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Research Article

Assessing the Effects of *Solanum incanum* Aerial Parts on Hematological and Biochemical Parameters in a Rat Model

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Abstract

Solanum incanum is a woody, thorny, biennial herb with spherical, yellow fruits containing numerous black seeds. Belonging to the Solanaceae family, the plant is traditionally used in Arab countries for the treatment of skin and fungal diseases, toothaches, scorpion stings, and hemorrhoids. This study aimed to evaluate the toxicological and safety profile of aqueous extracts of *Solanum incanum* aerial parts in male albino rats at high, medium, and low doses over a period of 14 and 28 days. The rats were divided into control and experimental groups, receiving various doses of the plant extract. Hematological parameters (such as Red Blood Cell count, Hemoglobin concentration, White Blood Cell count, Hematocrit, Mean Corpuscular Volume, Mean Corpuscular Hemoglobin, Mean Corpuscular Hemoglobin Concentration, Platelet Count and Lymphocyte Count) and biochemical markers (including AST, ALT, ALP, Total Protein, Glucose, and Cholesterol) were monitored to assess blood health and liver function. Statistical analysis revealed that while hematological parameters showed no significant changes (except WBC and PLT at low dose after 14 days, RBC and HGB at medium dose and LYM after 28 days), liver enzyme levels (AST, ALT, ALP) decreased significantly. Glucose levels increased, and cholesterol levels decreased. These findings suggest potential hepatoprotective effects of the extract, though its impact on glucose metabolism raises concerns, particularly at higher doses. Further research is recommended.

Keywords: *Solanum incanum*, Hematological Effects, Biochemical Markers, Liver Function, Dose-Dependent Response, Male Albino Rats

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Introduction

A growing number of individuals rely on herbal medicines for healthcare due to the high cost and adverse side effects associated with conventional treatments. Consequently, there is a need for scientific documentation on the safety and potential toxicity of medicinal plants. One such plant is *S. incanum*, commonly referred to as "Hadaq," thorn apple, bitter apple, or bitterball. Native to Arab countries, sub-Saharan Africa, the Middle East, and India, *S. incanum* belongs to the Solanaceae family. The plant is renowned for its bioactive compounds, which have applications in treating various human and animal ailments. In Arab countries, it is used to alleviate sore throats, toothaches, stomachaches, headaches, painful menstruation, liver pain, and rheumatism, among other conditions (Lashin *et al.*, 2021; Belayneh *et al.*, 2021).

The hydromethanol extracts of *S. incanum* leaves and roots have demonstrated anti-ulcerogenic properties in *in vivo* studies, exhibiting protective effects on gastric mucosa rather than directly reducing acid secretion (Belayneh *et al.*, 2021). Phytochemical investigations of *S. incanum* have isolated nine compounds, including steroidal glycoalkaloids, neolignans, phenolics, and coumarin glucosides (Sakah and Zhang, 2020). Preliminary analysis has confirmed the presence of flavonoids, tannins, saponins, alkaloids, terpenoids, glycosides, and steroids in the plant's extracts (Demisse and Awoke, 2016).

The root extract of *S. incanum* has been shown to possess antihyperglycemic and antihyperlipidemic activities, likely due to its diverse bioactive phytochemicals, which include flavonoids, tannins, phenols, and anthraquinones (Andargie *et al.*, 2022). Additionally, the plant exhibits potent antimicrobial activity, effective against bacteria, yeasts, dermatophytes, and certain agricultural pathogens (Griffin *et al.*, 2016). Glycoalkaloids such as solamargine, solasodine, and solasonine have been identified as key components in the plant's anticancer activity. Solamargine, for instance, induces apoptosis in cancer cells by activating both the Fas and mitochondrial apoptotic pathways (Desta *et al.*, 2020; Yu *et al.*, 2017). The primary objective of this research was to evaluate the toxicological and safety profile of *S. incanum* aerial parts through hematological and biochemical assessments in male albino rats. The study aimed to analyze the dose-dependent response to high, medium, and low doses of aqueous extracts over two time periods (14 and 28 days), with a particular focus on liver function and potential hepatoprotective or toxic effects.

