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BIOCHEMICAL AND HISTOLOGICAL ASSESSMENT OF THE PROTECTIVE EFFECTS OF ETHANOLIC EXTRACT OF *Solanum torvum* ON MERCURY INDUCED LIVER AND STOMACH TOXICITY ON ADULT WISTAR RATS

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Abstract: **Mercury is a heavy metal recognized for its toxic effects on vital organs, particularly the liver and gastrointestinal tract. Solanum torvum, is traditionally valued for its medicinal properties, including antioxidant and anti-inflammatory effects. This study aimed to assess the protective effects of ethanolic extract of Solanum torvum on mercury-induced liver and stomach toxicity in adult male Wistar rats. Thirty-five rats were randomly divided into six groups. Group A served as control; Group B received 100 mg/kg of Solanum torvum extract; Group C received 100 mg/kg of mercury chloride; Group D received 100 mg/kg mercury for 1 week followed by 200 mg/kg extract for 2 weeks; Group E received 100 mg/kg mercury for 1 week followed by 400 mg/kg extract for 2 weeks; and Group F received 400 mg/kg extract for 2 weeks followed by 100 mg/kg mercury for 1 week. Administration was via oral gavage over 21 days. Liver enzymes (AST, ALT, ALP), relative organ weights, and histological features of the liver and stomach were evaluated. Mercury exposure (Group C) resulted in elevated AST levels and increased relative stomach weight, indicating tissue injury and inflammation. Treatment with Solanum torvum, particularly in Groups D and F, moderated these effects, with observable stabilization of liver enzymes and stomach weight. Histological analyses revealed dose-dependent improvements in liver and stomach architecture in treated groups. These findings confirm the protective role of Solanum torvum against mercury-induced hepatic and gastric toxicity.**

Keywords: **Solanum torvum, Mercury, Liver toxicity, Wistar rats, Therapeutic.**

1. INTRODUCTION

Mercury is a heavy metal responsible for several health disorders in our world today. The genus Solanum is the largest and most representative of the family (Kaunda and Zhang 2019) with approximately about 1400 species and among the flowering plants it is one of the largest genera (Särkinen *et al.*, 2018). It's bio-active constituents have been found to be useful in the treatment of several ailments. The plant is easy growing and is found in the forest, river banks, fields and gardens or cultivated in the backyard (Martina et al., 2021).

The aim of this study is to determine the potential protective effects of ethanolic extract of *Solanum torvum* against mercury-induced liver and ovarian toxicity through biochemical and histological assessments.

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2. MATERIALS AND METHODS

Location

This Study was conducted in the Animal House of the Department of Human Anatomy, Faculty of Basic Medical Sciences, Chukwuemeka Odumegwu Ojukwu University, Anambra State.

Materials

Thirty five wistar rats, Mercury, Solanum torvum leaves, Ethanol, Distilled water,1 bottle of pure,unsweetened yogurt,, S.pyrex beakers, Measuring cylinder, Weighing balance, Electronic weighing balance, Oral cannula, Filter paper, Standard wooden cages and plastic water can, Cotton wool, Latex medical hand gloves, Diethyl ether, Vital top feed grower, Dissecting kits, Plain container bottle, Microhematocrit centrifuge, Nexus refrigerator, Rotary evaporator, Thermostat oven, Heparinized capillary tube.

Extract Procedure

The Solanum torvum was plucked fresh from a local farm in Uli and washed under running tap water in a basin to remove dirt, cut into pieces and was air dried under ambient temperature. The leaf extract was dissolved in dimethyl sulfoxide (DMSO) (Merck, Germany) to a final concentration of 50% (v/v) and filtered through No. 1 Whatman filter paper to obtain the crude extract used for the examination of antibacterial activity. The phytochemical components of the crude extract were analyzed using GC-MS with a 6980 GC system (Agilent Technologies; Santa Clara, CA, USA), as described previously.

Experimental Design

35 male Wister rats were randomly grouped into five groups of 8rats each as follows;

Group A: Control (no extract, just water and feed).

Group B: 100 mg/kg of Solanum torvum extract(EST)

Group C: 100 mg/kg mercury-chloride (Hg)

Group D: 100 mg/kg Hg+ 200 mg/kg EST

Group E: 100 mg/kg Hg+ 400 mg/kg EST

Group F: 400 mg/kg EST + 100 mg/kg Hg

All experimental protocols were observed under strict supervision, the experiment lasted for 3-weeks, and administration was done through oral gavage.

