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Research Article

The Protective Rolls of *Taraxacum officinale* against Carbon Tetrachloride Infarction in the Liver

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ABSTRACT

Carbon tetrachloride (CCl_4) is a liquid that is colorless, transparent, inflammable, and volatile. Its central carbon atom is surrounded by four Cl^- atoms. As a result, the objective of this effort was to estimate the anti-oxidant properties of silver nanoparticles (AgNPs) made utilizing aqueous plant extracts from *Taraxacum officinale* leaves. A green synthesis of AgNPs using a synergistic aqueous extract from *T. officinale* leaves was tested against liver damage in rats caused by CCl_4. The rats were randomly distributed into seven groups: Group 1: Control group, Group 2: Olive oil group, Group 3: AgNPs-treated group (100 mg/kg BW.), Group 4: AgNPs-treated group (200 mg/kg BW.), Group 5: CCl_4 + Olive oil group, Group 6: (CCl_4 + Olive Oil) + 100 mg/kg of AgNPs-treated group, and Group 7: (CCl_4 + Olive oil) + 200 mg/kg of AgNPs-treated group one a week for 6 weeks. This study demonstrated a sustainable method for synthesizing AgNPs utilizing *T. officinale* leaf (TOL) extract. To characterize the synthesized *T. officinale* leaf-silver nanoparticles (TOL-AgNPs), various microscopic and spectroscopic methods were used. The effectiveness of the biosynthesized TOL-AgNPs against CCl_4 was tested to assess their antioxidant potential. The antioxidant properties of synthetic TOL-AgNPs were also evaluated. Histopathological research showed that all groups treated with nano-extract had less severe inflammatory responses. Our findings demonstrated that AgNPs synthesized using the leaves of *T. officinale* possess a potential anti-oxidant activity against CCl_4-induced liver injury in rats.

Keywords: Carbon tetrachloride, hepatoprotictive effect, oxidative stress, silver nanoparticles, *Taraxacum officinale*

INTRODUCTION

Carbon tetrachloride (CCl_4) is a liquid that is colorless, transparent, inflammable, and volatile. It features four Cl^- atoms surrounding the carbon atom at its center. In addition to happening naturally, it may also occur as a result of a variety of chemical reactions. It has an atmospheric half-life of between 30 and 100 years due to its chemical stability.[1] CCl_4 is quickly absorbed by the body by inhalation, ingestion, and cutaneous absorption.[2]

According to estimates, the typical adult daily CCl_4 intake is 0.1 ml. This poisonous substance distributes throughout the body, with maximum concentrations through the hepatic, kidney, brain, fat, muscle, and blood after exposure throguh ingestion, inhalation, or dermal absorption.[3] To establish the acute toxicity of CCl_4, several animal tests have been conducted. For example, studies on rats have demonstrated that the fatal dosage (LD_{50}) is reach after severe oral ingestion, and that the body weight varies from 4.7 to 14.7 mL/kg based on dietary circumstances and supplements that are supplied.[4]

A well-known example of a chemical liver injury is CCl_4-induced liver damage. A powerful liver toxin called CCl_4 has been linked to cell death, inflammation, and oxidative stress in histopathological studies.[5] Medications used to treat liver problems have inadequate therapeutic efficacy and may have negative effects.[6] As a result, interest in alternative or complementary therapies as well as research into novel drugs has surged.[7]

With its distinctive properties and wide-ranging uses in industries including agriculture, food, and medicine, nanotechnology has become one of the most important and appealing areas of research.[8] Nanoparticles have well-known uses in the biomedical sector as antibacterial, antioxidant, and antitumor agents due to characteristics including their tiny size, high surface area to volume ratio, visual, magnetic, chemical, and physical capabilities.[9]

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Due to their versatile theranostic properties, nanoparticles of noble metals: Including (silver, gold, platinum, copper, zinc, titanium, and magnesium) have attracted a lot of attention for use in biomedical applications.[10] However, although physical and chemical processes are employed to make nanoparticles, they are linked to injurious substances that are dangerous to handle. As an alternative, attention is being drawn to plant-mediated production of metal nanoparticles because of their quick time requirements, low cost, and environmental friendliness.[11] Proteins, polysaccharides, flavonoids, terpenoids, tannins, alkaloids, amines, ketones, and aldehydes are examples of bioactive secondary metabolites that are found in plants. These substances are also used as lowering, stabilizing, and capping agents in the alteration of metal ions to metallic nanoparticles, producing desired nanoparticles with specific properties.[12]

Silver nanoparticles (AgNPs) have overtaken other biosynthesized metal nanoparticles in the past 20 years due to their distinctive biological, chemical, and physical properties.[13] Numerous studies have demonstrated that a lower concentration of $AgNO_3$ has improved chemical stability, catalytic activity, biocompatibility, and other desirable properties as well as inherent therapeutic potential despite the fact that silver is lethal at higher concentrations.[14] According to reports, AgNPs may have antioxidant, anticancer, and antibacterial properties.[15] An especially noteworthy benefit of AgNPs over bulk metals and their salts is their controlled, delayed release of silver.[16] The new-age bionanoformulations' guiding principle is the integration of traditional medicine with nanotechnology.

The perennial plant *Taraxacum officinale*, sometimes known as dandelion, is a member of the Asteraceae family, according to Classification of *T. officinale*.[17]

Kingdom : Plantae
Phylum : Magnoliophyta
Class : Magnoliopsida
Subclass : Asteridae
Order : Asterales
Family : Asteraceae
Subfamily : Cichorioideae
Genus : Taraxacum
Species : officinale
Subject : *Taraxacum officinale*

It is interesting that this herb has a lengthy history of usage as a medicine. Medicinal uses for the root and young tips predominate.[18] Liver, pancreas, and stomach functions are all enhanced by dandelion. It is employed to treat rheumatism, hepatitis, anemia, and liver cirrhosis,[19] prebiotic, analgesic, anti-hyperglycemic, anti-oxidative, anti-carcinogenic, and anti-inflammatory properties.[20]

MATERIALS AND METHODS

Collection of Plant and Leaf Extract Preparation

The dried *T. officinale* leaf (TOL), weighing 500 g, was obtained from Erbil's (Pirmam Roads) in September 2021 and was dried at room temperature in the shade. The plant was identified by Professor Dr. Abdulla Shakur of Salahaddin University-College Erbil's of Education. In the Department of Biology, distilled water was combined with 25 g of the powdered plant material (1:10, sample to solvent ratio) and sonicated for 60 min (power sonic 405/lab tech) while maintaining a temperature of 40 C. The resulting extract was then concentrated using a rotating evaporator with a regulated vacuum after being filtered using Whatman No. 1 filter paper with a Buchner funnel. The concentrated extract was kept at 4°C in an airtight container after being air-dried.

Silver Nanoparticle Synthesis

300 mL of warmed distal water was added to 10 g of the dried plant powder to make the nanoparticle. After 10 min of cooking using a magnetic stirrer, this mixture was filtered through Whatman No.1 filter paper and kept at 4°C for storage. Then, using a magnetic stirrer, 100 mL of the obtained extract was to be added to 1000 mL of 1 Mm aqueous $AgNo_2$ and heated for 60 min at 40°C. Ultraviolet-visible (UV-Vis) spectra were used to identify the production of AgNPs following centrifugation of the reduced mixture at 5000 rpm for 30 min. The resulting particle was then dissolved in deionized water and the supernatant was thrown away. To get rid of any materials that were adsorbs on the surface of the AgNPs, the same washing procedure was carried out 2–3 times with deionized water and ethanol.[21]

Characterization of AgNPs

The most crucial, straight forward, and fundamental method to validate the creation of synthesized nanoparticles is UV-Vis spectroscopy. UV-Vis spectra between 200 and 800 nm were captured using (Agilent Technologies, Santa Clara, CA, USA). An Fourier transform-infrared (FT-IR) spectrophotometer was used to conduct the analysis to analyze the functional group that the surface of the generated AgNPs included (Perkin Elmer Spectrum 100 FT-IR, 710 Bridgeport, CT, USA). The FT-IR spectra were scanned in the transmittance mode at a resolution of 4 cm^{-1} with wave numbers ranging from 4000 to 400 cm^{-1}.[22] An X-ray diffractometer used 2 scans from 30 to 80° at 0.04°/min with a constant value of 2 s to capture the X-ray diffraction (XRD) patterns of the AgNPs (Rigaku, Japan). Sigma 300 (Carl Zeiss, Germany) was employed together with EDX analysis to evaluate the cell surface characteristics and identify the elemental structure of produced AgNPs. On a fresh coverslip, a modest quantity of AgNPs (10 L) was drop-cast before being dried. Following a gold sputter, the samples were examined using an scanning electron microscopy (SEM) and an energy dispersive X-ray (EDX).[23]

Animal Housing and Breeding

The Albino rats were kept in a room with a temperature of 22 ± 2°C and a 12/12-h light/dark cycle. Each rat weighed between 160 and 200 g, in the animal house of education college/Salahaddin University, the rats were kept 1 week for acclimatization.

Experimental Design

Fifty-six female Wistar albino rats (weighing 160–200 g) are used in the present study. The animals have been housed in

conventional conditions (22 ± 2°C, 45 ± 5% moisture, and 12 h light-dark cycles). Throughout the trial of the experiment, the rats received conventional rat feed and had an unlimited access to tap water and libitum.

