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Protective effects of leaf aqueous extracts from *Gardenia ternifolia Schumach.* on alcoholic liver disease in Wistar rats

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ABSTRACT

Background: Gardenia ternifolia (GT) is a plant of the Rubiaceae family, with a wide range of ethnopharmacological properties. However, its hepatoprotective effects were poorly investigated. This work aimed at assessing the hepatoprotective activity of GT leaf aqueous extracts against chronic ethanol-induced damage *in vivo*.
Materials and methods: Male Wistar albino rats were given orally 10 % ethanol (10 mL/kg) and different doses of GT extracts (50, 100, and 200 mg/kg) or distilled water (negative control) simultaneously and daily for 28 days. Normal controls were fed with a normal diet while positive controls received, in addition to ethanol, silymarin (50 mg/kg). After treatment, animals were sacrificed, blood and liver samples were collected, various biochemical parameters were quantified and the histological sections were performed. Moreover, a qualitative phytochemical analysis of this extract was carried out.
Results: GT administration significantly reduced alanine aminotransferase (10.35 ± 2.13 U/L and 9.07 ± 2.13 U/L vs 24.43 ± 4.28 UI/L) and aspartate aminotransferase (14.25 ± 3.02 and 18.32 ± 2.13 UI/L vs 34.61 ± 3.23 UI/L) activities at doses of 50 and 100 mg/kg respectively in comparison with the negative control. Likewise, serum triglyceride and total cholesterol levels were significantly reduced by GT extract, especially at the dose of 200 mg/kg compared to the ethanol-treated group. Histological examination showed that the extract protected the liver by reducing hepatic cytolysis, and leukocyte infiltration. Different secondary metabolites including condensed tannins, phenolic acids, and saponins were found in the GT extract but none of these compounds corresponded to epicatechin, coumarin and naringenin.
Conclusion: These results show that GT extract may be a potential therapeutic agent against alcoholic liver disease.

1. Introduction

Excessive alcohol consumption is one of the major problems of our society, due to its negative socio-economic impact on families and the threat it represents to population health. According to statistics available globally, around 3.0 million deaths are recorded each year due to the harmful use of alcohol [1]. In 2016, alcohol use was ranked as the 7th risk factor of death in the world, leading to 2.2 % of deaths in females and 6.8 % in males [2]. In Africa, the consumption-related disease burden is increasing, with the percentage of deaths attributable to harmful alcohol use rising from 2.4 % in 2004 to 6.4 % in 2012 [3]. Moreover, greater exposure is expected in the coming years. According to the World Health Organization (WHO), drinkers from the African continent consume about 40 g of pure alcohol per day which is higher than that of the South-East Asian region [1]. In Cameroon, alcohol consumption is estimated to be 2.6 L of pure alcohol per capita for men and women more than 15 years old [4]. The country is counted among the greatest alcohol consumers in Central and West Africa with about 660 million liters of beer in 2016 [5]. According to Cameroon's medical council, three-fourths of the 7500 deaths from liver diseases in Cameroon in 2020 were due to alcohol products [6].

Alcoholic liver disease (ALD) is a frequent pathology that ranges from simple steatosis to hepatocellular carcinoma [7]. Once ingested, alcohol is primarily metabolized in the liver by three different enzymatic

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systems including alcohol dehydrogenase, catalase, or the cytochrome-P450-enzymes (CYP 2E1) into acetaldehyde. Then, acetaldehyde is converted by acetaldehyde dehydrogenase, into acetate, a precursor in lipogenesis. Indeed, acetaldehyde metabolism releases high amounts of NADH in mitochondria which further reduces the β-oxidation of free fatty acids, promoting thereby the storage of fats. Previous studies also demonstrated that alcohol consumption generates oxidative stress and an inflammatory response which lead to alcoholic hepatitis and related complications [8]. To date, the recommended treatments strongly suggest abstinence and the use of corticosteroids in patients with severe alcoholic hepatitis [7]. Moreover, the use of nutritional therapy is increasingly encouraged. Recent studies documented the properties of many food-edible plants against ALD including mango, apricot, and grapefruits [8]. Despite these advances, there are no FDA-approved treatments approved against ALD.

Gardenia ternifolia also called ''*Djinalii gorki*'' in the *fufulde* language (a dialect of North Cameroon) is a medicinal plant of the family of Rubiaceae, used in African pharmacopeias for its multiple virtues. The leaf is reported to possess antidiabetic and hypotensive activities [9,10], anti-sickling and anti-radical effects [11], and anti-cancer properties [12]. Crushed fruits are used by traditional healers to treat haemorrhoidal lesions [13] while the roots were shown to display anti-malarial activities *in vivo* [14]. However, the hepatoprotective activities were little studied. More recently, a protective effect was demonstrated in rats with the aqueous leaf extract at the dose of 200 mg/kg against carbon tetrachloride-induced hepatotoxicity [15]. Moreover, the phytochemical analysis of this extract revealed a higher presence of saponins and tannins. Based on the previous data, the present study investigated the protective effects of aqueous extract from the leaf of *Gardenia ternifolia* against chronic ethanol-induced liver injury.

2. Material and methods

2.1. Plant material collection

The leaves of *Gardenia ternifolia* (GT) were harvested in the morning and before flowering between April and May 2019 in *Selbe Darang*, a small village in the Ngaoundere II sub-division (Cameroon), with the assistance of Mr Awé Victor, a botanist. The plant was identified at the National Herbarium of Cameroon in Yaoundé under the reference N °27407/SRF Cam.

2.2. Aqueous extract preparation

The leaf of GT was washed with distilled water, dried in the shade for a month, and pounded to obtain a powder which was then sieved using an analytical sieve provided by Xianxiang Jiashun Machinery Co. Ltd (Henan, China). The powder obtained was stored in hermetically sealed glass jars and placed out of direct sunlight at room temperature until use. The aqueous extract was prepared by macerating 20 g of powder in 200 mL of distilled water for 24 h. Then the macerate was filtered using Whatman No. 1 paper and the filtrate collected was used for treatments.

2.3. Qualitative phytochemical analysis and HPLC

The leaf powders were used to screen the presence of saponins, condensed tannins, phenolic acids, and flavonoids using standard protocols as previously described [16].

The GT extract composition was also investigated by high-performance liquid chromatography (HPLC)/UV using an UltiMate 3000 HPLC system (Thermo Fisher Scientific). Briefly, 10 μL of the extract (10 mg/mL), and the standards (epicatechin, coumarin and naringenin, all at 0.1 mg/mL) were injected into a C18 column (250 × 4.5 mm, 5 μm, 100 Å, Luna, Phenomenex, Aschaffenburg, