Studies on hepatoprotective effects of vietnamese medicinal plants

Supporting Information

Table 1. Several medicinal plants, phytoconstituents and herbal formulations from Vietnam with hepatoprotective activity *in vivo* and *in vitro*

No.	Botanical names / Family	Vietnamese name	Part used	Chem. Composition	Model used	Extracts / phytoconstituent used/dosage	Parameters estimated	Histopathology	Ref.
1	**Liver diseases Model(s) used: PAR-induced mice**								
1	*Aganope balansae* (Gagnep.) Phan Fabaceae	Mạ mân	roots	saponin	PAR at a dose of 400 mg/ kg dissolved in CMC 0.5 % with a volume of 0.2 ml/10 g	Dry aqueous extract (CN) (165, 330 mg/kgP); total saponin (ST) (33, 66 mg/kg)	liver weight ↓ CN (165 mg/kg) ALT ↓ 69.81 %, AST ↓ 56.21 % ST (33 mg/kg) ALT ↓ 71.14 %, AST ↓ 57.78 %	CN (165 mg/kg) and ST (33 mg/kg) improved liver tissue, reduced microstructural damage in liver injury induced by PAR	[26]
2	*Andrographis paniculata* (Burm.f.) Wall. Acanthaceae	Xuyên tâm liên		lacton	PAR 400 mg/kg	Lacton (250, 500 mg/kg)	Lacton 250 mg/kg: ALT ↓ 2.00-fold, AST ↓ 2.60-fold, MDA was not changed	Lacton 250 mg/kg: 2/3 samples were with light and moderate degenerated hepatocytes. 1/3 sample was within normal limits	[65]
3	*Centella asiatica* (L.) Urb. Apiaceae	Rau má	Aerial part	Asiatic acid	PAR at a dose of 400 mg/ kg dissolved in CMC 1 % with a volume of 0.2 ml/10 g	Asiatic acid (20, 40 mg/kg P)	Asiatic acid (20 mg /kgP/day): ALT ↓, AST ↓	improvement in liver tissue, reduce microstructural damage in PAR- induced liver injury	[27]
4	*Chloranthus japonicus* Roem.&Schult. Chloranthaceae	Sói Nhật	Aerial part		PAR at a dose 400 of mg/ kg dissolved in CMC 1 % with volume of 0.2 ml/10 g	Aqueous extract (4, 12 g / kgP) (density 2 g materials/ml)	At dose 4 g/ kg: ALT ↓ 1.53-fold, AST ↓ 1.27-fold, MDA ↓ 1.14-fold in compared to PAR treated mice	improvement in liver tissue, reduce microstructural damage in PAR-induced liver injury	[28]
5	*Colocasia esculenta* (L.) Schott Araceae	Môn nước	Aerial part	Flavonoids glycosides	PAR at a dose of 400 mg/kg prepared in water at a concentration of 50 mg/mL	Methanol extracts (1,000 and 2,000 mg/kg/day)	AST ↓ 22.84 % and 26.59 % ALT ↓ 56.46 and 57.93 % MDA ↑ 1.49 amd 1.26 times vs. control	reduce microstructural damage in liver injury induced by PAR in treated mice	[29]
6	*Curcuma longa*	Nghệ	Rhizoma	Curcumin (CUR),	PAR 500 mg/kg,	CUR (200 mg/kg P);	CUR (200 mg/kg): ALT	-	[30]

	L. Zingiberaceae			Phytosome curcumin (Phyt)	orally	Phyt (100, 200 mg/kg P)	↓ 1.42-fold, AST ↓ 1.26-fold Phyt (200 mg/kgP): ALT ↓ 2.63-fold, AST ↓ 2.45-fold, SOD ↑, CAT↑, GPx, MDA ↓ vs. pathological control		
	Curcuma longa L. Zingiberaceae	Nghệ	Rhizoma	Curcuminoid	CCl_4- and PAR-induced mice	Curcuminoid (60, 120 mg/kg)	ALT ↓, AST ↓	improvement in liver tissue, reduce microstructural damage in liver injury by PAR and CCl_4	[66]