Rats were divided into seven groups at random (N = 8). Group 1: Rats in the control group received distilled water and a regular meal. Group 2: Rats received weekly intraperitoneal injections of 1 mL/kg BW olive oil for a period of 6 weeks. Group 3: For 6 weeks, rats in the AgNPs-treated group received daily oral gavage doses of 100 mg/Kg BW of AgNPs. Group 4: For 6 weeks, rats in the AgNPs-treated group received 200 mg/Kg BW of AgNPs orally. Group 5: For 6 weeks, rats in the CCl_4 + olive oil group received a single subcutaneous injection of the mixture (1:1) mg/kg. BW of CCl_4 and olive oil. Group 6: CCl_4 + Olive oil + AgNPs-treated group: Rats were given a single dose of the mixture (CCl_4 + Olive oil) subcutaneously once per week at a dose of (1:1) mg/kg.BW for 6 weeks, followed by the administration of AgNPs daily administered by oral gavage in a dose of 100 mg.kg b. for 6 weeks. Group 7: CCl_4+Olive Oil + AgNPs-treated group: Rats were given a single dose of the mixture (CCl_4 + Olive Oil) subcutaneously once per week at a dose of (1:1) mg/Kg. BW for 6 weeks, followed by the administration of AgNPs daily by oral gavage at a dose of 200 mg.kg body weight for 6 weeks.

Collection of Tissues and Blood Samples

At the end of the study period, rats were given general anesthesia before being decapitated and slaughtered. Blood samples were then taken by heart puncture and drawn for biochemical analysis. A little amount of blood — about 5 mL — was collected in a gel tube, left to remain at room temperature for 30 min, and then gently centrifuged for 15 min at 3000 rpm. Additionally, liver tissues were gathered, removed, and cleaned in sterile saline. All of the obtained liver tissues underwent autopsy and were divided into pieces. Then, until the histological investigation, the tissue was promptly preserved in 10% formalin saline.

Determination of Liver Function Test

Using kits and an enzymatic-colorimetric approach with an auto-analyzer, the liver function tests alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP) were conducted (COBAS kenza 450 TX - Fully automated biochemical analyzer, France).

Oxidative Stress Evaluation

With the use of Solarbio kits from China, malondialdehyde (MDA), superoxide dismutase (SOD), and glutathione (GSH) were measured. The variance seen among absorbance at 532 nm, 450 nm, and 600 nm is used to compute the MDA content.[24] An absorption at 560 nm shows that SOD activity declines as the interaction solution's blue color deepens. SOD can eliminate oxygen and prevent the synthesis of methionine.[25] GSH will interact with 2,5-dithiobis-(2-nitrobenzoic acid) to create 2-nitro-5-mercaptobenzoic acid and glutathione disulfide (GSSG). The highest absorbance of the 2-nitro-5-mercaptobenzoic acid in the yellow material is 412 nm.[25] All absorbencies identified by a microplate reader.[25]

Histopathological Examination

Liver tissue samples from various groups were autopsied and afterward histopathologically analyzed.[26] All samples were immediately placed in 10% buffered formalin for 24 h, rinsed in ordinary saline, and then dehydrated using successively diluted alcohol solutions (70%, 95%, 100%). The paraffin wax was then used to embed tissue pieces that had been cleared in xylene. Using a microtome, pieces of paraffin blocks with a thickness of 6 microns were cut, the tissue slices were placed on glass slides, deparaffinized with xylene, stained with Hematoxylin and Eosin (H and E), cleared with xylene, and mounted with DPX. Scores were given to the histological alterations.[27]

Statistical Analysis

The normality and lognormality tests were run after the one-way analysis of variance test (one-way ANOVA) using the GraphPad Prism (version 8.0). The findings were represented by the mean and standard deviation (SD). The differences between the groups were considered statistically significant when "*P*" < 0.05.

RESULTS AND DISCUSSION

UV-Vis Spectroscopy

Synthesized AgNPs' UV-Visible Spectroscopic Profile and Color Change. Figure 1 shows that after 30 min of incubation at room temperature in the dark, the color of the reaction mixture seemed to shift from light brown to dark brown. In actuality, under the same conditions, the $AgNO_3$ solution without plant extract remained colorless. The shift in hue was seen as proof that AgNPs were forming as a result of the reduction of Ag^+ ions.[28,29] AgNPs are present because the absorbance of AgNPs from 200 to 800 nm displays a maximum between 440 and 450 nm. The surface plasmon resonance features of spherical and aggregate AgNP generation are illustrated by the prominent absorption peak At 434 nm.[30]

After 1 day and 60 days, UV-Vis spectroscopy was used to determine the AgNPs' temporal stability. The presence of the distinctive at 434 nm peak in the produced AgNPs confirms their stability [Figure 1]. As a consequence of this finding, we may conclude that the produced AgNPs exhibited great water stability because a little decrease in absorbance was noted at

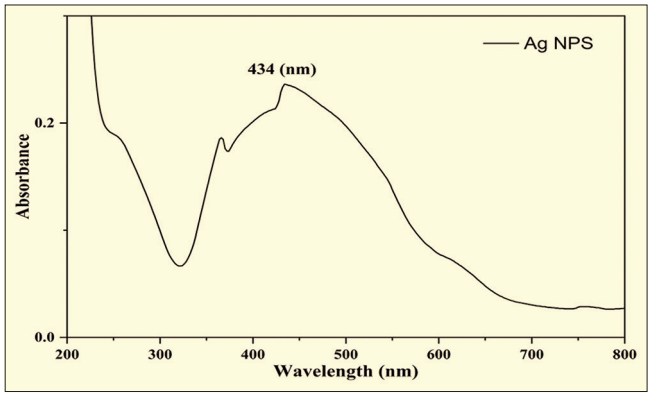

Figure 1: The results of ultraviolet/visible spectra of *Taraxacum officinale* leaf-silver nanoparticles

434 nm. Recent studies on the green synthesis of AgNPs using plant extracts from salvia hispanica and pomegranate leaves, among others, yielded findings that were almost identical to those of this kind of study.[29,31-33] This indicates that *T. officinale* leaves contain phytochemicals that can function as capping and reducing agents when effectively extracted.

FT-IR Spectroscopy Analysis

Using FT-IR spectroscopy, it was possible to identify the functional group that took part in the green synthesis of AgNPs as reduction and coating agents from TOL extract. Figure 2 shows the TOL extract's FT-IR spectral bands and manufactured AgNPs made from the leaf extract. The produced AgNPs showed sharp transmittance maxima at 3439, 1762, 1384, 1136, 875, and 825 cm^{-1} [Figure 2].

With a little variation in peak positions, the FT-IR spectra of *T. officinale* aqueous leaf extracts and synthetic AgNPs were quite comparable. This blatant resemblance shows that some of the remaining phytochemical moieties that are present in the TOL extract are present on the surface of the produced AgNPs. The peaks in the FT-IR spectra clearly show that *T. officinale* aqueous leaf extracts function as decreasing and steadying agents. Strong peaks at 3439 cm^{-1} were indicative of the hydroxyl and amine (N-H) functional groups' O-H stretching vibration type.

The stretching vibrations of the hydroxyl (O-H) and amine (N-H) groups were thought to be responsible for the absorbance maxima between 3000 and 3600 cm^{-1}. While proteins, peptides, and amino acids are assumed to create N-H stretching, polyphenols display O-H stretching vibration instead.[34]

The phenolic group of compounds included in leaf extract acts as strong capping and reducing agents when silver nitrate is reduced, resulting in the formation of AgNPs. Due to the high concentration of secondary metabolites that dissolved in the sample, two additional strong peaks at 2088 and 2078 cm^{-1} were seen. These peaks indicated the existence of alkynes with triple bond C≡C stretched vibration. The peaks at 1762 cm^{-1} are caused by the amide I band and the -C=C- stretching vibration band. The 1384 cm^{-1} peak was assumed to be caused by the -C-N- stretching band and the amide I band of proteins in the leaf extract.[35]

The band of amide I connected to the carbonyl group's (C=O) stretch mode when it was joined to the amide linkage. The CH out of plane bending vibrations was attributed to the maxima at 1136 and 875 cm^{-1}. For stability and to avoid agglomeration, the proteins may be coated or encapsulated around the produced AgNPs.[36] Thus, it became clear from the FT-IR analysis that proteins and bioactive substances, including polyphenols, found in the TOL extracts play a significant role in the production of AgNPs.[32,36,37]

XRD Analysis

T. officinale leaf-silver nanoparticles (TOL-AgNPs) crystal structure was ascertained by powder XRD, as demonstrated in [Figure 3]. The planes (111), (200), (220), and (311) are correspondingly represented by Θ2 = 34°, 38.1°, 44.2°, 64.5°, and 77.6°, where Bragg's reflections were discovered. X-ray diffractograms were used to identify four diffraction peaks (111), (200), (220), and (311) to determine the composition of the created AgNPs. These peaks fit Ag planes according to the typical face-centered cubic structures of Ag (Joint Committee on Powder Diffraction Standards; JCPDS no. 04-0783). The formed AgNPs' crystalline arrangement was further sustained by the (111) reflection peak's high intensity in comparison to the other reflections. The findings confirm those of earlier studies, which showed identical AgNP diffraction peaks.[38,39]

