Available online on 15.12.2025 at http://jddtonline.info

Journal of Drug Delivery and Therapeutics

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A Systematic Review on Hepatoprotective Medicinal Plants, Their Bioactive Compounds, and Pharmaceutical Formulations

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Article Info:

Article History:

Received 09 Aug 2025
Reviewed 25 Oct 2025
Accepted 21 Nov 2025
Published 15 Dec 2025

Cite this article as:

Bhardwaj SK, Satapathy T, A Systematic Review on Hepatoprotective Medicinal Plants, Their Bioactive Compounds, and Pharmaceutical Formulations, Journal of Drug Delivery and Therapeutics. 2025; 15(12):193-216 *DOI: http://dx.doi.org/10.22270/jddt.v15i12.7500*

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Abstract

The liver is a vital organ responsible for metabolism, detoxification, and maintaining physiological balance, yet it is highly vulnerable to damage from alcohol, drugs, toxins, and infections. Conventional treatments for liver disorders often have limited efficacy and may cause additional hepatic stress, highlighting the need for safer alternatives. Medicinal plants have emerged as promising hepatoprotective agents due to their antioxidant, anti-inflammatory, antifibrotic, and antiviral properties. Herbs such as *Silybum marianum, Phyllanthus niruri, Picrorhiza kurroa, Curcuma longa, Tinospora cordifolia, Glycyrrhiza glabra, Boerhaavia diffusa,* and *Ginkgo biloba* have shown significant protective effects in experimental models.[2] Popular herbal formulations like silymarin and Liv-52 are widely used for liver disorders and demonstrate beneficial outcomes in preclinical studies. In India, particularly in Chhattisgarh, these plants form an integral part of traditional medicine and exhibit promising local effectiveness. However, despite strong experimental evidence, clinical validation remains limited. To achieve global acceptance, further research focusing on standardized extracts, well-designed clinical trials, and modern dosage formulations is essential to confirm the therapeutic potential of these hepatoprotective medicinal plants.

Keywords: Hepatoprotective agents, Herbal medicines, Polyherbal formulations, Liver disorders

Introduction:

The liver is a vital organ responsible for diverse metabolic, detoxifying, and synthetic functions essential for maintaining physiological balance.[1] It plays a central role in carbohydrate, lipid, and protein metabolism and in detoxifying exogenous substances such as drugs and environmental toxins. However, due to its involvement in these biochemical pathways and the abundance of metabolic enzymes, the liver is highly susceptible to injury from various toxicants, chemicals, and pharmaceutical agents.[2] Among hepatotoxic substances, paracetamol (acetaminophen) is one of the most commonly used experimental models for inducing liver damage, as its overdose leads to oxidative stress, depletion of glutathione, and hepatocellular necrosis.[3] Paracetamol-induced hepatotoxicity in experimental animals, particularly rats, has been extensively employed to evaluate the hepatoprotective potential of medicinal compounds.[4] In recent years, there has been increasing scientific interest in identifying plant-derived hepatoprotective agents that can restore liver function by counteracting oxidative stress, inflammation, and fibrosis.[5] Traditional medicinal systems, such as Ayurveda, have long utilized herbs like *Curcuma longa*, *Phyllanthus niruri*, and *Tinospora cordifolia* for treating liver ailments.[6] Scientific validation of these plants has confirmed their antioxidant, anti-inflammatory, and enzyme-stabilizing properties, supporting their therapeutic potential in mitigating liver injury and promoting hepatic regeneration.[7]

Table 1: Hepatoprotective Potential of some medicinal plants in Chhattisgarh:

Name of the plant	Source or Family	Plant parts used	Hepatotoxicity inducing agents/ Cell line	Extracts Studies	Biochemical and Histopathological Parameters studied
Alhagi camelorum. [8]	Fabaceae	Leaves	Valproic acid	Hydroalcoholic-extract	AST and ALT, HPLC, DPPH, SOD, NO, Histopathological examination etc.
Punica granatum lin. [9]	Lythraceae Subfamily Punicodeae	Leaf or Peel	CCl4and D- D-GalN	Polyphenol-extract	ALT, ALP, AST etc.
Ganoderma lucidum. [10]	Ganodermataceae	Fruiting bodies	H2O2-induced liver injury	Water-extraction	GLPB2, GLPC2, 1H and 13C NMR, ALT and AST levels.
Sabia parviflora Wall. [11]	Sabiaceae	Stems	cell lines (HepG2 and LO2)	Ethanol-extracts	Cell Viability Assay
Pseudobulbs of Pleione bulbocodioides. [12]	Orchidaceae	Dry pseudobulbs	N-acetyl-p-aminophenol, H2O2	Ethanol-extracts	In-vitro assays, Antioxidants activity.
Erythrina senegalensis . [13]	Fabaceae,	Stem and root bark	PCM-induced	Aqueous-extract	ALT, AST and ALP
Alangium salviifolium. [14]	Cornaceae	Bark	CCl_4	Methanol-extract	AST, ALT, and ALP, OD, CAT.
Elytraria acaulis . [15]	Acanthaceae	root	PCM-induced	Maceration-extract	AST, SGOT, ALT SGPT, ALP and TB.
Capparis sinaica veil . [16]	Capparaceae	Aerial part	CCl4-induced	Methanolic-extract	HDL, ALB, GSH, CAT, SOD, GR, TL, TG, TC, LDL, G, TBil, alanine and AST and ALAT and ASAT, ALP and MDA, histopathological Studies.
Cassia occidentalis. [17]	Caesalpiniaceae	Leaves	PCM and ethyl alcohol-induced	Aqueous-ethanolic extract	AST and ALT, ALP, cholesterol, serum total lipids and Histopathological change.
Moringa Oleifera. [18]	Moringaceae	Leaf	Bisphenol A-Induced	Ethanolic-extracts	TC, TG, ALT and AST, ALP, albumin and TP, ELISA, GSH and SOD, Liver Tissue Homogenate and Sera, histological studies.
Hymenodictyon excelsum Wall . [19]	Rubiaceae	Bark	PCM-Induced	Methanol-extract	SGOT, SGPT, ALP, TBil, TP and histopathological examination.
Vitex negundo Linn . [20]	Lamiaceae	Leaf	PCM-induced	Ethanol extract	ALT, AST, ALP, histopathological analysis.
Amaranthus spinosus. [21]	Amaranthaceae	Leaf	CCL4- injected	Methanol-extract	SOD, CAT and MDA, ALT, AST and ALP.
Zanthoxylum armatum. [22]	Rutaceae	Bark	CCL4-induced	Ethanolic-extract	ALT and TB and SOD, CAT and GSH.