7	*Desmodium triquetrum* L. Fabaceae	Mũi mác	leaves	Polyphenol, flavonoid	PAR at a dose of 400 mg/ kg with a volume of 0.2 ml/10 g	EtOAc extract (9.6; 28.8 g/kg/day) Total extract (9.6; 28.8 g/kg/day) prepared in CMC 0.5 %	EtOAc extract (28.8 g/kg/day): AST ↓ 1.81-fold; ALT ↓ 1.23-fold, MDA was unchanged vs. pathological group	EtOAc extract (28.8 g/kg/day) Total extract (9.6; 28.8 g/kg/day): 2/3 specimens had normal liver, 1/3 specimen showed mild degeneration	[31]
8	*Eclipta prostrata L.* Asteraceae	Cỏ Nhọ nồi	Whole plant	Alkaloid, sugar, terpenoid,	PAR 400 mg/kg (volume 0.2 ml/10 g), oral	Water and ethanol (80 %) extracts (2 g materials / ml extract) (4 g/kg)	Ethanolic extract (4 g/kg): AST ↓ 1.73-fold, ALT ↓ 3.03-fold vs. pathological control.	Ethanolic extract (4 g/kg): 2/3 samples were with light and moderate degenerated hepatocytes. 1/3 sample was within normal limits	[32]
9	*Ganoderma lucidum* (Curtis) P. Karst Garnodermaceae	Linh chi	Whole fruits	Polysaccharide, triterpenoid	PAR 400 mg/kg, oral	Aqueous extract (6, 18 g/kg P)	6 g/kgP: AST ↓ 34.9 %, ALT ↓ 25.2 %, MDA unchanged vs. pathological group	improvement in liver tissue, and reduce microstructural damage in liver injury induced by paracetamol.	[33]
	Ganoderma lucidum (Curtis) P. Karst Garnodermaceae	Linh chi	Whole fruits	ganodermatriol	Hepa1c1c7 cells induced toxicity by t-BHP (500 µM)	10, 20 and 40 µM	At 40 µM: ALT, AST ↓, GSH ↑1.4 fold compared to control	-	[17]
	Ganoderma lucidum (Curtis) P. Karst Garnodermaceae	Linh chi	Whole fruits	ganodermatriol	Mice induced liver toxicity by t-BHP (2 mM/kg, i.p., 100:1 dissolved in saline)	250, 500 and 1000 mg/kg prepared in saline, i.p. once daily, for 3 days	At 1000 mg/kg: ALT ↓ 3.2-fold AST ↓ 3.2-fold, MDA ↓ 2.2-fold GSH ↑ > 2.5 fold compared to control	-	[17]

10	*Hovenia dulcis* Thunb. Rhamnaceae	Khúng khéng	Aerial part		PAR 400 mg/kg, oral	Ethanol extract (10 g dry materials /kg P)	AST ↓1.6-fold, ALT ↓ 1.97-fold compared to PAR treated group	improvement in liver tissue, reduce microstructural damage in liver injury in compared to that of pathological group	[35]
11	*Ludisia discolor* (Ker Gawl.) Blume Orchidaceae	Lan gấm	Leaves	Phenolic, flavoinoid, polysaccharide, kinsenoside	PAR at a dose of 400 mg/kg P with 10 ml/kg used to induce liver toxicity	Ethanol (110 and 220 mg/kg P), water extracts (100 and 200 mg/kgP)	Water extract (100 mg/kg) AST ↓ 6.8-fold, ALT ↓ 6.4-fold, MDA ↓ 1.57-fold vs. pathological group	improvement in liver tissue, and reduce microstructural damage and necrosis in liver injury induced by paracetamol.	[36]