SEM and EDX Analysis

Using SEM methods, the morphological properties of greenly synthesized AgNPs were identified. The majority of the spherical shape in SEM images of produced AgNPs, with an average size of 50 nm, was observed [Figure 4]. The results obviously showed that the synthetic AgNPs substantially

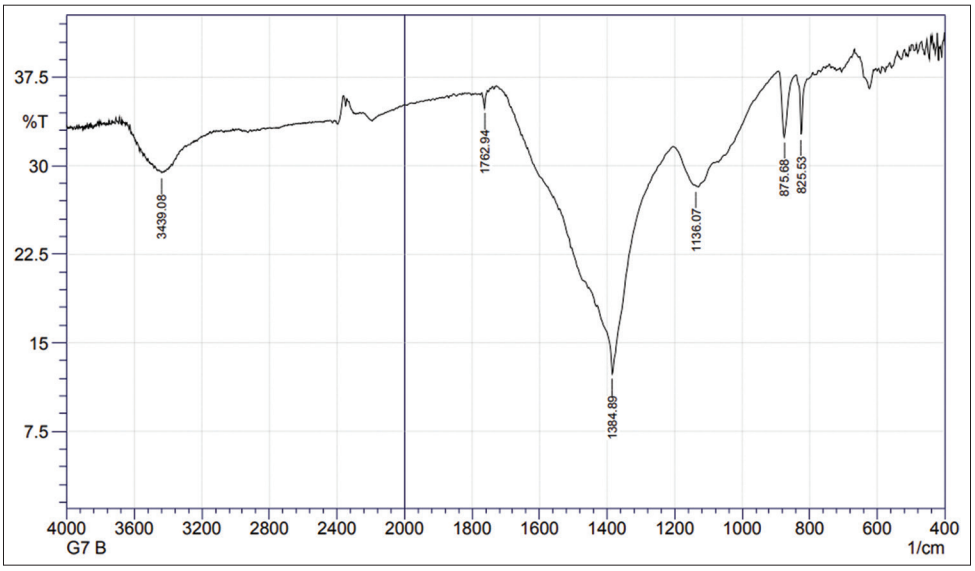

Figure 2: The results of Fourier transform-infrared spectrum of *Taraxacum officinale* leaf-silver nanoparticles

comprise tiny grains of material that have clumped together to form crystals with almost uniform spherical shapes and smooth surfaces. Similar findings have already been published.[34,37,40] The elemental analysis of the material has been shown in Figure 4 by the EDX spectrum of the produced AgNPs. Silver peaks can be detected in the spectrum, indicating that silver ions are one of the ingredients used to make synthetic AgNPs. The weight percentage and atomic percentage of the Ag peak were 41 and 3.21, respectively. Au, Na, and Cu, among other peaks, were seen. These components were derived from the TOL extract biomolecules that were attached to the surface of the AgNPs.[35,41,42]

Examination of Biochemical Analysis

The injection of CCl_4 markedly ($P = 0.05$) improved the activity of the AST and ALP a liver blood marker enzymes as matched to the control group. Although there has been a little rise in the ALT level, it is not statistically significant. Table 1 showed that when TOL-AgNPs were used in comparison to the CCl_4 group, increases in the production of these enzymes were considerably reduced ($P = 0.05$) by 100 mg/kg BW and 200 mg/kg BW, respectively.

The results of the present study showed that CCl_4 -induction in rats considerably raised the levels of AST and ALP and marginally but insignificantly raised the levels of ALT. As a result of the acute hepatocyte damage and impaired membrane integrity brought on by CCl_4, the hepatocytes' enzymes leak out.[43] The abnormal elevations in ALT, AST, and ALP were, however, dramatically reduced following treatment with TOL-AgNPs, coming to those in the control. These findings support prior research in that TOL-AgNPs have the capacity to defend against CCl_4-induced hepatocyte damage.[44] That reported the protective consequences of polyphenolic compounds in TOL-AgNPs against CCl_4-induced liver cirrhosis.