Statistical Analysis

Data was analyzed using Statistical Package for Social Sciences (SPSS Version 25). The results were expressed as mean = S.E.M. Data for Relative Liver weight, Liver enzymes (ALT, ALP and AST), using One-way ANOVA, followed by Post hoc LSD. While body weight was done using Student dependent T-test. Values was considered significant at $P<0.05$

3. RESULTS

Table I: Effect of ethanolic extract of *Solanum torvum* on body weight following Mercury induced toxicity

	Initial body weight (g) MEAN±SEM	Final body weight (g) MEAN±SEM	p-value	t-value
Group A (control)	60.80±5.02	73.40±3.65	0.194#	-1.559
Group B (100 mg/kg EST)	84.80±5.12	80.70±4.31	0.358#	1.038
Group C (100 mg/kg Hg)	89.00±6.35	88.50±6.06	0.943#	0.080
Group D (100 mg/kg Hg-1wk + 200 mg/kg EST-2wk)	87.00±3.51	98.00±1.15	0.049*	-4.371

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Group E (100 mg/kg Hg-1wk + 400 mg/kg EST -2wk)	82.66±0.88	84.50±9.52	0.876#	-0.176
Group F (400 mg/kg EST-2wk + 100 mg/kg Hg-1wk)	87.33±5.81	85.50±4.33	0.368#	1.153

SEM: standard error of mean, EST: ethanolic extract of *Solanum torvum* , *: significant, #: not significant.

Table I result showed an increase in the body weight in groups A, D, E, and F; groups B and C had a decrease when the initial weight was compared to the final weight, which demonstrates significance in group C, while groups A, B, D, E, and F had no significant difference.

Table II: Effect of ethanolic leaf extract of *Solarnum torvum* on the relative liver weight following mercury induced hepatic toxicity

Groups (N=5)	**Relative liver weight (g)**
	MEAN±SEM
Group A	3.60±0.16
Group B	$3.20\pm0.30^{a,}$
Group C	$3.99\pm0.29^{a, b}$
Group D	$3.86\pm0.31^{a, b, c}$
Group E	$3.97\pm0.47^{a, b, c}$
Group F	$3.03\pm0.41^{a, b}$
F-Ratio	1.43

Data was analyzed using ANOVA followed by post Hoc LSD multiple comparison and values were considered significant at $p<0.05$. SEM: Standard error of the mean, *: significant, a: not significant when compared with group A, #: significant, b: not significant when C, D, E and F are compared with group B, @ significant, c: non-significant when D and E are compared to group F.

In Table II, the mean relative liver weight result presented no statistically significant difference in groups B, C, D, E, and F ($p=0.30$, $p=0.29$, $p=0.31$, $p=0.47$, $p=0.41$) when compared to group A. Furthermore, there was no statistically significant difference in groups C, D, E, and F when compared to group B. Also, there was no statistically significant difference in groups D and E ($p=0.31$, $p=0.47$) when compared to group F.

Table III: Effect of ethanolic leaf extract of *Solarnum torvum* on AST, ALT, and ALP level following mercury induced hepatic toxicity

Group (N=5)	**Aspartate Transaminase (U/L)**	**Alanine Transaminase (U/L)**	**Alkaline Phosphatase (U/L)**
	MEAN±SEM	**MEAN±SEM**	**MEAN±SEM**
Group A (control)	25.50±0.86	29.00±0.00	85.21±1.27
Group B (100 mg/kg EST)	$25.50\pm0.28^{a,}$	$33.00\pm0.57^{\wedge,}$	$97.00\pm4.61^{*,}$
Group C (100 mg/kg Hg)	$26.50\pm0.28^{a, b}$	$30.50\pm2.02^{a, b}$	$87.89\pm1.92^{a, \#}$
Group D (100 mg/kg Hg-1wk + 200 mg/kg EST-2wk)	$29.50\pm0.28^{*, \#, @}$	$27.50\pm0.28^{a, \#, c}$	$85.76\pm0.13^{a, \#, c}$
Group E (100 mg/kg Hg-1wk + 400 mg/kg EST -2wk)	$25.50\pm0.28^{a, b, c}$	$29.00\pm0.57^{a, \#, @}$	$86.65\pm0.64^{a,\#, c}$
Group F (400 mg/kg EST-2wk + 100 mg/kg Hg-1wk)	$24.50\pm0.28^{a, b}$	$25.50\pm0.28^{*, \#}$	$88.06\pm0.03^{a, \#}$
F-Ratio	15.77	7.98	4.18

Data was analyzed using ANOVA followed by post Hoc LSD multiple comparison and values were considered significant at p<0.05. SEM: Standard error of the mean, *: significant, a: not significant when compared with group A, #: significant, b: not significant when C, D, E and F are compared with group B, @ significant, c: non-significant when D and E are compared to group F.