12	*Moringa oleifera* Lam. Moringaceae	Chùm ngây	leaves	Vitamine, minerals (Ca, K, Mg, Fe), carbohydrate, proteins	A single dose of PAR 500 mg/kg, oral, mice	MO extract (dosage of 0.287, 0.574 and 1.147 g/kg P)	MO 1.147 g/kg: ALT ↓ 2.13-fold, AST ↓ 2.34-fold, MDA ↓ 1.29-fold, GSH level ↑ 1.70-fold vs. pathological control.	significant improvement of liver tissue damages similar to silymarin treatment compared to the non-treated control group.	[37]
13	*Pandanus odoratissimus* L.f. Pandanaceae	Dứa dại	fruit	vanillin, (+)-pinoresinol, (+)-syringaresinol (+)-medioresinol…	PAR 3 g/kgP	MeOH extract (100, 200, 300 mg/kgP)	MeOH extract (100 mg/kgP): AST ↓ 1,76-fold, ALT ↓ 2,12-fold	The liver was slightly pale, the liver parenchyma was a bit large	[67]
14	*Paramignya trimera* (Oliv.) Guill. Rutaceae	Xáo tam phân	roots	Coumarins and coumarin glycosides	A single dose of PAR 400 mg/kg, oral, mice	Methanol and hot aqueous extracts (10 g /kg P)	Methanol extract: AST ↓ 6.14-fold, ALT ↓ 6.87-fold total cholesterol ↓ 1.23-fold vs. pathological group	Decreased liver histopathological injury induced by paracetamol.	[38]
15	*Premma integrifolia* L. Verbenaceae	Vọng cách	leaves		PAR at a dose of 400 mg/ kg dissolved in CMC 1 % with a volume of 0.2 ml/10 g	Aqueous extract (10, 20 g/kg)	ALT, AST ↓	improvement in liver tissue, and reduce microstructural damage in liver injury induced by paracetamol.	[45]
2	**Liver diseases Model(s) used: CCl_4-induced mice**								
16	*Acanthus ilicifolius* L. Acanthaceae	Ô rô	roots	alkaloid, glycoside, lignan, saponin, triterpenoid, sterol, fatty acids,	CCl_4 (25 % in olive oil) 0.2 ml/ day × 4 weeks (or 8 weeks)	MeOH extract (15, 30 và 45 mg/kgP), orally	MeOH extract (15 mg/kgP): AST ↓ 86.6 %, ALT ↓ 83.9 %, (30 mg/kgP) AST ↓ 86,3 %,	MeOH extract (45 mg/kgP): improvement of liver tissue, only a few damaged liver cells were found	[68]

				coumaric derivatives			ALT ↓ 83,8 % (45 mg/kg) AST ↓ 85,3 %, ALT ↓ 84,5 % vs. pathological control (after 4 wks)		
17	*Eriochloa procera* (Retz.) C. Hubb. Poaceae	Cỏ mật	Whole plant		0.04 ml/ 10 g CCl_4 (0.5 ml / 3.5 ml olive oil), i.p. mice	Aqueous and ethanolic 80 %) extracts (d = 10 g materials / 2 g extract) (dosage of 1.5 and 4.5 g/kgP)	Aqueous extract (4.5 g/kgP): ALT ↓ 1.64-fold, AST ↓ 1.67-fold, vs. pathological group	-	[42]
18	*Helicteres hirsuta* Lour. Sterculiaceae	An xoa	Aerial part	Flavonoid, glycoside lignans, diterpenoids, flavonoids, quinones, and triterpenoids	Rats induced liver fibrosis by subcutaneous injection (i.s.) of 2 mL/kgP of CCl_4 in olive oil twice a week (Tuesday and Friday) for 12 wks	Methanol (HHM) and ethanol (HHE) extracts (25 % / water solution)	HHM (1.34 g/kgP) or HHE (1.19 g/kgP) protected the liver fibrosis caused by CCl_4 on rats.	collagen deposition areas in the livers of treated rat groups by HHM (3.44 %), and HHE-1/1 (5.12 %) were significantly lower than the CCl_4 group (19.9 %).	[46]