Materials and Methods

Study Area

The aerial parts of *Solanum incanum* were collected from Al-Faki Hashim village in the Al-Kadaru region, Khartoum North, Sudan. The study was conducted over a period from 2017 to 2021.

Plant Material

After collection, the plant material was thoroughly cleaned and dried in the shade, away from moisture, in a

well-ventilated area. Once fully dried, the plant was ground into a fine powder using an electric grinder. The powder was stored in an airtight glass container to maintain its quality.

Experimental Animals

Male albino rats were sourced from the National Research Center in Khartoum and the Faculty of Pharmacy at the University of Khartoum. The animals were housed in group-specific cages and provided with adequate environmental conditions, including proper temperature, ventilation, and lighting. Food and water were supplied in sufficient amounts (National Research Council, 2011).

Preparation of Plant Extract

To prepare the plant extract, 200 grams of the powdered plant material was mixed with 1600 ml of boiling water in a glass beaker and left to steep for 24 hours. The mixture was then filtered, with the filtrate collected and the residue discarded. The collected filtrate was concentrated by evaporation using a water bath set at 45°C until fully dried. The resulting dried extract was stored in glass containers for future use.

Administration of Extract

The experiment involved 20 adult male rats, each weighing between 90 and 130 grams, and aged 12–14 weeks. The rats were divided into four groups, with five rats per group. The plant extract was administered orally via a stomach tube daily for a duration of one month.

- Group 1 received 8 mg/kg of body weight.
- Group 2 received 24 mg/kg of body weight.
- Group 3 received 40 mg/kg of body weight.
- Group 4 (Control) was provided with a normal diet without extract administration. (Salah and Anwar, 2015).

Measurement of Hematological and Biochemical Variables

The aqueous extract was administered at low, medium, and high doses to the respective groups. Blood samples were collected using capillary tubes from the corner of the eye at three time points: prior to extract administration (control), after 14 days, and after 28 days. The serum was separated by centrifugation and stored at -20°C until further analysis. On the 30th day, hematological and biochemical variables were measured (Cooper and Moulton, 1996; Lushaj and Zec, 2018; Tietza, 1995).

Biochemical Tests

Commercially available kits from BioSystems S.A. (Barcelona, Spain) and Coromatest (Linear Chemicals, Spain) were used to conduct biochemical investigations. The following tests were performed:

AST (Aspartate Aminotransferase) Test: This test was conducted using BioSystems commercial solutions according to the kit's instructions. Briefly, 1 ml of reagent was mixed with 50 µl of serum, and the reaction was monitored at 37°C. Readings were taken every minute for three minutes using a spectrophotometer, and AST concentration was calculated.

ALP (Alkaline Phosphatase) Test: Performed with BioSystems kits, following the manufacturer's protocol, measurements were taken at 405 nm.

ALT (Alanine Aminotransferase) Test: This test also followed BioSystems instructions, using a commercial reagent solution.

Total Protein Test: Using a commercial reagent from BioSystems, the total protein content in the serum was measured at a wavelength of 545 nm.

Glucose Test: The serum glucose concentration was determined using a BioSystems reagent, measured at 500 nm and conducted at 37°C in a water bath.

Cholesterol Test: Serum cholesterol levels were measured using a commercial reagent from BioSystems, following the provided instructions, and readings were taken at a wavelength of 500 nm.

Statistical Analysis

Data were expressed as mean $\pm$ standard deviation (SD). Statistical significance was assessed using Student's t-

test, performed with GraphPad Software (San Diego, California, USA). A p-value of <0.05 was considered statistically significant (Rosemary, 2004).

Results and Discussion

In this study, the effects of *Solanum incanum* aqueous extract were evaluated at three different doses, low, medium and high (8, 24, and 40 mg/kg/day, respectively), administered orally for four weeks. Hematological and biochemical parameters were analyzed in male albino rats from both the control and treated groups after 14 and 28 days.

Hematological results after 14 and 28 days of treatment are summarized in Tables 4.1 – 4.5. The following hematological parameters were measured: white blood cells (WBC), red blood cells (RBC), hemoglobin (Hgb), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), platelet count (PLT), and lymphocyte count (LYM).