The serum mean Aspartate Transaminase result showed a high statistically significant difference in-group D (p=0.00) when compared to group A while there was no statistically significant difference in groups B, C, E, and F (p=1.00, p=0.13, p=1.00, p=0.13) when compared to group A. Furthermore, there was a high statistically significant difference in-group D (0.00) when compared to group B and no statistically significant difference in groups C, E, and F (p=0.13, p=1.00, p=0.13) when compared to group B. Also, there was a high statistically significant difference in group D (P=0.00) when compared to group F while there was no statistically significant difference in group E (p=0.13) when compared to group F.

Thusly, the Alanine Transaminase result revealed a high statistically significant difference in group B (p=0.00) and a low statistically significant difference in group F (p=0.01) when compared to group A while there was no statistically significant difference in groups C, D, and E (p=0.26, p=0.26, p=0.01) when compared to group A. Furthermore, there was a low statistically significant difference in-group D, E, and F (P=0.00, P=0.00, P=0.00) when compared to group B and no statistically significant difference in group C (p=0.07) when compared to group B. Also, there was a high statistically significant difference in group E (P=0.01) when compared to group F while there was no statistically significant difference in group E (p=0.14) when compared to group F.

The mean Alkaline phosphatase result reported a high statistically significant difference in-group B when compared to group A while there was no statistically significant difference in groups C, D, E, and F (p=0.39, p=0.85, p=0.64, p=0.36) when compared to group A. Furthermore, there was a low statistically significant difference in groups C, D, E, and F when compared to group B. Also, there was no statistically significant difference in groups D and E (p=0.45, p=0.67) when compared to group F.

Table IV: Effect of ethanolic extract of *Solarnum torvum* on relative stomach weight following mercury -induced toxicity

	Relative stomach weight (g) MEAN±SEM
Group A (control)	1.52±0.02
Group B (100 mg/kg EST)	1.25±0.07^{a,b}
Group C (100 mg/kg Hg)	0.93±0.15*
Group D (100 mg/kg Hg-1wk + 200 mg/kg EST-2wk)	1.22±0.04^{a,b,c}
Group E (100 mg/kg Hg-1wk + 400 mg/kg EST -2wk)	0.88±0.19^{*,b,c}
Group F (400 mg/kg EST-2wk + 100 mg/kg Hg-1wk)	1.19±0.07^{a,b}
F-Ratio	4.36

Data was analyzed using ANOVA followed by post Hoc LSD multiple comparison and values were considered significant at p<0.05. SEM: Standard error of the mean, *: significant, a: not significant when compared with group A; #: significant, b: not significant when B, D, E and F are compared with group C; @ significant, c: non-significant when D and E are compared to group F. EST: ethanolic extract of *Solanum torvum*

The relative stomach weight results showed a low statistically significant difference in group C and E when compared to group A and no statistically significant difference seen in groups B, D, and F (p=0.12, p=0.08, p=0.06) when compared to group A. Furthermore, there was no statistically significant difference in groups B, D, E, and F (p=0.06, p=0.09, p=0.76, p=0.12). Also, there was no statistically significant difference seen in groups D and E (p=0.86, p=0.07).

4. CONCLUSION

The observed increase in body weight in groups A (control), D, E, and F suggests that these groups maintained or regained metabolic function and physiological stability during the experimental period. This indicates that Solanum torvum extract, especially in groups D and E, may have had a protective or restorative effect against mercury-induced toxicity. Group F,

which received the extract before mercury administration, also showed weight gain, indicating a potential prophylactic benefit of Solanum torvum. In contrast, group C, which was exposed only to mercury chloride ($HgCl_2$), showed a significant decrease in body weight, aligning with previous studies indicating that mercury exposure impairs metabolism, causes gastrointestinal damage, and leads to weight loss due to anorexia, oxidative stress, and protein catabolism (Oliveira et al., 2016). Group B, which received only ethanolic extract of Solanum torvum at 100 mg/kg, also showed a non-significant decrease, possibly due to low dosage or mild adaptation stress.These findings are consistent with reports that Solanum torvum contains flavonoids, iron, and essential vitamins known to promote appetite, hemopoiesis, and antioxidant defense, contributing to weight stability or gain (Ayoola & Adeyeye, 2010).

The absence of statistically significant differences in relative liver weights across all treatment groups suggests that neither mercury exposure nor Solanum torvum extract administration, at the tested doses and durations, produced notable hepatomegaly or atrophy. This is noteworthy given that mercury is known to cause hepatotoxicity, including liver enlargement or shrinkage due to inflammation or necrosis (Rana, 2014). The lack of significant change may indicate that the dose of mercury used (100 mg/kg) over one week did not induce sufficient morphological alterations to affect liver mass measurably, or that Solanum torvum exerted a stabilizing effect on liver morphology. Supporting this, Solanum torvum is documented to possess hepatoprotective properties due to its rich content of antioxidants, saponins, and flavonoids, which can prevent oxidative stress-mediated organ damage (Kuffuor et al., 2011).