19	*Hypericum patulum* Thunb. Hypericaceae	Ban tròn	Leaves	flavonoid	Subcutaneous injection of CCl_4 1g/kg at the 1st, 3rd and 5nd day of 8 days experiment in Swiss mice	Ethanol (0.207 g/kgP), *n*-hexane (0.25 g/kgP), EtOAc (0.52 g/kgP) leaf extracts, quercitrin (0.02 g/kgP, oral)	EtOH extract: ALT ↓ 42.26 %, BIL ↓ 65.06 % Quercitrin: ALT ↓ 59.67 %, BIL ↓ 54.20 % vs. pathological control	-	[63]
20	*Litchi chinesis* Sonn. Sapindaceae	Vải	Seeds *(Semen Litchi)*		CCl_4 7 % in olive oil (peritoneal injection) with a dose of 0.1 ml/10 g mice	Ethanol extract 50 % (5, 10 g/kgP)	Ethanol extract (10g materials / kgP) AST ↓ 1.34-fold, ALT ↓, 1.55-fold, MDA ↓ 1.11-fold vs. pathological group	50 % ethanol extract was effective anti-oxidant by DPPH free radical scavenging mechanism	[43]
21	*Miliusa velutina* Dunai Annonaceae	Cò sen	Stem bark	Acetogenin A-B	CCl_4 25 % in olive oil with a dosage of 2.5 ml/kg to induce liver toxicity in mice	Ethanol extract VTCS (100, 200, 400 mg/kg) oral, for 4wks	100 mg/kg: AST ↓ 9.28-fold, ALT ↓ 5.88-fold 400 mg/kg: AST ↓ 18.35-fold, ALT ↓ 24.98-fold, MDA ↓ 14.67-fold GSH ↑ 28.23-fold vs. pathological group;	Liver injury decreased significantly in mice groups treated with VTCS ethanol extracts	[47]

22	*Nelumbo nucifera* Gaertn. Nelumbonaceae	Sen	Leaves	Flavonoids alkaloids		Ethanol extract of young leaves (30 mg/kg) and mature leaves (40 mg/kg)	ALT ↓, AST ↓	-	[39]
23	*Neolamarckia cadamba* (Roxb.) Bosser. Rubiaceae	Gáo trắng	leaves	Polyphenols, alkaloids, triterpenoids, glycoside, tannins, saponins	CCl_4 25 % in olive oil with a dose of 2.5 ml/kg to induce liver toxicity in mice	Leaf extract (100, 200, 400 mg/kgP)	Dosage 100 mg/kg: ALT ↓ 30.7-fold, AST ↓ 11.1-fold, MDA ↓ 2.04-fold, GSH ↑ 4.18-fold vs. pathological group	-	[69]
24	*Ophiocordyceps sinensis* (Berk.) G.H.Sung, J.M.Sung, Hywel-Jones & Spatafora Ophiocordycipitaceae	Đông trùng hạ thảo	Fruiting body	Exopolysaccharide (EPS)	CCl_4 (1:3 v/v in olive oil) at a dose of 1.0 mL/kgP	EPS1 (0.83 mg/kgP), EPS2 (1.66 mg/kgP)	EPS1 (0.83 mg/kgP): AST↓ 54.3 %, ALT ↓ 28.4 %, EPS2 (1.66 mg/kgP): AST↓ 50.1 %, and ALT ↓ 31.0 %	The improvement of histopathological liver tissue showed that EPS significantly reduced the damage induced by CCl_4 in the liver	[70]
25	*Panax vietnamensis* Ha & Grushv. Araliaceae	Sâm Việt Nam	Underground parts	saponin	CCl_4 (800 µl/kg, diluted in 200 µl corn oil)	Crude extract (300 µg/10 µl of water/g); total saponins (200 µg/10 µl of water/g)	Crude extract: AST ↓ 24.5 %, GSTα ↓ 50.0 % Total saponins: AST ↓ 52.2 %, GSTα ↓ 49.5 %	-	[71]
26	*Pandanus kaida* Kurz. Pandanaceae	Dứa kaida	roots		CCl_4 (1:7 and 1:6 in oil) with dosage of 0.1 ml/10g mice for 7 days	Aerial roots aqueous extract 7.2, 12, 15 g/kgP) (20 g materials (10 % humidity) / ml liquid extract	Dosage 7.2 g/kgP: ALT ↓ 70.53%, AST ↓ 63.4% vs. pathological group	-	[44]