Table 4.1 The effects of *Solanum incanum* aqueous extract on hematological parameters in male albino rats after 14 days of dosing

Parameters	Control Group	Treated Groups		
		8 mg/Kg	24 mg/Kg	40 mg/Kg
WBC($\times 10^3$ /ul)	11.34 $\pm$ 4.64	10.92 $\pm$ 7.78*	7.62 $\pm$ 3.01	9.38 $\pm$ 1.40
RBC($\times 10^6$ /ul)	7.07 $\pm$ 0.56	7.07 $\pm$ 0.56	6.60 $\pm$ 0.24**	7.08 $\pm$ 0.66
HGb g/dL	11.96 $\pm$ 0.60	12.06 $\pm$ 0.79	11.26 $\pm$ 0.313*	12.06 $\pm$ 1.04
HCT fl	39.54 $\pm$ 2.81	40.56 $\pm$ 3.19	37.34 $\pm$ 1.35	40.18 $\pm$ 3.28
MCV fl	55.96 $\pm$ 2.50	57.38 $\pm$ 1.18	56.54 $\pm$ 0.48	56.82 $\pm$ 2.21
MCH pg	16.88 $\pm$ 0.83	17.08 $\pm$ 0.66	17.06 $\pm$ 0.37	17.06 $\pm$ 0.84
MCHC g/dL	30.28 $\pm$ 0.80	29.78 $\pm$ 0.76	30.18 $\pm$ 0.81	30.04 $\pm$ 0.54
PLT ($\times 10^3$ /ul)	1040.8 $\pm$ 109.81	707.4 $\pm$ 318.8*	950.4 $\pm$ 70.44	989.8 $\pm$ 180.34
LYM %	76.94 $\pm$ 18.66	69.48 $\pm$ 31.13	90.28 $\pm$ 3.45	60.24 $\pm$ 10.68

Values are expressed as mean $\pm$ SD of five replicates.

*Significant at $p<0.05$; **significant at $p<0.01$

Table 4.2. The effects of *Solanum incanum* aqueous extract on hematological parameters in male albino rats after 28 days of dosing

Parameters	Control Group	Treated Groups		
		8 mg/Kg	24 mg/Kg	40 mg/Kg
WBC($\times 10^3$ /ul)	10.86 $\pm$ 4.56	8.72 $\pm$ 5.10	7.87 $\pm$ 3.76	11.56 $\pm$ 2.79
RBC($\times 10^6$ /ul)	6.61 $\pm$ 0.344	5.81 $\pm$ 2.015	6.75 $\pm$ 0.46	7.04 $\pm$ 0.55
HGb g/dL	12.22 $\pm$ 0.60	10.14 $\pm$ 5.736	12.82 $\pm$ 0.90	12.88 $\pm$ 1.082
HCT fl	38.26 $\pm$ 2.55	34.02 $\pm$ 12.252	39.77 $\pm$ 3.266	32.56 $\pm$ 17.35
MCV fl	58.82 $\pm$ 2.318	58.1 $\pm$ 1.809	58.82 $\pm$ 0.884	55.8 $\pm$ 5.799
MCH pg	18.72 $\pm$ 0.44	15.12 $\pm$ 8.465	19.02 $\pm$ 1.108	18.32 $\pm$ 0.983
MCHC g/dL	31.86 $\pm$ 1.35	25.68 $\pm$ 14.372	32.275 $\pm$ 1.844	31.78 $\pm$ 1.98
PLT ($\times 10^3$ /ul)	1029.8 $\pm$ 248.6	933.4 $\pm$ 140.13	1085.2 $\pm$ 220.26	948.4 $\pm$ 449.20
LYM %	44.72 $\pm$ 3.497	46.96 $\pm$ 22.37	65.8 $\pm$ 14.78*	63.89 $\pm$ 4.22*

Values are expressed as mean $\pm$ SD of five replicates.