Boerhavia diffusa.[23]	Nyctaginaceae	Root	HepG2 cell induced	Methanol--extract	Boeravinone B and caffeic acid
Agathis robusta.[24]	Araucariaceae	Aerial parts	CCl4-induced	Methanolic Extracts	ALT, AST, MTT Assay.
Roselle and beetroots.[25]	Chenopodiaceae	Beet roots	CCl_4 and *E. coli*-induced	Methanolic-extracts	GSH, SOD, MDA, c CAT, DPPH, FRAP, CAT and histopathology evaluated.
Parkia Biglobosa Husk.[26]	Fabaceae	Bean	CCl4-induced	Methanol-extract	AST, ALT, TBil, DB, ALP, TB and histological studies.
Green tea.[27]	Theaceae	Dried leaves	Thioacetamide (TAA)-produced	Methanol-extract	ALP, ALT, AST and B, SOD, CAT and MD, histological studies.
Hoslundia opposite.[28]	Lamiaceae	leaves	PCM-induced	Ethanol-extract	UA, Cholesterol, Urea, Creatinine, B, TB, TA.
Cordia Africana.[29]	Boraginaceae	Stem Bark	Acetaminophen (APAP)-induced	Methanol Extract	ALT, AST, ALP, GGT, and the level of TB TC, TGs, HDL, and LDL.
Anogeissus acuminate.[30]	Combretaceae	Leaf	Alcohol and Ethanol-induced	Ethanol-Extract	AST, ALT, ALP, GGT, and TB, histological studies.
Achillea millefolium.[31]	Asteraceae	Leaf	CCl4-induced	Macerated by hydroalcoholic solvent	GPT, GOT and ALP.
Sarang Banua (Clerodenrum fragrans Vent Willd).[32]	Verbenaceae.	leaves	Alloxan-induced	Ethanol and ethyl acetate-extract	SGOT, SGPT, and serum glucose.
Eucalyptus camaldulensis.[33]	Myrtaceae	Leaves	CCl4-induced	Hydro-distillation	TG, CT, HDL, and LDL ALT and AST.
Withania somnifera ***Rubia cordifolia.***[34]	Solanaceae or nightshade Rubiaceae	Leaves Roots	CCl4-induced	Water extract	TB, ALP, histological studies.
Boerhavia diffusa L.[35]	Nyctaginaceae	Roots	TAA-induced	Aqueous-extract	GOT, ACP, GPT, and ALP, but not GLDH and bilirubin.
Ziziphus oenophilia.[36]	Rhamnaceae	Roots	I+R	Ethanolic-extract	SGPT, SGOT, SALP, BL, SOD, CAT, GPx and HST.
Seabuckthorn *(Hippophae rhomboids).*[37]	Elaeagnaceae	leaf	lead acetate-intoxicated	Drinking-water	AST, ALT, ACP, and ALP.
***Blumea lacera* (*B. lacera*) .**[38]	Asteraceae	leaf	CCl_4-induced	Ethanol-extract	AST, ALT, and ALP, CCl_4, GAA, TBA, DMSO, NED, O-(H_2O_2), and DTNB.
Persicaria maculosa (linn.) ***Tannic acid (TA).***[39]	Polygonaceae Actinidiaceae	Root parts Standard sources	CCl_4-induced	Aqueous-extracts	ALT, AST, ALP and BIL, Histopathological analysis.
Tamarix articulate.[40]	Tamaricaceae	leaves	CCl4-induced	Methanolic-extract	AST, ALT, ALP, Bil, histological studies.

Morinda citrifolia L.[41]	Rubiaceae	fruit	APAP-induced,	Ethanolic-extract	SGPT, Histopathological studies.
Beta vulgaris.[42]	Amaranth (Amaranthaceae)	Roots	Acetaminophen-induced.	Ethanolic-Extract	AST, ALT, ALP, GSH, MDA.
Brassica nigra.[43]	Brassicaceae	Seeds	PHZ-Induced	Aqueous-extract	ALP, AST, ALTand TP, histological studies.
Alstonia congensis.[44]	Apocynaceae	Bark	CCl4-induced	Methanolic-extract	ALP, ALT, AST, B, LPO, TB, ALB, GSH and SOD, CAT and GPx, histopathological analysis.
Galium aparine L.[45]	Rubiaceae	Flower	APAP-induced	MEOH-extracts	AST, ALT, and BIL.
Polygonum persicaria.[46]	Polygonaceae	Roots	CCl4-induced	Aqueous-extract	Histological Studies.
Mangifera indica.[47]	Anacardiaceae	leaf	PCM-induced	Aqueous-extract	ALT, AST and ALP.
Garlic (Allium sativum).[48]	Alliaceae	Whole Parts	Nickel-induced	Ethanolic-Extract	ALT, AST, LDH, GPT, GOT, ALP, MDA., TB, GSH, CAT, GSH-Px, SOD etc.
Alchornea cordifilia.[49]	Euphorbiaceae.	leaves	CCl4-induced	Aqueous-extract	ALP, ALTand AST.
Annona muricata.[50]	Annonaceae	Fresh leaves	TAA-induced	Ethanolic-Extract	SOD, CAT, MDA, B, TB, ALB, ALP, ALT, and AST.
Citrus sinensis.[51]	Rutaceae	fruits	CCl4-Induced	Ethyl acetate-extract	AST and ALT, Histopathological Examination.
Chenopodium album.[52]	Amaranthaceae	Aerial parts	CCl4-Induced	Methanolic-extract	ALT, AST, ALP and histological studies.
Moringa oleifera.[53]	Moringaceae	leaves	PHZ -induced	Aqueous extract-	ALP, AST, ALT and TB.
Ginger (Zingiber officinale Roscoe) ***Lemon (Citrus limon L.).***[54]	Zingiberaceae Rutaceae	Rhizomes fruits	CCl4-Induced	Juice-extract	ALP, G-GT, ALAT, ASAT, D-Bil, T-Bil, Histopathological Study.
Jasminum grandiflorum L. alleviates.[55]	Oleaceae	Dried flower	CCl4-Induced	Ethanol-extract	AST andALT, Histopathological study.
Wild Strawberry Fragaria vesca L.[56]	Rosaceae	Fresh fruits	PCM-Induced	Ethanol-extract	AST.
Decryodes edulis (African Black Pear).[57]	Amaranthaceae	Leaf	APAP-induced	Aqueous-extract	ALT, AST and ALP.
Solanum lycopersicum (Tomato).[58]	Solanaceae	Fresh ripe tomato fruits	INH+RIF- induced	Distilled-water	AST, ALT, ALP and bilirubin.
Parkinsonia aculeate.[59]	Fabaceae	Seed	CCl4-Induced	Methanol-extract	SOD, CAT, MDA.
Caralluma europaea (AECe).[60]	Apocynaceae	Stem	CCl4-Induced	Aqueous-extract	AST,ALT, ALP, TB, DB, MDA, TP, TG, TC, VLDL-c,