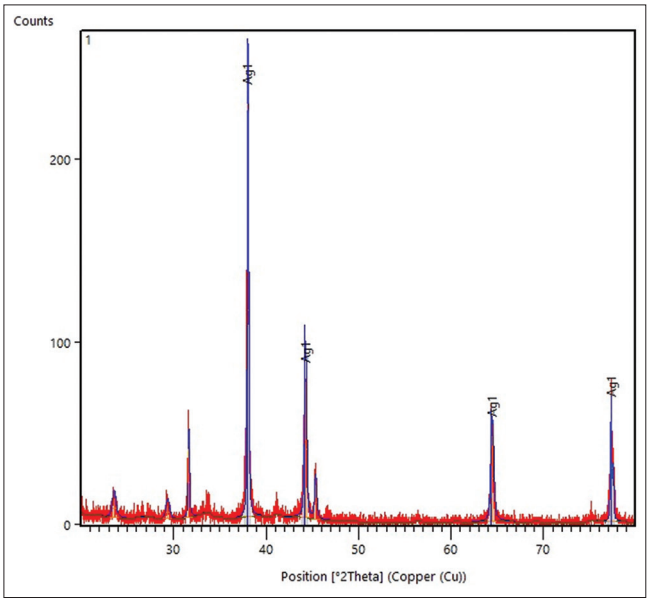

Figure 3: X-ray diffraction analysis of the *Taraxacum officinale* leaf-silver nanoparticles

Estimation of Oxidative Stress Biomarkers

Table 2 provides MDA levels. The findings showed that the MDA levels in the CCl_4 group were substantially higher ($P = 0.05$) than those in the control group. In comparison to the CCl_4 group, the *T. officinale* AgNPs treated groups at doses of 100 mg/kg BW and 200 mg/kg BW considerably ($P = 0.05$) lowered the MDA level.

Rats treated with CCl_4 had considerably lower ($P = 0.05$) SOD activity and marginally higher (statistically non-significant) GSH levels than the control group. Administration of 100 mg/kg BW and 200 mg/kg BW of *T. officinale* AgNPs in comparison to CCl_4 rats resulted in a rise in lipid peroxidation, a decrease in the activities of antioxidant enzymes, and a substantial increase ($P = 0.05$) in GSH levels.[43]

Throughout their lives, both humans and animals are exposed to hepatotoxic substances. Unfortunately, there is no effective medication for liver disease prevention or therapy. Consequently, academics, owners of domestic animals, and the general public are becoming more interested in complementary and supportive treatments.[45] Free radicals and oxidative stress from hazardous chemicals that cause lipid peroxidation, such as CCl_4, lead to liver damage.[26] MDA is a significant biomarker of lipid peroxidation.[6] The findings of this investigation confirm the harmful effects of CCl_4.[46] It was corroborated by histopathological findings, an elevated

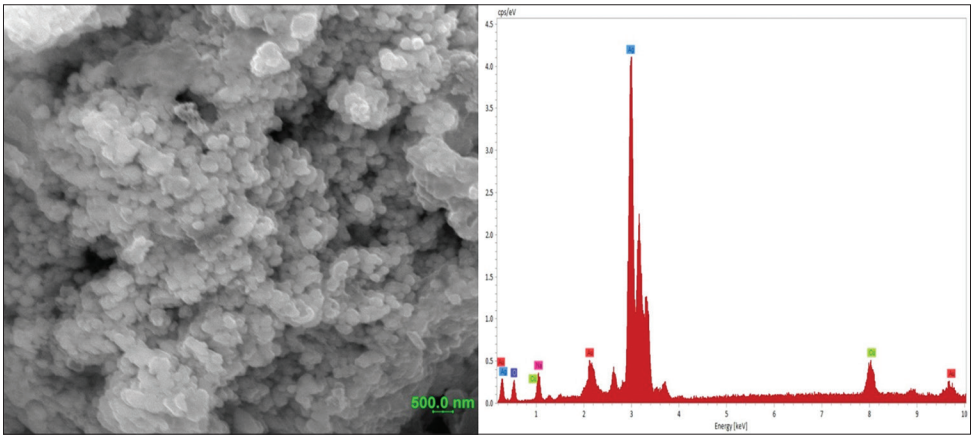

Figure 4: The photos of the scanning electron microscope and energy dispersive X-ray of the *Taraxacum officinale* leaf-silver nanoparticles

Table 1: The effect of CCl_4 and TOL-AgNPs on indices of hepatotoxicity

Groups	Experimental parameters		
	AST (U/L)	ALT (U/L)	ALP (U/L)
Control	88.02±7.724[b]	28.36±4.893[a]	106.8±7.155[b]
Olive oil	108.12±24.456[a]	30.04±9.371[a]	101.38±10.164[b]
AgNPs 100 mg/kg	101.76±14.285[a]	29.58±10.262[a]	110.2±27.797[b]
AgNPs 200 mg/kg	126.32±45.265[a]	25.5±10.321[a]	111.2±20.104[b]
CCl_4+Olive oil	149.92±8.320[a]	33.82±4.223[a]	155.8±33.789[a]
CCl_4+Olive oil+AgNPs 100 mg/kg	101.56±17.928[a]	24.72±2.192[a]	95.6±10.502[b]
CCl_4+Olive oil+AgNPs 200 mg/kg	93.42±28.241[b]	26.98±7.487[a]	82±25.700[b]