*Significant at $p<0.05$; **significant at $p<0.01$

Table 4.3. Comparison between Control group and treating group (8 mg/Kg b.w of aqueous extract) of *Solanum incanum* after 14 and 28 days for haematological parameters in rats

Parameters	After 14 days				After 28 days			
	t-value	p-value	S	%Change	t-value	p-value	S	%Change
WBC	0.1036	0.0460	S*	3.70 d	0.6788	0.25820	NS	19.71 d
RBC	0.01115	0.49569	NS	No change	0.87721	0.202973	NS	12.10 d
HGB	0.2235	0.414370	NS	0..84 i	0.80629	0.221692	NS	17.02 d
HCT	0.53609	0.30324	NS	2.58 i	0.7859	0.22728	NS	11.08 d

MCV	1.15405	0.140894	NS	2.54 i	0.54734	0.299538	NS	No change
MCH	0.41721	0.343748	NS	1.18 i	0.94965	0.185047	NS	19.23 d
MCHC	1.00241	0.172749	NS	1.65 d	0.95721	0.183244	NS	19.40 d
PLT	2.21049	0.02901	S*	31.98 d	0.75527	0.235869	NS	9.38 d
LYM	0.45951	0.329049	NS	9.70 d	0.82881	0.215627	NS	5.01 i

d=decrement ; i=increment ; S = Significant, NS = Non-significant ;

*Significant at $p<0.05$; **significant at $p<0.01$

After 14 days: Only two p-values meet the significance threshold of $p<0.05$. None meet the $p<0.01$ threshold.

After 28 days: None meets the $p<0.05$ and $p<0.01$ thresholds.

Table 4.4. Comparison between Control group and treating group (24 mg/Kg b.w of aqueous extract) of *Solanum incanum* after 14 and 28 days for haematological parameters in rats

Parameters	After 14 days				After 28 days			
	t-value	p-value	S	Change (%)	t-value	p-value	S	Change (%)
WBC	1.50	0.857	NS	32.80 d	1.02828	0.169016	NS	27.53 d
RBC	1.70383	0.0063408	S**	6.65 d	0.54009	0.302941	NS	No change
HGB	2.29293	0.02551	S*	5.85 d	1.19977	0.134628	NS	4.91 i
HCT	1.57578	0.76863	NS	5.56 d	0.74656	0.239825	NS	3.9 i
MCV	0.50846	0.312427	NS	1.04 i	0.00404	0.498446	NS	No change
MCH	0.43916	0.336085	NS	1.07 i	0.56862	0.293692	NS	1.60 i
MCHC	0.1947	0.425241	NS	0.33 d	0.39083	0.353774	NS	1.30 i
PLT	1.54941	0.079938	NS	8.62 d	0.34893	0.3687	NS	5.44 d
LYM	1.56981	0.077549	NS	17.34 i	2.47286	0.021327	S*	47.14 i

d=decrement ; i=increment ; S = Significant, NS = Non-significant

*Significant at $p<0.05$; **significant at $p<0.01$

After 14 days: Only 0.0063408 meets the $p<0.01$ threshold and 0.02551 meets the $p<0.05$ threshold. The rest are not significant.

After 28 days: Only 0.021327 meets the $p<0.05$ threshold. The rest are not significant.

Table 4.5. Comparison between Control group and treating group (40 mg/Kg b.w of aqueous extract) of *Solanum incanum* after 14 and 28 days for haematological parameters in rats

Parameters	After 14 days				After 28 days			
	t-value	p-value	S	% Change	t-value	p-value	S	% Change
WBC	0.9025	0.19656	NS	17.28 d	0.31737	0.379545	NS	6.45 i
RBC	0.020	0.492058	NS	0.14 i	1.46644	0.090351	NS	6.51i
HGB	0.185	0.428918	NS	0.84 i	1.1877	0.134509	NS	5.40 i
HCT	0.3308	0.374645	NS	1.62 i	1.17583	0.136734	NS	14.90 d
MCV	0.575	0.29055	NS	1.54 i	1.08214	0.155552	NS	5.13 d
MCH	0.33776	0.372117	NS	1.07 i	0.82903	0.215564	NS	No change
MCHC	0.55205	0.297997	NS	0.79 d	0.10469	0.459601	NS	No change
PLT	0.5401	0.301916	NS	4.83 d	0.35451	0.366059	NS	7.83 d
LYM	1.73592	0.060395	NS	21.71 d	3.05109	0.007897	S**	42.87 i

d=decrement ; i=increment ; S = Significant, NS = Non-significant

*Significant at $p<0.05$; **significant at $p<0.01$

After 14 days: None of these p-values meet the significance thresholds of $p<0.05$ or $p<0.01$.