					LDL-c, HDL-c, urea, Cr, and uric acid.
***Nelumbo nucifera* Gaertn.**[61]	Nelumbonaceae	Seedpod	APAP-induced	Macerated with hot distilled water	HepG2 cells.
***Cordia lutea* Lam.**[62]	Boraginaceae	Flowers	PCM-induced	Maceration-extract	ALT, AST, ALP DB, TB, A, G and TP, Histopathological changes.
***Annona cherimola* Mill.**[63]	Annonaceae	Leaves	PCM-induced	Ethanol-extract	AST, ALT and ALP, Histopathological changes.
***Morus alba* (linn).**[64]	Moraceae	Leaves	PCM-induced	Alcohol (90%) and aqueous extract	SGOT and SGPT12. ALP13. and B, Preliminary phytochemical studies, Histopathological Study.
***Garuga pinnata*.**[65]	Burseraceae	Leaves	CCl4-Induced	Ethanol-extract	SGOT, SGPT), ALP, ACP, GSH, SOD, CAT, LPO, and TP.
***Hymenodictyon excelsum* Wall.**[66]	Rubiaceae	Bark	PCM-induced	Methanol-extract	SGOT, SGPT, ALP, serum TP and B, LPO, MDA, GSH, SOD, CAT, SEM, Histopathological observation.
***Flacourtia jangomas* (Lour.).**[67]	Salicaceae	Leaves and fruit	PCM-induced	Methanol-extract	AST, ALT, and LDH, MDA.
***Gentiana olivieri*.**[68]	Gentianaceae	Aerial parts	CCL4-induced	Ethanol-extract	MDA, and liver tissue glutathione level,
***Cayratia pedata* var. Glabra.**[69]	Vitaceae	Aerial plant	PCM-induced	Ethanol-extract	SGOT, SGPT, ALP, and TB, SOD, CAT, GPx and GST, Acute Toxicity Studies,Histopathologic al Studies.
***Cnidoscolus Phyllacanthus*.**[70]	Euphorbiaceae	Leaves	D-galactosamine induced	Alcoholic-extraction	ALT, SGPT, AST, SGOTand ALP, Histological studies.
***Sonneratia apetala*.**[71]	Lythraceae	Fruits	APAP-induced	Distilled water for 3 h before filtration.	ALT,AST, GSH, GSH-Px, SOD and MDA, histological studied.
***Tamarindus indicus* lin.**[72]	Fabaceae	Fruit	I+R	Aqueous-extract	SGOT, SGPT, ALP, TP, GSH, LPO, SOD, CAT, Liver HST.
***Lasimorpha senegalensis*.**[73]	Araceae	Leaf	PCM-induced	Methanol-extract	ALT, AST, ALP), TB, DB, histopathological studies.
***Litsea martabanica*.**[74]	Lauraceae	Leaf	CPF-Induced	Decoction extracted with 95% ethanol.	MCV, MCH, MCHC, and PLT, BUN and Cr, TP, ALB, TB, DB, AST, ALT, and ALP, Histological Examination.

***Cassia fistula*.**[75]	Leguminosae	Leaf	CCL4-induced	Methanol-extract	SGOT and SGPT, bilirubin and ALP.
***Sweet basil (Ocimum basilicum L.)*.**[76]	Lamiaceae	Specimens of basil	Acetaminophen-induced	Water-extraction	ASTand ALT, Histological analysis.
***Schouwia thebica*.**[77]	Aceraceae	Aerial parts	CCl4-induced	Diethyl ether, chloroform, ethyl acetate, and n-butanol	ALT, AST, and GGT, and Glucose, Triglycerides, and Cholesterol.
***Tephrosia villosa*.**[78]	Legumes	Whole plant	CCl4 and PCM-induced	Ethanolic-extract	SGOT, SGPT, ALP, and DB, histopathological exam.
***Chenopodium botrys L*.**[79]	Chenopodiaceae	Aerial parts	Lead-induced	Methanolic and Aqueous-extract	LPO, ALPase, ACPase and SDH.
***Ougeinia dalbergioides*.**[80]	Papilionoideae	Barks	CCl4 and PCM-induced	Ethanolic and aqueous-extract	ALP, SGPT, SGOT, TB and DB.
***Salvinia auriculata Aubl*.**[81]	Salviniaceae	Plant powder	MTX-Induced	Methanol-extract	ALT, AST, and LDH, Immunohistochemical Studies, Histopathological Studies,
***Momordica dioica* roxb.**[82]	Cucurbitaceae	Leaves	CCL4-induced	Ethanolic and aqueous	AST, ALT, SALP and TB, Histopathological examination.
Ensete ventricosum (Welw.)[83]	Musaceae	Leaf	I and RIF -Induced	Macerated by using 80% methanol	ALT, ALP, and AST, histopathological studies.
***Ocimum sanctum L*.**[84]	Lamiaceae	Basil Leaf	PCM-induced	Extracted by percolation with ethyl acetate	SGOT and SGP.
***Triphala*.**[85]	Euphorbiaceae	Triphala	CCl4-induced	Water-extract	ALT, AST, MDA, TNF-α, and IL-6, Histopathological analysis.
***Crassocephalum vitellinum*.**[86]	Asteraceae	Leaf	RIF-induced	Ethanolic-extract	ALT, ALP, AST, histomorphology study.
***Euphorbia nivulia* Buch.**[87]	Euphorbiaceae	Aerial parts	CCl4-induced	Hydro alcoholic -extract	AST, ALT and ALP.
***Tagetes lucida*.**[88]	Asteraceae	Root	CCl4-induced	Ethanolic-extract	TP, A, TB, and AST and ALT, and ALP.
***Blumera lacera*.**[89]	Asteraceae	Leaves	RIF-Induced	Ethanolic-extract	SGOT, SGPT, ALP, TB,DB, histopathological studies.
***Suaeda vermiculata*.**[90]	Amaranthaceae	Whole herbs	PCM-induced	Either aq. Ethanol-extract	AST, ALT, SOD, CAT, GR, LP, NO.
***Ocimum basilicum*.**[91]	Lamiaceae	Whole plant	APAP -induced	Chloroform, diethyl ether, ethyl acetate, and methanol-extract.	ALP, TB, TP, albumin, AST, ALT, creatinine, and BUN.
***Malus hupehensis tea*.**[92]	Rosaceae	Leaves	I- and RIF-induced	Ethanol-extract	LT, AST, TBIL, MDA, GSH-ST, SOD, GSH,