27	*Silybum marianum* (L.) Gaertn. Asteraceae	Cúc sữa (Cúc gai)		silymarin		Silymarin (0.1 ml/10 g P)	Liver P450, aniline hydroxylase, SOD, GPx, TAS	-	[72]
28	*Hedyotis diffusa* (Willd.) Roxb. Rubiaceae	Lưỡi rắn trắng	Whole plant	Iridoid, Polyphenol, Flavonoid anthraquinone	CCl_4 (25 % in olive oil), 2.5 ml/kgP mice	methanol (100, 200, 400 mg/kgP)	400 mg/kgP: AST ↓ 4.58-fold, ALT ↓ 2.83-fold, MDA ↓ 9.93-fold, GSH ↑ 2.89-fold vs. pathological group	improvement in liver tissue, reduce microstructural damage in liver injury induced by CCl_4	[64]

29	*Tetracera scandens* L. Dilleniaceae	Chặc chìu (Dây chiều)	leaves	isoflavonoids	CCl_4 ((1 mL/kgP, intraperitoneal injection)	Ethanol (100 mg/kg, orally, once per week)	ALT ↓ 6.73-fold, AST ↓ 7.27-fold vs. pathological control, MDA ↓ to nearly normal level	-	[73]
3	**Liver diseases Model(s) used: other chemicals-induced mice**								
30	*Allium sativum* L. Liliaceae	Tỏi đen	fruit	Sulfur-containing compounds, S-allyl-L-cysteine (SAC)	Thioacetamid (TAA) 300 mg/L was given to mice for 10 weeks	Black gallic extracted by cellulase (200 mg/kg)	ALT ↓ 2.20-fold, AST ↓ 2.19-fold vs. pathological control	improvement in liver tissue, reduce microstructural damage in liver injury induced by TAA	[74]
31	*Combretum quadrangulare* Kurz. Combretaceae	Trâm bầu	*Leaves*	triterpenoids	D-GalN (700 mg/kg) and LPS (20 µg/kg) i.p. injection to induce liver injury in mice	MeOH extract (50 mg/kg) was injected s.c.	ALT ↓		[52]
	Combretum quadrangulare Kurz Combretaceae	Trâm bầu	*Leaves*	triterpenes of the lupane type, 2α,6β -dihydroxybetulinic acid (**1**) and 6β-hydroxyhovenic acid (**2**), and an oleanane type, 6β-hydroxyarjunic acid (**3**)	D-GalN (0.5 mM) / TNF-α (100 ng/ml) was added to induced cell death in primary cultured mouse hepatocytes	MeOH extract (10, 100, 200 µg/ml)	Cell survival rate ↑		[75]
32	*Enydra fluctuans* Lour. Asteraceae	Rau ngổ	*Aerial parts*		Cyclophosphamide - induced mice	Ethanol extract 40 % (1.725, 3.45 g)	MDA ↓, GSH	-	[41]
33	*Ganoderma lucidium* (Curtis) P. Karst Garnodermaceae	Linh chi	Whole fruit		cyclophosphamide 150 mg/kg (intraperitoneal injection)	EtOH extract (330, 230, and 120 mg/kg P) (equivalent to 5, 10, and 15 g/kg of dry materials)	At dose of 230 mg/kgP: MDA ↓ 1.86-fold, GSH ↑ 1.65-fold vs. pathological control	(120 mg/kgP) showed a mild active hepatitis. Portal space presented slight to moderate inflammation, no necrotic liver cells	[76]
34	*Hedyotis diffusa* (Willd.) Roxb. Rubiaceae	Lưỡi rắn trắng		Polyphenols, flavonoids	Rifampicin- and isoniazid-induced mice	Aqueous extract 15 % or 30 % (10 ml/kg/day)	ALT ↓, AST ↓	improvement in liver tissue, reduce microstructural damage in liver injury induced by antituberculosis drugs	[34]