After 28 days: Only 0.007897 meets the $p<0.01$ threshold. The rest are not significant.

White Blood Cells (WBC): After 14 days, non-significant reductions were observed in WBC counts at doses of 24 mg/kg (32.80%) and 40 mg/kg (17.28%). After 28 days, WBC levels showed non-significant decreases at 8 mg/kg (19.71%) and 24 mg/kg (27.53%), while a slight, non-significant increase of 6.45% was noted at 40 mg/kg (Tables 4.3-4.5).

Red Blood Cells (RBC): After 14 days, RBC counts decreased non-significantly by 6.65% at 24 mg/kg, while a significant increase of 0.14% was noted at 40 mg/kg, with no change at 8 mg/kg. After 28 days, RBC counts showed a non-significant decrease of 12.10% at 8 mg/kg and an increase of 6.51% at 40 mg/kg. No change was recorded at 24 mg/kg (Tables 4.3-4.5).

Hemoglobin (HGb): After 14 days, Hgb levels showed non-significant increases of 0.84% at 8 and 40 mg/kg, with a significant decrease of 5.85% at 24 mg/kg. After 28 days, Hgb levels increased non-significantly by 4.91% and 5.40% at 24 and 40 mg/kg, respectively, and a 17.02% decrease was noted at 8 mg/kg (Tables 4.3-4.5).

Hematocrit (HCT): After 14 days, HCT levels increased non-significantly at doses of 8 and 40 mg/kg by 2.58% and 1.62%, respectively, with a non-significant decrease of 5.56% at 24 mg/kg. After 28 days, HCT levels decreased non-significantly at 8 and 40 mg/kg by 11.08% and 14.90%, respectively, while an increase of 3.95% was recorded at 24 mg/kg (Tables 4.3-4.5).

Mean Corpuscular Volume (MCV): After 14 days, MCV showed non-significant increases at all doses: 8

mg/kg (2.54%), 24 mg/kg (1.04%), and 40 mg/kg (1.54%). After 28 days, a non-significant decrease of 5.13% was recorded at 40 mg/kg (Tables 4.3-4.5).

Mean Corpuscular Hemoglobin (MCH): Non-significant increases in MCH were observed across all doses after 14 days: 8 mg/kg (1.18%), 24 mg/kg (1.07%), and 40 mg/kg (1.07%). After 28 days, MCH decreased non-significantly by 19.23% at 8 mg/kg, while a non-significant increase of 1.60% was noted at 24 mg/kg (Tables 4.3-4.5).

Mean Corpuscular Hemoglobin Concentration (MCHC): After 14 days, non-significant decreases were seen at all doses: 8 mg/kg (1.65%), 24 mg/kg (0.33%), and 40 mg/kg (0.79%). After 28 days, MCHC showed a non-significant decrease of 19.40% at 8 mg/kg and a slight increase of 1.30% at 24 mg/kg, with no change at 40 mg/kg (Tables 4.3-4.5).

Platelet Count (PLT): After 14 days, platelet counts decreased non-significantly at 24 mg/kg (8.62%) and 40

mg/kg (4.83%), while a significant decrease of 31.98% was recorded at 8 mg/kg. After 28 days, non-significant decreases in platelet counts were observed at all doses: 8 mg/kg (9.38%), 24 mg/kg (5.44%), and 40 mg/kg (7.83%) (Tables 4.3-4.5).

Lymphocyte Count (LYM): After 14 days, lymphocyte levels decreased non-significantly at 8 mg/kg (9.70%) and 40 mg/kg (21.71%), with a non-significant increase of 17.34% at 24 mg/kg. After 28 days, significant increases were observed at 40 mg/kg (42.87%) and 24 mg/kg (47.14%) ($p < 0.05$), while a non-significant increase of 5.01% occurred at 8 mg/kg (Tables 4.3-4.5). Biochemical Results: The biochemical effects of *Solanum incanum* extract after 14 and 28 days of treatment are presented in Tables 4.6 and 4.7. The following markers were analyzed: Aspartate Aminotransferase (AST), Alanine Aminotransferase (ALT), Alkaline Phosphatase (ALP), Total Protein, Glucose, and Cholesterol.