The same letter in the columns means a non-significant differences among parameters at $P<0.05$[a, b, c]. AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, ALP: Alkaline phosphatase, TOL-AgNPs: *Taraxacum officinale* leaf-silver nanoparticles, CCl_4: Carbon tetrachloride

Table 2: The effect of CCl_4 and TOL-AgNPs on assessment of oxidative stress

Groups	Experimental parameters		
	MDA	GSH	SOD
Control	1.19±0.38[b]	71.02±9.64[a]	72.32±5.14[a]
Olive oil	1.32±0.37[b]	76.86±62.64[a]	78.42±6.86[b]
AgNPs 100 mg/kg	1.36±0.72[b]	79.71±28.14[a]	89.16±2.76b[c]
AgNPs 200 mg/kg	1.29±0.64[b]	81.86±9.29[a]	84.51±1.46[a]
CCl_4+Olive oil	2.76±0.83[a]	59.63±11.96[a]	63.58±5.33[a]
CCl_4+Olive oil+AgNPs 100 mg/kg	1.25±0.64[b]	70.70±13.47[a]	79.22±14.30[b]
CCl_4+Olive oil+AgNPs 200 mg/kg	2.08±0.78[a]	66.66±23.07[a]	82.40±6.21[b]

The same letter in the columns means a non-significant differences among parameters at $P<0.05$[a, b, c]. TOL-AgNPs: *Taraxacum officinale* leaf-silver nanoparticles, CCl_4: Carbon tetrachloride, MDA: Malondialdehyde, GSH: Glutathione, SOD: Superoxide dismutase

MDA level, and a declining GSH level. similar to the findings of the research by Gad *et al.*[47] Groups 6 and 7 dramatically reduced MDA levels, comparable to the outcomes shown in Group 5.[48] SOD and GSH levels were higher than in the CCl_4 group. It was discovered that Groups 6 and 7 were effective for hepatoprotection. Compared to the CCl_4 group, the GSH and SOD levels in this group rose. These findings align with the body of literature.[26] Compared to the CCl_4 group, the La group's MDA levels dropped while SOD and GSH levels rose, which is consistent with the literature.[49] The findings confirm the effectiveness of several *T. officinale* AgNPs as antioxidants.[50]

Histopathological Examination

The histopathologic results of the liver tissue of the animals in the control group revealed usual liver architecture with normal central vein and normal arrangement of hepatocytes [Figure 5a and b]. Tissue sections from the TOL-AgNP-treated group alone showed a normal structure equivalent to the control to the control groups [Figure 5c and d].

In the CCl_4-treatment groups, many changes are occurs like (vein wall disruption, necrosis around the vein), cholestasis (bile out in channel), inflammatory cells infiltration, hepatocyte necrosis, fatty liver changes, arteria sclerosis, sinusoid wideness (dilatation), as shown in [Figure 5e-h].

However, the histological sections of the concurrently treated groups with TOL-AgNPs at an oral dosage of 100 mg/kg revealed that TOL-AgNPs maintained hepatocyte arrangement, no fatty liver changes and mild perivascular hepatocytic infiltration were seen, as well as a noticeable decline in penetration of the inflammatory cells., as shown in [Figure 5g-J], respectively.

Liver damage is a major health issue and a global public health burden.[51] The assertion was substantiated by necrosis and inflammatory cell infiltration discovered during the histological investigation of microphotographs of liver sections.[52]

In this investigation, CCl_4 injection led to considerable inflammatory cell infiltration, passive hyperemia, hepatocyte degradation, and the emergence of fat vacuoles across the whole liver. The liver damage generated by CCl_4 was reduced by protecting the hepatocyte basal membrane and reducing inflammatory cell infiltration with a fat accumulation of AgNPs, as in earlier studies.[52] In our investigation, administering AgNPs decreased inflammation and hepatocellular disintegration while maintaining the structure of the remark cords. Histopathological data revealed that TOL was the most effective hepatoprotective species, as previously reported by Karkos *et al.*[53]

When compared to normal control rats, animal given CCl_4 had higher blood levels of ALT, AST, and ALP ($P = 0.05$), according to the study's findings. A sudden increase in serum transaminases indicated that CCl_4 caused serious toxicity. Necrosis and inflammatory cell infiltration seen during the histological analysis of microphotographs of liver sections supported the claim.[52] In this work, rats who were drunk