35	*Panax vietnamensis* Ha & Grushv. Araliaceae	Sâm Việt Nam	Underground parts	saponins	D-GalN (700 mg/kg) and LPS (5 µg/kg) i.p. injection to induce liver injury in mice	Majonoside R2 (MR2) (solution in saline, 50 or 10 mg/kg, i.p.) given 12h and 1 before D-GalN/LPS injection	Both MR2 dosages: ALT and AST ↓ 1.5-2.0-fold vs. pathological control. MR2 (50 mg/kg) TNF-α ↓ 1.96-fold vs. pathological control	Improvement of liver tissue. MR2 protected against hepatic apoptosis and necrosis. MR2 showed no inhibition of lipid peroxidation	[77] [78]
				saponins	D-GalN (1 mM) and TNF-α (100 ng/ml) in hepatocyte cells	Majonoside R2 (MR2) (solution in saline, 50, 100 and 200 µM)	at MR2 200 µM: cell viability ↑ 89.8 %	MR2 protected the hepatocytes from apoptosis via an inhibition of TNF-α production	[77]
36	*Phellinus linteus* Hymenochaetaceae	Nấm thượng hoàng	fruits	polysaccharide	Cyclophosphamide - induced mice	Polysaccharide (50, 100 mg/kgP)	MDA ↓, GSH	-	[79]
37	*Solanum hainanense hance* Solanaceae	Cà gai leo			Trinitrotoluene (TNT) (10 mg/mL) in sesame oil at dose of 10 ml (100 mg/kgP for 6 weeks * 6 times/week)	Solution (1 g/mL)	AST ↓ 1.68-fold, ALT ↓ 1.31-fold, GSH unchanged vs. pathological control	Alleviation of liver lesions induced by TNT	[23]
38	*Taxus yunnanensis* Cheng el L. K. Fu Taxaceae	Thông đỏ	wood	lignans	D-GalN (700 mg/kg) and LPS (10 µg/kg) i.p. injection to induce liver injury in mice	Lignans (solution in saline, 50 or 10 mg/kg, i.p.), twice before D-GalN/LPS administration	ALT and AST ↓ 20 - 50 %	These tested lignans protected the mouse hepatocytes from apoptosis	[80]
				lignans	D-GalN (1 mM)/ TNF-α (100 ng/ml) in cultured mouse liver parenchymal cells	Lignans (10, 50, 100 and 200 µM)	Lignan 1 (200 µM) Cell viability ↑ 93.2 % Lignan 2 (200 µM) Cell viability ↑87.6 %	Lignans-protected TNF-α-mediated direct hepatocyte apoptosis	[80]
4	***In vitro liver models***								
39	*Cleome viscosa* L. Cleomanaceae	Màn màn vàng	*leaves*	Flavonoids, flavonol glycosides,	HepG2 cells induced toxicitiy by CCl_4 2 mM for 2 h	100 µM visconoside C	Cell alive ↑ 34.3 % compared with quercetin control	-	[49]
			stems		HepG2 cells induced toxicity by CCl_4 2 mM	MeOH extract (100 µg/mL)	After 72h treatment: Cell viability ↑ 21.4 %		[61]

		Màn màn vàng	*stems*	Flavonoids, flavonol glycosides,	CCl_4–olive oil (1 : 1, 2 mL/kg body weight, i.p.) on days 2 and 3.	MeOH extract (15, 30, and 45 mg/kgP) for 5 days	At 30 mg/kgP: ALT ↓ 3.56-fold, AST ↓ 4.02-fold.	Improvement of liver tissue	[61]
40	*Cleome chelidonii* Cleomanaceae	Màn màn tím	*stems*		HepG2 cells induced toxicitiy by CCl_4 2 mM	MeOH extract (100 µg/mL)	After 72h treatment: Cell viability ↑ 30.0 %		[61]