Table 4.6. The effects of *Solanum incanum* aqueous extract on biochemical parameters in male albino rats after 14 days of dosing

Parameters	Control Group	Treated Groups		
		8 mg/Kg	24 mg/Kg	40 mg/Kg
AST	172.61±16.52	154.80±33.57	132.98±21.49**	114.06±28.99**
ALT	26.26±5.04	28.98±9.78	23.74±10.50	25.00±6.35
ALP	416.804±37.12	256.49±115.71	139.66±47.51	106.17±59.09*
Total Protein	7.31±0.91	6.71±0.59	7.13±0.74	7.29±0.51
Glucose	52.93±24.62	51.06±18.59	92.99±21.11*	67.39±16.10
Cholesterol	74.50±4.26	69.24±5.73	69.02±4.43*	50.12±14.66

Values are expressed as mean ± SD of five replicates.

*Significant at $p < 0.05$; **significant at $p < 0.01$

Table 4.7. The effects of *Solanum incanum* aqueous extract on biochemical parameters in male albino rats after 28 days of dosing

Parameters	Control Group	Treated Groups		
		8 mg/Kg	24 mg/Kg	40 mg/Kg
AST	172.61±16.52	3.69±2.27**	5.50±3.17**	6.83±3.43**
ALT	26.26±5.04	4.93±2.72**	8.79± 3.84**	5.24±3.12**
ALP	416.804±37.12	3.12±0.34**	3.15±0.41**	15.32±26.7**
Total Protein	7.31±0.91	5.98±0.32**	6.1±0.31*	6.02±0.41*
Glucose	52.93±24.62	95.8±14.3**	114.25±31.7**	97.8±15.18**
Cholesterol	74.50±4.26	70.4±13.31	66.25±8.77	58.00±11.5**

Values are expressed as mean ± SD of five replicates.

*Significant at $p < 0.05$; **significant at $p < 0.01$

Table 4.8. Comparison between Control group and treating group (8 mg/Kg b.w of aqueous extract) of *Solanum incanum* after 14 and 28 days for biochemical parameters in rats

Parameters	After 14 days				After 28 days			
	t-value	p-value	S	Change (%)	t-value	p-value	S	Change (%)
AST	1.06438	.159113	NS	10.32 d	22.6491	0.00001	S**	97.86 d
ALT	0.55127	.298253	NS	10.36 d	8.3252	0.000016	S**	81.23 d
ALP	1.62748	.071143	NS	38.46 d	9.93441	0.00001	S**	99.25 d
Total Protein	1.22957	.126895	NS	8.21 d	3.05711	0.007826	S**	18.19 d
Glucose	0.13537	.447833	NS	3.53 d	3.36571	0.004924	S**	80.99 i
Cholesterol	1.64468	.069328	NS	7.06 d	0.65665	0.264918	NS	5.50 d

d=decrement ; i=increment ; S = Significant, NS = Non-significant ;

*Significant at $p < 0.05$; **significant at $p < 0.01$

After 14 days: None of these p-values meet the significance thresholds of $p < 0.05$ or $p < 0.01$

After 28 days: All the p-values except 0.264918 meet the threshold of $p < 0.01$

Table 4.9. Comparison between Control group and treating group (24 mg/Kg b.w of aqueous extract) of *Solanum incanum* after 14 and 28 days for biochemical parameters in rats

Parameters	After 14 days				After 28 days			
	t-value	p-value	S	Change (%)	t-value	p-value	S	Change (%)
AST	3.26925	.005684	S**	22.96 d	19.67662	0.00001	S**	96.81 d
ALT	0.48522	.320264	NS	9.60 d	5.70297	0.00036	S**	66.53 d
ALP	1.0524	.161681	NS	66.49 d	8.75971	0.00002	S**	99.24 d
Total Protein	0.07702	.470251	NS	2.46 d	2.49541	0.02063	S*	16.55 d
Glucose	2.76197	.0123	S*	75.68 i	3.27399	0.0068	S**	115.85 i
Cholesterol	1.99174	.04077	S*	7.36 d	1.8690	0.05191	NS	11.07 d

d=decrement ; i=increment ; S = Significant, NS = Non-significant ;

*Significant at $p<0.05$; **significant at $p<0.01$

After 14 days: 0.005684 and 0.0123 meet $p<0.01$ and $p<0.05$, respectively. 0.04077 also meets $p<0.05$

After 28 days: 0.00001, 0.00036, 0.00002 and 0.0068 meet $p<0.01$. 0.02063 meets $p<0.05$ and 0.05191 was non-significant.