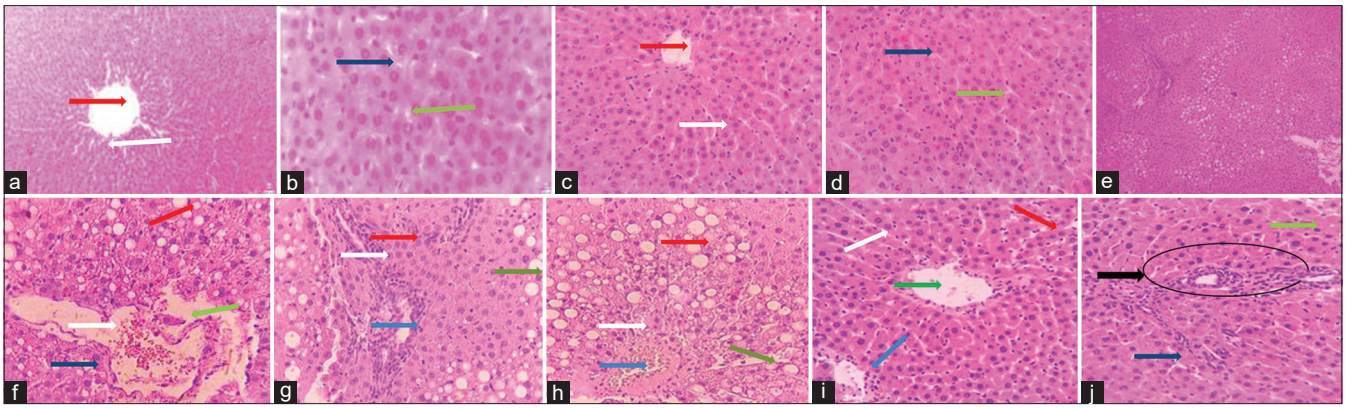

Figure 5: Histopathological examination demonstrating the effects of *Taraxacum officinale* leaf-silver nanoparticles (TOL-AgNPs) against CCl_4 on rat's liver tissues following addition of (AgNPs). (a and b) The control group: Showed normal histological structure: Central vein (red arrow), hepatocytes and sinusoids (white arrow), normal nucleus (blue arrow), normal Kupffer cells (green arrow), (H and E, ×10, ×40, respectively); (c and d) The TOL-AgNPs -treated group: The section through the liver of TOL-AgNPs alone group showed, maintained normal liver architecture, no significant histopathological changes were seen in which: Normal central vein (red arrow), normal sinusoids (white arrow), normal hepatocytes (blue arrow), and normal binuclear (green arrow), (H and E, ×10, ×40, respectively); (E and F) CCl_4 + olive oil group: The liver section through the CCl_4 group showed: Fatty changes (red arrow), vein wall disruption (white arrow), necrosis around the vein (blue arrow): Sinusoid wideness, sinusoidal cell hypertrophy, and apoptosis (green arrow), (H and E, ×10 and ×40 respectively); (g and h) CCl_4 + Olive oil group showed epithelia cell pyknosis of bile duct (red arrow), waste nuclement in the bile duct (white arrow), mild perivascular inflammation, periductal inflammatory cells infiltration (blue arrow), fatty liver changes (green arrow), (H) showed fatty liver changes (red arrow), inflammatory cell infiltration (white arrow), arteria sclerosis, vascular congestion and vascular hyaline changes (blue arrow), and sinusoid (dilatation) (green arrow), (H and E, ×10, ×40, respectively); (i and j) CCl_4 and Olive oil + AgNPs of *T. officinale* treated group showed maintained hepatocyte arrangement: mild sinusoid dilation (red arrow), normal sinusoid (white arrow), vascular congestion (blue arrow), vascular dilation (green arrow), mild portal chronic inflammation (black arrow), normal sinusoid (white arrow), mild sinusoid dilation (blue arrow), karyomegally, mild periductal chronic inflammation, and vascular dilation (green arrow) (H and E, ×10, ×40, respectively)

with CCl_4 had their raised liver function levels brought back to normal levels by administering AgNPs of *T. officinale* at a dosage of 100 mg/kg B.W.

The findings of this investigation confirm the harmful effects of CCl_4[46] were verified by elevated MDA levels, declining GSH levels, enzyme activity, and histopathological results. similar to the findings of the Gad *et al.*[47] MDA levels were dramatically reduced in the AgNPs group. These findings align with the body of literature.[26] The results support the antioxidant efficiency of selected plant species.

CONCLUSION

In this study, green biosynthesized AgNPs, TOL-AgNPs, were found to have an antioxidant potential on rat liver injury. One of the greatest methods of understanding the underlying structure of hepatotoxicity and development, in addition to, complete therapeutic options, is to use a rodent model for liver injury. According to the present study, such antioxidants, anti-inflammation, and enhanced potency of TOL-AgNPs against CCl_4 toxicity were achieved through the lowering amounts of the biochemical parameters as well as restoring their amounts to standard levels across all nano-extract treatment groups. In addition, the decrement in damages caused by CCl_4 in animals treated was revealed by microscopic proofs that showed considerable antioxidant activity.

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