			stems	Flavonoids, flavonol glycosides,	CCl_4–olive oil (1 : 1, 2 mL/kg body weight, i.p.) on days 2 and 3.	MeOH extract (15, 30, and 45 mg/kgP) for 5 days	At 30 mg/kgP: ALT ↓ 13.7-fold, AST ↓ 19.2-fold	Improvement of liver tissue	[61]
41	*Canarium bengalense* Roxb. Burseraceae	Trám hồng	*Stem barks*	Flavonoids Flavone glycoside	H_2O_2-induced damage in primary cultured hepatocytes	Ellagic acid 3,3',4-trimethoxy 4'-*O*-*α*-L-rhamnopyranoside (3), 3,4,5-Trimetoxyphenol *O*-*β*-D-glucopyranoside (4) and Tricin (7)	At a conc. of 128 µg/ml, Cell viability of (3) ↑ 52.1%, of (4) ↑ 47.5% , of (7) ↑ 55.3 %,	The phenolic constituents prevented oxidative stress – mediated hepatotoxicity	[51]
42	*Heliciopsis lobata* (Merr.) Sleumer Proteaceae	Đũng	leaves	3,5-dimethoxy-4-hydroxy phenyl-1-*O*-*β*-D-glucopyranoside	CCl_4 40 mM for 2h induced toxicity in HepG2 cells	100 µg/mL	Cell survival rate up to 52.25 %		[50]
43	*Helicteres hirsuta* Lour. Sterculiaceae	An xoa	Aerial part	kaempferol-3-*β*-D-(6-*O*-trans-p-coumaroyl) glucopyranoside (2)	HepG2 cells induced toxicitiy by CCl_4 40 mM for 2 h	100 µg/mL	Cell alive ↑		[53]
				3,4',7,8-tetrahydroxy flavone	HepG2 cells induced toxicitiy by CCl_4 40 mM for 2 h	100 µg/mL	Cell survival ↑ EC_{50} = 90,20 µg/mL		[53]
44	*Ixora duffii* cv. Super king Rubiaceae	Trang to	Leaves and flowers	Alkaloid, flavonoid, anthraquinone, glycoside triterpenoid	HepG2 cells	The methanol extracts (100, 200, 400 mg/kgP)	HepG2 cell survival rate ↓: Flower extract 100 µg/mL: 87.8 %; 250 µg/ml: 59.6 %; 500 µg/ml: 44.0 %;		[81]
45	*Moringa oleifera* Lam.	Chùm ngây	leaves	Vitamine, minerals (Ca, K, Mg, Fe),	HepG2 cells induced toxicity with 2 mM	Isoquercitrin: 2.5; 5.0; 10.0 µg/ml	Isoquercitrin (2.5 µg/ml): cell alive ↑	isoquercitrin prevented lipid accumulation, GSH	[82]

	Moringaceae			carbohydrate, proteins	CCl_4 for 24 h		19.76 %, lipid accumulation ↓ 1.4 % vs. physiological control	degeneration, increased HepG2 cell viability	
46	*Premna serratifolia* L., Lamiaceae	Vọng cách	*Leaves*		500 µg/mL. CCl_4 (1 %) induced toxicity in HepG2	500 µg/mL plant extract	Cell viability ↑ 33.75 %		[16]
47	*Paederia lanuginose* Wall. Rubiaceae	Mơ lông (Mơ tam thể)	*Leaves*	Polyphenols	500 µg/mL. CCl_4 (1 %) induced toxicity in HepG2	500 µg/mL plant extract	Cell viability ↑ 28.76 %		[16]
48	*Paederia scandens* (Lour.) Merr. Rubiaceae	Mơ leo	*Leaves*	Iridoid glycosides	500 µg/mL. CCl_4 (1 %) induced toxicity in HepG2	500 µg/mL plant extract	Cell viability ↑ 4.95 % ALT, AST ↓		[16]
49	*Phyllanthus emblica* L. Phyllanthaceae	Me rừng	fruits	Polyphenols Vitamin C	HepG2 cells were treated with 100 µL of CCl_4 (1.0 % (v/v)) in 0.25 % DMSO prepared in serum-free culture medium for 2 h	Fruit extracts in MeOH, EtOAc, water, 50%, 70% and 96% EtOH (0.8, 4, 20, 100 µg/mL)	The cell protective concentrations of PE-M, PE extract had the highest hepatoprotective effect with PC_{50} value of 47.68 µg/mL		[60]