Table 4.10. Comparison between Control group and treating group (40 mg/Kg b.w of aqueous extract) of *Solanum incanum* after 14 and 28 days for biochemical parameters in rats

Parameters	After 14 days				After 28 days			
	t-value	p-value	S	Change (%)	t-value	p-value	S	Change (%)
AST	3.92374	.002198	S**	33.92 d	21.9684	0.00001	S**	96.04 d
ALT	0.34805	0.368391	NS	4.80 d	7.92681	0.000023	S**	80.05 d
ALP	1.98247	0.41366	NS	74.53 d	7.46222	0.000036	S**	96.32 d
Total Protein	0.03407	0.486828	NS	27.0 d	2.8683	0.010442	S*	17.65 d
Glucose	1.09927	0.151814	NS	27.32 i	3.46759	0.004236	S**	84.77 i
Cholesterol	3.56923	0.365	NS	32.72 d	2.99176	0.008644	S**	22.15 d

d=decrement ; i=increment ; S = Significant, NS = Non-significant ;

*Significant at $p<0.05$; **significant at $p<0.01$

After 14 days: 0.002198 meets $p<0.01$. The rest are not significant.

After 28 days: 0.00001, 0.000023, 0.000036 and 0.008644 meet $p<0.01$.

0.010442 meets $p<0.05$.

Aspartate Aminotransferase (AST): After 14 days, a non-significant decrease of 10.32% in AST levels was recorded at 8 mg/kg, while significant reductions were observed at 24 mg/kg (22.96%) and 40 mg/kg (33.92%) ($p<0.05$). After 28 days, significant reductions were seen across all doses, with reductions of 97.86% (8 mg/kg), 96.81% (24 mg/kg), and 96.04% (40 mg/kg) ($p<0.05$) (Tables 4.8-4.10).

Alanine Aminotransferase (ALT): After 14 days, non-significant decreases in ALT levels were observed at all doses: 8 mg/kg (10.36%), 24 mg/kg (9.60%), and 40 mg/kg (4.80%). However, after 28 days, significant reductions in ALT levels were noted at all doses: 81.23% (8 mg/kg), 66.53% (24 mg/kg), and 80.05% (40 mg/kg) ($p<0.05$) (Tables 4.8-4.10).

Alkaline Phosphatase (ALP): After 14 days, a significant reduction of 74.53% was observed at 40 mg/kg, while non-significant decreases were noted at 8 mg/kg (38.46%) and 24 mg/kg (66.49%) ($p<0.05$). After 28 days, significant reductions were observed at all doses, with ALP levels decreasing by 99.25% (8 mg/kg), 99.24% (24 mg/kg), and 96.32% (40 mg/kg) ($p<0.05$) (Tables 4.8-4.10).

Total Protein: After 14 days, non-significant reductions in total protein levels were recorded across all doses: 8.21% (8 mg/kg), 2.46% (24 mg/kg), and 27.0% (40 mg/kg). However, after 28 days, significant reductions were noted at 8 mg/kg (18.19%), 24 mg/kg (16.55%), and 40 mg/kg (17.65%) ($p<0.05$) (Tables 4.8-4.10).

Glucose: After 14 days, non-significant changes in glucose levels were noted: a decrease of 3.53% at 8

mg/kg, and increases of 75.68% (24 mg/kg) and 27.32% (40 mg/kg). After 28 days, significant increases were seen at all doses, with glucose levels rising by 80.99% (8 mg/kg), 115.85% (24 mg/kg), and 84.77% (40 mg/kg) ($p<0.05$) (Tables 4.8-4.10).

Cholesterol: After 14 days, a non-significant decrease in cholesterol levels by 7.06% was observed at 8 mg/kg, while significant reductions were noted at 24 mg/kg (7.36%) and 40 mg/kg (32.72%) ($p<0.05$). After 28 days, a non-significant reduction in cholesterol was observed at 8 mg/kg (5.50%), while significant reductions occurred at 24 mg/kg (11.07%) and 40 mg/kg (22.15%) ($p<0.05$) (Tables 4.8-4.10).