					DIL,Histological studies.
Nigellia sativa.[93]	Ranunculaceae	Seeds (oil)	I+RIF+P	Suitable solvent	ALP, ALT, AST, TP and BL and HST.
Ophiocordyceps Sinensis.[94]	Ophiocordycipitaceae	Mycelia	CCl_4-Induced	Aqueous and methanol-extracts	ROS, ALT and AST, histopathological examination.
Ruta Graveolens and Angelica Sinensis.[95]	Rutaceae Umbellifers	Whole Plants	CCl4-Induced	Methanolic-extracts	DPPHIn-VitroHepatoprotective Activity.
Ephedra Alata.[96]	Ephedraceae	Whole Raw Material	Intoxication with Deltamethrin Pesticide	Macerated-extract	ALT, ALP, Bil and Urea, GSH, GST, and MDA.
Bryophyllum pinnatum.[97]	Crassulaceae	Leaves	Alcohol-induced	Boiled-extract	ALT, AST, ALP, AST, ALP,
Ficus benghalensis.[98]	Moraceae	Aerial roots	I+ RIF	Methanolic-extract	ALP, ALT, AST, TP and BL, TBARS and GSH
Averrhoa bilimbi .[99]	Oxalidaceae	Leaves	Alcohol-induced	Ethanolic-extract	Biochemical parameters, histopathological examination.
Acalypha communis Mull.[100]	Euphorbiaceae	Leaves	Intoxication of TAA and RIF-induced	Aqueous-extract	Preliminary Phytochemical Screening, SGOT, SGPT, ALP, TB, T P, histopathological studies.
Cordia macleodii.[101]	Boraginaceae	leaves	CCl_4-induced	Ethanolic extract	GPT, GOT, ALP and total bilirubin.
Thymoquinone.[102]	Ranunculaceae	Seeds	Tert-butyl hydroperoxide	Aqueous ethanolic-extract	ALT and AST.
Acalypha indica.[103]	Euphorbiaceae	Leaf	CCl4- induced	Methanolic Extracts	ALT, AST, ALP, ACP and LDH, LPO.
Plectranthus amboinicus.[104]	Lamiaceae or mint	Leaf	DMBA-induced	Ethanolic-extract	ALT, AST, ALP, and B, TP, A and GLB, Histopathological observation.
Equisetum Arvense.[105]	Equisetaceae	Aerial parts	CCl4- induced	Methanolic-extract	AST, ALP, and Histopathological studies
Halenia Elliptica.[106]	Gentianaceae	Whole plant	CCl4- induced	Methanolic-extract	ALT, AST, ALP, and TBIL, Histopathological studies
Cuscuta Chinensis.[107]	Convolvulaceae	Seeds	APAP-induced	Aqueous and ethanolic	SOD, catalase CAT, and GPx, and MDA.
Cochlospermum Planchoni.[108]	Coclospermaceae	Rhizomes	CCL4-induced	Aqueous-extract	TB, ALP, ALT.
Tylophora indica.[109]	Asclepiadaceae	Leaves	CCL4-induced	Methanolic-extract	SGPT, SGOT, ALP and B.
Rhubarb Roots.[110]	Polygonaceae	Whole rhubarb	CCl4 Induced	Suitable-solvent	AST, ALT, ALP, TP, Alb, TBL, DBL. And

		roots			IDBL, MDA and activity of CAT, SOD, GSH and GPx Histopathological Examination.
Andrographis paniculata.[111]	Acanthaceae	Leaf	Methotrexate-Induced	Aqueous-extract	GCMS study, SOD, CAT, GSH, GPx.
Rosa rugosa.[112]	Rosaceae	Flower bud	Ameliorates Acetaminophen-Induced	Ethanol-extract	ERS, ERS Ameliorates APAP-Provoked Apoptosis and Ferroptosis in AML-12 Hepatocytes, Inhibition of Sirt1 Eliminates ERS-Mediated LKB1/AMPK/Nrf2 Axis, ALT, AST, LDH, TNF-α, IL-1β, IL-6, PGE2, NO, T-AOC, SOD, GSH, GPX-P, CAT.
Garlic Extract *(Allium sativum)*.[113]	Allium sativum	Shade-dried bulbs	PCM-induced	Ethanol-extract	ALP, ALT, AST, Histopathological analyses, RBCs, Platelet, Hemoglo, Hema. DPPH free radical.
Artemisia Vulgaris L.[114]	Asteraceae	Aerial parts	Cisplatin-induce	Suitable-solvent	Phytochemical screening, ALT, AST, ALP and TSB.
Euphorbia fusiformis.[115]	Euphorbiaceae	Tubers	RIF-induced	Ethanol-extract	SGOT, SGPT, GGTP, ALP, total B and TP.
Mulaka *(Raphanus Sativus Linn.)*.[116]	Rutaceae	Kanda (rhizome)	PCM-induced	Suitable-solvent	SGPT, SGOT, ALP, TP, ALB, TB, Chol, Urea, Cr, Triglyceride, Histo-pathological examination.
Dactylorhiza hatagirea.[117]	Orchidaceae	Root	PCM-induced	Hydroalcoholic-extract	AST, ALT, ALP and B, Physicochemical evaluation.
Jojoba *(Simmondsia chinensis)*.[118]	Buxaceae.	Seed cake	PCM-induced	Aqueous-extracts	AST, ALT, GGT, ALP, and LDH, Histopathological study.
***Scoparia dulcis** L.*[119]	Scrophulariaceae	Whole plant	CCL4-induced	Methanol, diethyl ether and petroleum ether-extract	AST, ALT, ALP, TB and Histopathological studies
Trichosanthes Cucumerina.[120]	Cucurbitaceae	Whole plant	CCL4-induced	Methanolic-extract	ALT, AST, ALP, TB, TP and ALB, GSH and MDA Histopathologic changes.
Tridex procumbens l..[121]	Asteraceae	Leaves	Polluted water-induced	Methanolic-extract	AST, ALT, ALP, TP, B, Body weight before & after treatment.
Naringi crenulate (roxb.).[122]	Rutaceae	Leaf and bark	CCl4 Induced	Ethanol-extracts	SGOT, SGPT, ALP, TP, ALB, globulin, total, conjugated and unconjugated bilirubin's., SOD, CAT, GPx and GRD and TBARS.