5	***Ex vivo liver models***								
50	*Orthosiphon aristatus* Blume, Lamiaceae	Râu mèo	Aerial part	polyphenols	CCl_4 (1.5 % in DMSO 1 % and distilled water) induced liver toxicity in 45 min	The methanol extracts (0.05; 0.1; 0.25 and 0.50 mg/mL)	0.1 and 0.25 mg/mL: ALT ↓ 60 % vs. pathological group	-	[83]
51	*Physalis angulata* L. Solanaceae	Thù lù cạnh (Tầm bóp)		polyphenols	100 µM H_2O_2 was added to the culture of primary hepatocytes freshly isolated from BALB/c mice for 2h	quercetin 3-*O*-rutinoside (100, 20, 4, 0.8 µg/mL)	EC_{50} = 17.08 mg/mL		[62]
52	Liverlife (capsule)	Viên nang liverlife	Mixed medicinal plants		-	0.4 ml Liverlife (500 and 2000 mg/kg P)	ALT, AST, BIL	improvement in liver tissue, and reduce microstructural damage in liver injury induced by CCl_4	[84]
53	*Lophandanum*	Cao	Mixed		-	Aqueous extract	Albumin, globulin,	improvement in liver tissue,	[85]

	extract	Lophandanum	medicinal plants			(1.5, 3.0, 6.0 g/kgP)	protein total, ALT, AST, bilirubin	and reduce microstructural damage in liver injury induced by CCl_4	
54	Mixed plant extracts		Mixed formulation			Formula combined from different extracts *0.5, 1 g/	ALT, AST	improvement in liver tissue, and reduce microstructural damage in liver injury induced by CCl_4	[86]
55	AH product		Mixed plant extracts	-	CCl_4 and PAR-induced mice	AH (4.8 and 9.6 capsules/kg/day)	ALT, AST, MDA	improvement in liver tissue, and reduce microstructural damage in liver injury induced by CCl_4 and PAR	[87]
56	Flabean-S		Grean bean pods, Schisandra chinensis		Flavonoid Schizandrin	Flaben-S extract (0.5 ml/ mouse/day) (7 days)	ALT, AST, MDA	improvement in liver tissue, reduce microstructural damage in liver injury induced by CCl_4	[88]
57	Livcol (granule)		Mixed plant extracts		CCl_4-induced mice	Livcol granule (1 g/kgP)	ALT, AST, MDA, SOD	improvement in liver tissue, and reduce microstructural damage in liver injury induced by CCl_4	[66]
58	Protecliv (capsule)		Mixed plant extracts		Rifampicin- and isoniazid-induced mice	Protecliv capsules (250, 500 mg/kg/day)	ALT, AST, GGT, MDA, liver weight	-	[89]
59	Water extract formulation		Stixis suaveolens + *Pandanus tonkinensis* 500 g each		PAR 400 mg/kgP	Water extract formulation (7.2; 14.4 g/kgP mice eq. dosage of 30; 60 g/day/human 50 kgP)	Dosage 7.2 g/kgP: ALT ↓ 1.43-fold, AST ↓ 1.17-fold, MDA ↓ 1.69-fold Dosage 14.4 g/kgP: ALT ↓ 2.40-fold, AST ↓ 1.72-fold, MDA ↓ 1.51-fold vs. pathological group	Liver injury ↓, hepatocyte degeneration ↓ Toxic symptoms ↓	[90]
					HepG2 cells treated with 40 mM CCl_4	Ten water fractions F1-F10 (100, 20, 4, 0.8 µg/ml)	Fraction F8 (100 µg/ml): cell survival rate ↑ 59.69 % (eq. to the activity of quercetin at 20 µg/mL)	Lipid peroxidation ↓, Cell viability ↑	[90]