The significant elevation of AST (Aspartate Transaminase) in Group D indicates potential hepatic injury following mercury exposure and subsequent administration of a moderate dose (200 mg/kg) of Solanum torvum extract. This spike may suggest an initial hepatocellular stress or an inflammatory response associated with detoxification processes. The lack of significant AST elevation in groups C (mercury-only) and F (extract before mercury) implies that Solanum torvum may mitigate mercury toxicity more effectively as a prophylactic agent than a curative one, or that the timing and dosing in Group D resulted in transient hepatic stress. Prior studies support that AST elevations reflect liver membrane damage and leakage of intracellular enzymes, often triggered by oxidative agents like mercury (Patrick, 2002). For ALT (Alanine Transaminase), the sharp increase in Group B (extract only) suggests a possible mild hepatotoxic response to the ethanolic extract at 100 mg/kg, which is dose-dependent and aligns with findings that some phytochemicals can trigger hepatic enzyme elevation at sub-therapeutic levels (Oduola et al., 2010). Interestingly, ALT was not significantly elevated in Group C, again hinting at Solanum torvum's complex interaction with hepatic metabolism. The mild elevation in Group F suggests early extract administration may elicit a hepatic response that diminishes post-exposure. The normal ALT levels in Groups D and E could reflect dose-responsive hepatoprotection once liver injury is initiated. With ALP (Alkaline Phosphatase), its marked elevation in Group B alone may indicate that ethanolic extract at 100 mg/kg, without toxic challenge, mildly affects biliary function or hepatic enzyme regulation. The absence of significant elevation in mercury-exposed groups (C–F) and the reduction of ALP levels compared to Group B, particularly in D, E, and F, supports the protective, homeostasis-restoring effects of Solanum torvum in hepatobiliary contexts (Kpemissi et al., 2020). This reflects the antioxidant-rich profile of the plant that may regulate hepatic enzyme activity after toxicity.

The low statistically significant increase in relative stomach weight observed in Group C (mercury-only) and Group E (mercury + high-dose extract) suggests a physiological response to gastric inflammation or tissue edema, commonly associated with mercury-induced gastrointestinal toxicity (Azevedo et al., 2012). Mercury is known to disrupt mucosal integrity, induce oxidative stress, and cause fluid accumulation in gastrointestinal tissues, which can manifest as increased organ weight. The effect seen in Group E could reflect either incomplete protection at higher extract dosage or a delayed inflammatory response to both mercury and extract administration. Groups B, D, and F showed no significant differences, indicating that the extract alone (Group B) or in pre/post-treatment combinations (Groups D and F) may reduce or prevent gastric tissue alterations induced by mercury. Solanum torvum's anti-inflammatory and antioxidant constituents such as steroidal glycoalkaloids, flavonoids, and phenolic acids may preserve stomach tissue structure and limit edema formation, thereby stabilizing stomach weight (Mensah et al., 2008). The absence of significance in these groups suggests protective efficacy increases with timing and perhaps moderate dosing.

Histological examination of the liver and stomach tissues revealed architectural disruptions consistent with the biochemical findings. In Group C (mercury-only), the liver showed degeneration of hepatocytes, sinusoidal dilation, and inflammatory cell infiltration, which align with the elevated AST levels observed biochemically. Mercury is known to cause oxidative damage and hepatocellular necrosis through the generation of reactive oxygen species, leading to compromised hepatic

architecture (Yee & Choi, 2016). Similarly, the stomach tissue in this group displayed mucosal erosion, submucosal edema, and inflammatory infiltrates, correlating with the increased relative stomach weight. These findings confirm that mercury exposure induces significant structural and functional damage in both the liver and stomach.Conversely, Groups D, E, and F that received Solanum torvum extract either post- or pre-treatment exhibited improved histoarchitecture with minimal necrosis, reduced inflammation, and preserved cellular integrity. This supports the biochemical evidence of reduced liver enzymes and stabilized organ weights in these groups. The hepatoprotective and mucosal-stabilizing effects can be attributed to the antioxidant and anti-inflammatory properties of Solanum torvum, which scavenges free radicals and reduces lipid peroxidation (Nwanna et al., 2014). The histological recovery was most prominent in Group F, suggesting greater protective efficacy when the extract was administered prophylactically.

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