Euphorbia pilulifera.[123]	Euphorbiaceae	Leaf	CCl_4- induced	Methanolic-extract	DPPH, MTT.
Mimusops elengi.[124]	Sapotaceae	Root	Anti-TB-induced	Hydro alcohol solvent	SGOT. SGPT, ALP, Histopathological study.
Woodfordia fruticosa Kurz.[125]	Lythraceae	Flowers	CCl4-Induced	PE, chloroform, ethyl alcohol and	Serum ALZT, B and triglycerides.
Punica granatum L var nana.[126]	Lythraceae	Leaves	CCl4-Induced	Methanolic-extract	AST, ALT, ALP, Alb, TC, TG, LDL, HDL, MDA, Histopathological study.
Citrullus Lanatus.[127]	Cucurbitaceae	Rind	Ethanol-induced	Aqueous-extract	ALT, AST, ALP, SOD and CAT, MDA and histopathological examinations
Steroidal Saponins.[128]	Agavaceae	Selected part	CCl4-Induced	Pure steroidal saponins-extracted	ALT, AST, ALP, TP, ALB, GLs and urea, SOD, catalase, GSH-Px, and GSH-Rd. Lipid MDA.
Eugenia uniflora l.[129]	Myrtaceae	Leaves	Gentamycin-induced	Aqueous-extract	AST, ALT, and ALP, Histological Studies.
Syzygium cumini.[130]	Myrtaceae	Seed	ROS-induced and ALX-induced diabetic rats	Ethanolic-extract	SOD, CAT, GSH, LPO, ST or SGOT, ALT, ALP, Histopathological Examination.
Capparis spinosa.[131]	Capparaceae	Root bark	CCL4-induced	Ethanolic extract	ALT and AST.
Allium roseum[132]	Liliaceae	Leaves	Cd-Induced	Many Suitable Solvent	FTIR-ATR, and NMR MDA, SOD, CAT.
Walnut oil and Caralluma tuberculate.[133]	Juglandaceae and Apocynaceae	Different parts	PCM-induced	Ethanol and water-extract	TC, TG, ALT, and HDL, Hematological parameters, Histopathology of the mice liver samples.
Cayratia trifolia (L.).[134]	Vitaceae	Leaves	NB-induced	Polar-extracts	ALP,AST,ALT, TB, DB Histopathological studies.
Adenanthera pavonine.[135]	Fabaceae	Leaves	Isoniazid+ Rifampicin	Methanolic- extract	SGOT, SGPT, ALP, LDH, Alb, TP, TB, CAT, SOD, MDA, GLT and HST
Cucurbita maxima.[136]	Cucurbitaceae (cucumber	Seed	PCM-induced and high fat diet-induced	Alcoholic-extract	SGPT, SGOT, ALP, TB, TB, TB, HDL, Triglycerides, VLDL, LDL, Histopathological studies.
Caesalpinia sappan l.[137]	Leguminosae	Herb	Alloxan Induced	Ethanolic-extract	AST and ALP, MDA.
Albizia Odoratissima.[138]	Fabaceae	Bark	Ethanol-Induced	Methanolic-extract	SGPT and SGOT, ALP, TB, urea, and creatinine, Histopathological examinations.
Cochlospermum tinctorium, Terminalia macroptera,	Buxaceae Combretaceae Apocynaceae	Roots Leaves Aerial parts	CCL4- induced	Aqueous and hydroethanolic extracts	DPPH radical scavenging, LAD and LHM, Other biochemical parameters, histopathological

Leptadenia hastata and Commiphora Africana.[139]	Burseraceae	Roots			structure of the liver.
Aegle marmelos correa ex Roxb.[140]	Rutaceae	Pulp/seeds	CCL4- induced	Water-extract	AST, ALT and Bilirubin. Histopathological studies
Pterocarpus marsupium Roxb.[141]	Papilionaceous	Stem bark	CCL4-induced	Aqueous and Methanol	TB, ALT, AST, and Histopathological studies of the liver
Olea europaea L.[142]	Oleaceae	Seeds	Methotrexate-induced	Three solvents (Chloroform, methanol, and 50% aqueous ethanol)	GPT, GOT, and ALP, DPPH assay, Histopathology studies.
Marine Macroalgae.[143]	red (Rhodophyta), green (Chlorophyta) and brown (Phaephyta)	Seaweeds	CCl4-induced	Water extracts	ALAT & ASAT, ALP, LDH, total bilirubin, and direct bilirubin, Histopathology studies.
Curcuma longa (Zingiberaceae)[144]	Zingiberaceae	Fresh rhizomes	Alcohol-Induced	Aqueous-Extract	Phytochemical Screening, ALAT, GPT, histopathological.
Bauhinia acuminata (linn).[145]	Caesalpiniaceae	Leaves	CCl4 induced	Ethanolic and aqueous-extracts	SGOT, SGPT and ALP, Histopathological examination.
Osmium sanctum.[146]	Lamiaceae	leaf	PCM-induced	Suitable solvent-extract	AST, ALT, and the histology of the liver.
Curcuma xanthorrhiza[147]	Zingiberaceae	Rhizome	CCl4-induced	Ethanolic-Extract	ALT, AST, ALP, Triglyceride, and TP levels, Histopathological examination.
Turmeric.[148]	Zingiberaceae	Rhizome	CCl4-induced	Ethanolic-Extract	TP, ALB, TB, ALT, AST, ALP, Catalase CAT, SOD, GSST, MDA, Histopathological analysis.
Mussaenda erythrophylla Lam.[149]	Rubiaceae	Stem	CCl4-induced	Ethyl acetate and methanol-extracts	SGOT, SGPT, ALP, TB, histopathological examinations.
Carissa edulis (vahl)[150]	Apocynaceae	Leaf	CCl4-induced	Ethanolic-extract	ALP, ALT, AST, TP, BIL, Albumin, HDL, CHL, TRIG, Histopathological examination.
Abroma augusta.[151]	Sterculiaceae, or Malvaceae	Leaves	*Non*-alcoholic fatty liver disease	*Ethanolic*-extract	ALT, AST, TG, TC, LDL, HDL, FFA and MDA, histopathological examinations.
Bombax costatum.[152]	Bombacaceae	Stem bark	CCl4-induced	Methanol-extract	MDA, CAT and GSH, histopathological examinations.
Catharanthus roseus.[153]	Apocynaceae	Leaf	Spartame-induced	Ethanol-Extract	T-Test, Histology.
Gooseberry And black mulberry.[154]	Moraceae	Suitable part	CCl4-induced	Aqueous and ethanolic-extracts	MDA,NO, Histopathological examination.

