/ml)	Glutathione (ng/ml)
Control (-Ve)	67.60±2.074d	4.82±0.192a
Control (+Ve)	158.80±3.271a	3.32±0.148b
Spirulina (25mg/kg) + sodium arsenite	97.40±1.673b	4.16±0.089a
Spirulina (50mg/kg) + sodium arsenite	83.80±2.387c	3.34±0.207b
Spirulina (75mg/kg) + sodium arsenite	87.40±1.949c	3.44±0.114b

The data were presented as mean ± S.E.
(* *) = highly significant at p< 0.01, (*) = significan a p≤0.05, (-) = Non significant p>0.05.
Acco ding o "D ncan" he mean val es we e a anged in a descending o de f om "a": "d"

Outcomes in Table (7) revealed the effect that varying doses of SP powder had on serum levels of antioxidant activity like malonaldehyde & glutathione. Results indicate that there was a significant reduction in the level of serum glutathion in the positive control group, compared to the negative control group with a man value of 3.32±0.148 (ng/ml) and 4.82±1.92 (ng/ml) . On the other hand, the results showed that the concentrations of malondahyde in serum increased substantially when contrasted with the positive control. On the other hand, the findings demonstrated that the level of malondialdehyde was much higher in the group that served as the positive control as opposed to the group that served as the negative control. When compared with the group serving as the positive control, the serum MDA levels in groups 3, 4, and 5 were shown to have reduced significantly (P under 0.05). Additionally, the highest value of MDA was found in group 4, which was observed.

The blood MDA levels were elevated in the current investigation by As feeding and reached their maximum levels in the experimental groups, increasing the trend from the beginning to the completion of the trial. This finding suggests that As feeding increased lipid peroxidation in the treated rat, indicating an increase in the formation of free radicals. Our results support a prior study that found elevated blood levels of lipid peroxidation to be related to high as exposure. In comparison to the control and

As-treatment groups, serum MDA levels were dramatically reduced by both the (agro-based spirulina) Ab-Sp and (commercially accessible spirulina) Com-Sp treatments. This result demonstrates that lipid peroxidation was reduced during the experiment and reverted to the control level with Ab-Sp and Com-Sp treatments alone **(Khair *et al*., 2021; Hu *et al*., 2020).**

As a result of therapy, considerably higher amounts of MDA have been identified in blood in contrast to the control group, while co-treatment with SP platensis resulted in lower MDA levels. Rats exposed to as had lower blood GSH levels, and when Spirulina platensis was also administered, the serum antioxidant capacity rose (GSH). MDA concentrations may rise as a result of arsenic. Because of the increased creation of ROS and oxidative stress brought on by the lipid peroxidation of membranes, arsenic exposure speeds up the destruction of phospholipids, which in turn causes cellular degeneration. Increased ROS production and oxidative stress, which can lead to an increase in glutathione consumption, may be the cause of the glutathione level being depleted following exposure to arsenic. As the original line of antioxidant resistance against arsenic-induced damage, glutathione has been demonstrated to be a major indicator of oxidative stress. Reduced tissue GSH levels signify oxidative injury **(Reda *et al*., 2019; Ahangarpour *et al*., 2018).**

Table (8): Protective Effect of Spirulina on Different Levels Serum Concentrations of arsnic Intoxicated Rats.

Parameters / Groups	Arsnic blood (ug)
Control (-Ve)	0.68±0.17e
Control (+Ve)	5.38±0.249a
Spirulina (25mg/kg) + sodium arsenite	3.26±0.182b
Spirulina (50mg/kg) + sodium arsenite	2.46±0.089c
Spirulina (75mg/kg) + sodium arsenite	1.88±0.148d

The data were presented as mean ± S.E.
(* *) = highly significant at p< 0.01, (*) = significan a p≤0.05, (-) = Non significant p>0.05.
Acco ding o “D ncan” he mean val es we e a anged in a descending o de f om “a”: “d”

When contrasted to the negative control group, the findings indicated that the blood level of arsnic was significantly elevated when rats were subjected to arsnic toxicity (positive control group), with a mean value of 5.38±0.249 ug. This was in contrast to the negative control group, which had a value of 0.68±0.17 ug. When compared to the positive control group, the arsnic concentration in the serum of rats that were administered aspirina at varying levels of intake resulted in a substantial drop across all groups, with a mean value of 3.26±0.182 ug; 2.46±0.089 ug; and 1.88±0.148 ug, respectively.

Arsenic feeding to the rats increased As loads in the lung, liver and kidney and caused hepatic and renal insufficiencies; and separate treatments of SP and selenium significantly reduced tissue loads and recovered the hepatic and renal insufficiencies. Researchers from a variety of institutions **(Balaji *et al*., 2014)** looked at the bioremediation capability of SP as it relates to the deletion of heavy metal ions from industrial effluents. According to **Ghosh *et al*., (2014)** research, giving goat's arsenic while also giving them spirulina appears to offer a protective mechanism against the toxicity caused by the arsenic. Based on the results of the research, **Hossain *et al*., (2013)**, using SP in conjunction with vitamin A as a treatment for chronic arsenicosis in rats is an effective strategy. According to **Vedi M. *et al*., (2013)** research, it also has a protective influence contrary to galactosamine-induced hepatotoxicity in mice. In arsenic-induced toxicities in ducks, spirulina has been presented to be advantageous for toxic symptoms as well as body weight & hematological parameters **(Islam *et al*., 2009).**

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