The findings showed a non-significant effect on WBC counts after 28 days, indicating that *Solanum incanum* does not significantly impact immune response at moderate doses. However, significant changes were observed in hemoglobin (Hgb) levels after 14 days and lymphocyte (LYM) counts after 28 days, following daily dose administration compared to the control. Other hematological parameters remained largely unchanged across all tested doses.

Significant reductions in AST levels at all doses after 28 days suggest potential hepatoprotective effects of *S. incanum*, rather than direct toxicity. The initial reductions at higher doses point to a dose-dependent influence on liver function. Similarly, reductions in ALT levels support the extract's hepatoprotective properties. Non-significant decreases initially suggest a moderate impact on liver function (Niagi *et al.*, 2015; Sambo and Pam, 2022).

The reduction in ALP levels may indicate a restorative effect on liver function, with higher doses showing near-complete normalization. However, the decrease in total protein levels could suggest impaired liver function or reduced protein synthesis, raising concerns about potential mild to moderate toxicity with prolonged exposure. This points to possible effects on both protein synthesis and lipid metabolism.

A significant increase in glucose levels at all doses after 28 days raises concerns about the extract's impact on metabolic processes, suggesting moderate to severe toxicity, warranting further investigation. Nonetheless, the plant's lipid-lowering properties demonstrate potential benefits in reducing cholesterol levels.

The study revealed a consistent, largely dose-dependent, significant change in biochemical parameters in male albino rats following daily administration of the extract. These results align with previous research on *S. incanum*, confirming its hepatoprotective and biochemical regulatory effects. The significant reductions in AST, ALT, ALP, and cholesterol levels affirm its therapeutic potential. However, the marked rise in glucose levels across all doses requires careful attention to the plant's metabolic effects.

The aqueous extract of *Solanum incanum* demonstrated mixed effects on hematological and biochemical markers. While significant improvements in liver enzyme levels suggest hepatoprotective properties, alterations in glucose and platelet levels, alongside variable responses in other parameters, indicate possible dose-dependent toxicity. These effects underscore the need for cautious evaluation and further research to thoroughly assess its safety and therapeutic potential.

Our findings synthesize the observed effects of *S. incanum* extract, highlighting both its potential benefits and risks. The study emphasizes the importance of further research to confirm these results and assess the extract's safety profile in a more comprehensive manner. While *S. incanum* shows promise as a therapeutic agent for liver protection and cholesterol management, careful consideration is needed regarding its effects on glucose metabolism and potential toxicity at higher doses.

Conclusion

The administration of *Solanum incanum* extract exhibited promising hepatoprotective effects, evidenced by the significant reduction in liver enzymes—AST, ALT, and ALP. Additionally, significant hematological improvements, particularly in RBC count and hemoglobin concentration, suggest potential hematopoietic benefits. However, the significant rise in glucose levels after 28 days indicates a potential risk of hyperglycemia, underscoring the need for further investigation into the extract's metabolic effects. Despite these concerns, *S. incanum* holds potential for therapeutic use in liver health and blood-related disorders, though caution is necessary due to its possible metabolic toxicity. Further studies are essential to fully characterize its toxicity profile and establish safe dosage limits.

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Ethical Approval

This study was conducted on healthy male albino rats weighing between 90 and 130 grams, housed under standard controlled conditions at the animal facility of the Faculty of Veterinary Medicine, Khartoum University. All relevant international, national, and institutional guidelines for animal care and use were strictly followed. Ethical approval for the study was granted under reference number 12 from the Faculty of Science and Technology, Omdurman Islamic University, in 2017.

CRedit Authorship Contribution Statement

Hatil H. El-Kamali: Conceptualization, Supervision, Methodology, Writing – Review and Editing . Amir M. Saad: Supervision, Writing – Review and Editing . Motea A. N. Aboras: Writing – Original Draft, Methodology, Data Curation, Formal Analysis . Somia A. M. El-Hassan: Investigation, Writing – Review and Editing . Abdalla M. Elimam: Investigation, Writing – Review and Editing

Declaration of Competing Interest: The authors declare no conflicts of interest.