Andrographis paniculata.[155]	Acanthaceae	Roots, leaves, and aerial part	CCl4-induced	Ethanolic extract	ALP, ALT, and AST.
Cichorium intybus L.[156]	Asteraceae	Root	CCl4-induced	Suitable solvent -extract	Histopathological properties.
Osbeckia octandra.[157]	Melastomataceae	Leaf	TAA-Induced	Methanol extract And hexane-extract	ALT, AST, ALP, histopathological study.
Pandanus odoratissimus.[158]	Pandanaceae	Seed	PCM-induced	Methanol-extract	SGOT, SGPT, ALP, and GGT, Histopathology.
Tecomella undulata.[159]	Bignoniaceae	Bark	PCM and CCL4 Induced	Ethanolic and ethyl acetate-extract	AST, ALT, ALP GSH and MDA.
Pometia pinnata.[160]	Sapindaceae	Suitable part	CDDP-induced	Ethanol-extract	AST, ALT, LDH, and total protein,
Canthium dicoccum.[161]	Rubiaceae	leaves	PCM-induced	Methanolic-extract	AST, ALT, ALP, and bilirubin levels, SOD, CAT, and MDA levels,
Parkia Biglobosa.[162]	Fabaceae	leaves	APAP-Induced	Methanol-extract	ALT, AST and ALP Histopathological Study.
Ficus Carica.[163]	Moraceae	Fruits	CCl4-induced	Maceration: Methanol-extract	ALT, AST, ALP and Bil, Histopathology.
Acacia confuses[164]	Leguminosae	Bark	CCL4-induced	Hydroalcoholic-extract	AST, ALT and MDA, and CYP2E1, SOD, GPX and CAT.
Lallemantia Royleana.[165]	Lamiaceae	Seeds	Drug-Induced Liver Injury	Alcohol-extract	Histopathological examination.
Cicer arietinum.[166]	Fabaceae	Seeds	CCl4-Induced	Ethanolic-extract	HDL, A, GSH, CAT, SOD, GR, TL, TG, TC, LDL, G, TBil, MDA, Histopathological studies.
Honey.[167]	Apideae	Honey	CCl4-induced	Natural honey	ALT and AST, Histopathological study.
Ganoderma applanatum.[168]	Ganodermataceae	Crude	CCl4-induced-Induced	Suitable solvent-extract	ALT, AST, TNF-α, and IL-6, histopathological study.
Vitex trifolia.[169]	Verbenaceae	Leaves	CCl4-induced	Ethanol and water- extract	TP, Histopathological studies, AST, ALT, ALP,
Gongronema latifolium.[170]	Apocynaceae	Leaves	Alloxan-Induced	Aqueous-Extract	AST, ALT, GGT, ALP, TP, and ALB,PCV, Hb, RBC, MCHC, MCV, MCH, and WBC Haematology Analyzer–MC-2800.
Typha elephantina.[171]	Typhaceae	Leaves	Paracetamol intoxicated	Aqueous-extract	WBC, PLT count, lymphocytes, AST level, ALT and ALP GSH, TBRAS, Histopathological analysis.
Argan oil (Argania spinosa L).[172]	Sapotaceae	Both Roasted oils and unroasted	CCl4-induced	Roasting process	ALT, AST, TB and DB, triglycerides, LDL, plasmatic creatinine, urea, uric acid, and

		Argan oil			MDA
***Pithecellobium Dulce*.**[173]	Legumes	Leaves	PCM-induced	Ethanolic-extract	Triglycerides, SGOT, SGPT, ALP, Bilirubin, Histopathological study.
***Pterocarpus santalinoides DC*.**[174]	Legume	Fresh leaves	CCl4	Methanol-extract	Yield of PSCME and PSSE upon Extraction, Phytochemical Analyses, QCA ALT and AST.
***Sterculia diversifolia*.**[175]	Malvaceae	Stem bark and leaves	Suitable inducing agent	Hydro-methanolic solvent (90%)	AST, ALP, ALT, and bilirubin, Histopathological liver.
***Cichorium Intybus and Cynara Scolymus*.**[176]	Asteraceae	root and leave	PCM-induced Induced	Ethanolic-extracts	SGOT, GGT and CPK.
***Vitis vinifera L*.**[177]	Vitaceae	Fruit	CCL4-induced	Distill water and with 70 % ethanol	AST and ALT, SALP, ALB and B, urea and creatinine, LDH, cholesterol and triglyceride, lipid peroxidation, reduced glutathione.
***Pongamia Pinnata*.**[178]	Fabaceae	Leaves	Isoniazid & Rifampin-Induced	Ethanolic-extract	AST, ALT, and ALP.
***Crocus sativus*.**[179]	Iridaceae	Petalsand both saffron petals and stamens	tert-Butyl Hydroperoxide-Induced	Suitable solvent -extract	SOD, CAT, GSH.
***Pittosporum neelgherrense*.**[180]	Pittosporaceae	Stem bark	CCL4, d-galactosamine and APAP-induced	Methanolic-extract	SGOT, SGPT.
***Centaurea Tougourensis* Boiss. & Reut.**[181]	Asteraceae	Aerial parts	Croton oil-induced streptozotocin-induced diabetes	Maceration After liquid-liquid extraction	ALAT, ASAT, HDL-C, LDL-C, Hepatoprotective activity.
***Homalium zeylanicum*.**[182]	Salicaceae	Bark and leaf	CCL4-induced	PE and hydro alcohol (70%) by hot maceration	DPPH, SOD, NO, OH, SGOT, SGPT, ALP, TP and TB, TBARS assay kit, liver sections.
***Cochlospermum vitifolium*.**[183]	Cochlo- Spermaceae	Bark	CCL4-induced	Hexane, dichloromethane, methanol	GPT and ALP
***Stingless Bee*.**[184]	Apidae	Honey makes in live colony	Drug-induced liver injury	Gathering honey from beehives	SGPT, SGOT, BT, ALP, SOD,GSH, GR and CAT.
***Calotropis procera, Kigelia Africana,* *Alchornea cordifolia and Hibiscus sabdariffa*.**[185]	Apocynaceae Bignoniaceae Euphorbiaceae Malvaceae	Leaves Leaves Leaves Calyces	PCM-induced	Distilled-water	TBARS, SOD, CAT, GPX, and d-amino levulinate dehydratase (d-ala-d) activities.

Desmodium repandum.[186]	Fabaceae	Leaves	PCM-Induced	Maceration: Ethanol-extract	Phytochemical screening, Hepatoprotective Activity.
Adhatodavasica.[187]	Acanthaceae	leaf	D-galactosamine-induced	Aqueous-extract	SGOT, SGPT, TBARS.
Justicia spicigera.[188]	Acanthaceae	Leaves	STZ-induced	Maceration with ethanol	DPPH, Blood Glucose and Body Weight Determination, LDL, VLDL, triglycerides, total lipids, and atherogenic index and TP, TB, DB, IDB, ALP, gamma glutamyl transferase, AAT, and ALT, Mitochondrial Isolation, SOD, CAT.
	Rubiaceae	Roots	CCL4-induced	Aqueous-extract	SGOT, SGPT, SALP and γ glumyltranferase
Chamomile capitula.[190]	Asteraceae	Fresh natural mature capitula	PCM-Induced	Aqueous-Ethanolic	Liver glutathione, Na+ K+- ATPase activity, B, glycogen and thiobarbituric acid.
Vernonia amygdalina.[191]	Daisy	Leaf	CCl4-Induced	Suitable-solvent	LDH, MDA, TAC, SOD, CAT, Glucose, TP, ALB, Total cholesterol, Triglyceride, LDL, HDL, AST, ALP, ALT, GGT.
Resveratrol* and *avocado oil.[192]	Resveratrol is a chemical which polyphenols called viniferins. Lauraceae	Oil Oil	PCM-induced	Suitable solvent-extract	TAS, TOS, histopathological examination.
Luffa echinata.[193]	Cucurbitaceae	Fruits	CCL4-induced	PE, acetone and methanolic-extracts	SGOT, SGPT, ALKP, TP and TA.
Phyllanthus niruri.[194]	Euphorbiaceae	Leaves and fruits	CCL4-induced	Methanolic and aqueous-extract	GOT, GPT, DPPH radical scavenging.
Schisandrae chinensis with Astragalus polysaccharides.[195]	Magnoliaceae	Dried fructus	CCL4-induced	Ethanol-extraxt	ALT, AST, ALP, MDA, GSH, CAT, SOD.
Swertiamarin isolated from Enicostemma Axillare.[196]	Gentianaceae	Whole plant	D-galactosamine	Ethyl acetate-extract	ASAT, ALAT, ALP, Triglycerides, Total cholesterol, TB, TP, Creatinine, ALB.
CGX- a modified traditional Chinese herbal drug.[197]	Liliaceae	Whole plant	CCL4-induced	Aqueous-extract	ALT, AST, LDH, MDA.
Tephrosia purpurea L. and Tecomella undulate.[198]	Fabaceae Bignoniaceae	Aerial parts and Stem Bark	TAA-induced	Aqueous ethanolic-extract	AST, gamma glutamyl, ALT, GSH, TB, ALP.
Aloe barbadensis Mill.[199]	Liliaceae	Dried aerial parts	CCL4-induced	PE, chloroform and methanol-extract	ALP, B, peroxidation, GSH, G6Pase and amidopyrine N-

					demethylase.
Hygrophila Auriculata and Apium graveolens.[200]	Acanthaceae Apiaceae	Seeds	PCM and TAA-induced	PE and methanol-extract	SGOT and SGPT, SDH, GLDH, ALP and B, Histopathological.
Clerodendrum inerme.[201]	Verbenaceae	Leaves	CCL4-induced	Ethanol-extract	ALT, AST, ALP, TGL, TC.
Gundelia tourenfortii.[202]	Asteraceae	Fresh edible stalk	CCL4-induced	Aqueous & ethanolic extract	ALT, AST, ALP, B and Histopathological studies.
Kalanchoe pinnata Pers.[203]	Crassulaceae	Leaves	CCL4-induced	Ethanolic-extract	SGOT, SGPT, ALKP, SBLN and Histopathological studies.
Phyllanthus amarus Schum. et. Thonn.[204]	Euphorbiaceae	Aerial part	Ethanol-induced	Aqueous-extract	AST, STG, ALT, STG, HTG, Histopathological examination.
Thunbergia laurifolia Linn.[205]	Acanthaceae	Leaves	Ethanol-induced	Aqueous-extract	SGOT, SGPT, ALKP, SBLN and Histopathological studies.
Piper chaba.[206]	Piperaceae	Fruit	D-gala, lipopolysaccharides	Aqueous-acetone extract	SGOT, SGPT, ALKP, TP, TA.
Hygrophila auriculata.[207]	Acanthaceae	Root	CCL4-induced	Aqueous-extract	AST, ALP, TP, TB, and
Laggera pterodonta.[208]	Asteraceae	Whole herb	CCL4, d-galn, d-galactosamine.	Ethyl alcohol and aqueous-extract	AST, ALP, TP, and TB.
Byrsocarpus coccineus Schum.[209]	Connaraceae	Leaf	CCL4-induced	Aqueous extract	ALP, AST and TP.
Decalepis hamiltonii.[210]	Asclepiadaceae	Roots	CCL4-induced	Aqueous extract	SOD, CAT, GPx, GR, and GST and GSH, Histopathological observations.

DISCUSSION:

The liver, being a central organ in metabolism, possesses a wide range of enzymes that facilitate numerous biochemical reactions but also render it vulnerable to damage from various toxicants, chemicals, and drugs. In hepatoprotective studies, paracetamol is commonly used as a hepatotoxic agent to induce liver injury, as excessive or prolonged use in humans leads to hepatic damage. Paracetamol-induced hepatotoxicity in rats, first reported in 2006, remains a well-established experimental model, often characterized by increased liver weight and volume due to water accumulation and tissue edema. Numerous plants exhibit hepatoprotective activities through diverse pharmacological mechanisms. Antioxidant plants such as *Curcuma longa*, *Phyllanthus niruri*, and *Tinospora cordifolia* enhance endogenous antioxidant defenses (SOD, CAT, GSH) and reduce lipid peroxidation. Anti-inflammatory compounds, including flavonoids and terpenoids from *Andrographis paniculata* and *Azadirachta indica*, inhibit pro-inflammatory mediators (TNF-α, IL-6, NF-κB). Antifibrotic agents like *Picrorhiza kurroa* and *Curcuma longa* reduce collagen deposition, while antiviral species such as *Phyllanthus niruri* demonstrate activity against HBV and HCV. Many of these plants also stabilize hepatic enzymes (ALT, AST, ALP, bilirubin), reflecting hepatocellular protection. In the regional context of Chhattisgarh, India—known as the "Herbal State of India"—traditional healers employ medicinal plants like *Tinospora cordifolia*, *Eclipta alba*, and *Boerhavia diffusa* for jaundice and liver disorders, supported by both ethnomedical knowledge and scientific validation. Globally, hepatoprotective botanicals such as silymarin from *Silybum marianum* are widely recognized, particularly in Europe and the USA, while Ayurvedic polyherbal formulations like Liv-52 are prevalent in Asia and Africa. Despite challenges in standardization limiting their clinical adoption in the West, advancements in formulation technologies (e.g., nanoparticle curcumin, silymarin phytosomes, liposomal extracts) have enhanced bioavailability, strengthening the global potential of plant-based hepatoprotective therapies.

Conclusion:

The findings of the present study indicate that *C. dicoccum* exhibits a pronounced protective effect against paracetamol-induced hepatotoxicity. The hepatoprotective action of MECD is primarily mediated through the attenuation of lipid peroxidation, attributable to its free radical scavenging potential, which in turn enhances the endogenous antioxidant defense system. This review-of-reviews underscores that hepatoprotective medicinal plants and their polyherbal formulations possess considerable therapeutic promise, supported by robust preclinical evidence and longstanding ethnomedicinal practices in India, particularly in regions such as Chhattisgarh. At the global level, agents such as silymarin, *Phyllanthus* spp., and curcumin remain the most extensively validated. Nevertheless, a large repertoire of promising botanicals still requires clinical substantiation. For global recognition and integration into contemporary therapeutic regimens, future investigations should prioritize well-designed clinical trials, comprehensive pharmacokinetic profiling, and the development of advanced drug delivery systems to enhance bioavailability and ensure standardization. *C. dicoccum* demonstrated marked hepatoprotection against paracetamol-induced toxicity by reducing lipid peroxidation through free radical scavenging and strengthening antioxidant defense. Overall, hepatoprotective plants show strong preclinical and ethnomedicinal support, with silymarin, *Phyllanthus*, and curcumin being globally validated. Future work should emphasize clinical trials, pharmacokinetics, and advanced delivery systems to improve bioavailability and standardization.

Conflict of Interest: The authors declare no potential conflict of interest concerning the contents, authorship, and/or publication of this article.

Author Contributions: All authors have equal contributions in the preparation of the manuscript and compilation.

Source of Support: Nil

Funding: The authors declared that this study has received no financial support.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data supporting this paper are available in the cited references.

Ethical approval: Not applicable.

List of Abbreviations

Abbreviations	Definitions/Meaning
A or ALB	Albumin
ACP	Acid Phosphatase
AH	Aniline Hydroxylase (Microsomal)
ALZT	Alanine Amino Transferase
ALX	Alloxan
ALT	Alanine Aminotransferase
ALP	Alkaline Phosphatase
ANTs	Anthracyclines
AP	Alkaline phosphatase
APAP	Acetaminophen
AST	Aspartate Aminotransferase
ASAT	Alanine Aminotransferase
B	Bilirubin
BUN	Urea (BUN-Blood Urea Nitrogen)
C	Cholesterol
CAT	Catalase
CAR	Carrageenan
CBC	Complete Blood Counts
CCl4	Corbon Tetrachloride
Cd	Cadmium
CDDP	Cisplatin
CHA	Concentrated Hydrochloric Acid
CPF	Chlorpyrifos
Cr	Creatinine
CT	Total Cholesterol
CYP2E1	Cytochrome P4502E1
DB	Direct Bilirubin
DC	Diabetic Control
DEN	Diethyl Nitrosamine
DE	Diabetic with extract
DM	Diabetes Mellitus
DMSO	Dimethyl Sulfoxide
DPPH	2,2-diphenyl-1-picrylhydrazyl.
EGTA	[ethylenebis(oxonitrilo)] tetra-acetate
ENZ	Enzymes
ETA	Ethionamide
ETN	Ethanol
G/GLB	Globulin
GAA	Glacial Acetic Acid
G6Pase	glucose-6-phosphatase
GGTP	Gamma Glutamyl Transpeptidase
GGT	Gamma-Glutamyl Transferase
GLUL	Glucose transporter

GLDH	Glutamate dehydrogenase
GPx	Glutathione Peroxidase
GPT	Glutamate Pyruvate Transaminase
GR	Glutathione Reductase
GSH	Glutathione
GPX/GSH-Px	Glutathione Peroxidase
GOT	Glutamate Oxaloacetate Transaminase
GSH	Glutathione
HDL	High-Density Lipoprotein
HYP	Hydroxypropyline
I	Isoniazid
IB	Indirect billirubin
INH+RIF	Isoniazid and Rifampicin
IV-C	Type IV Collagen
LDL	Low-Density Lipoproteins
LDH	Lactate Dehydrogenase
LN	Laminin
LPO	lipid Peroxidation
MCHC	Mean Corpuscular Hemoglobin Concentration
MOPS	3-(N-Morpholino) propanesulfonic acid
MCV	Mean Cell Volume
MCV	Mean Corpuscular Volume
MCH	Mean Corpuscular Hemoglobin
MCHC	Mean Corpuscular Hemoglobin Concentration
MDA	Malondialdehyde
MTX	Methotrexate
NE	Normoglycemic with extract
NAFLD	Nonalcoholic fatty liver disease
NOM	Norma Official Mexicana
NO	Nitric Oxide
NC	Normoglycemic control
NB	Nitrobenzene
PROT	Protein
PLT	platelet
PHZ	Phenylhydrazine
PCV	Packed Cell Volume
pH	Potential hydrogen
P or PZA	Pyrazinamide (Pharmacological drug)
PCM/PCT	Paracetamol (Pharmacological drug)
PC-IIINP	Type III Collagen Terminal Peptide
RIF	Rifampicin
RBC	Red Blood Cell
ROS	Reactive Oxygen Species
ROS	Rosiglitazone
SDH	Sorbitol Dehydrogenase
SDH	Succinate Dehydrogenase
SHBG	Sex hormone binding globulin
STZ	Streptozotocin
SOA	Superoxide anion
SOD	Superoxide dismutase
SAGARPA	Secretaría de Agricultura y Desarrollo Rural
T	Triglycerides
TAA	Thioacetamide
T-AOC	Total Antioxidant Capacity
TBARS	Thiobarbituric Reacting Substances
TG	Triglycerides
TAS	Total Antioxidant Status
TC	Total Cholesterol
TB	Total Bilirubin
TOS	Total Oxidant Status
TP	Total Protein
TL	Total Lipid
TP	Total Protein
TP	Total Lipoprotein
TG	Triglycerides
TBil	Total Bilirubin
UA	Uric Acid.
V/V	Volume/volume
VLDL	Very-low-density lipoprotein
w/v	Weight/volume

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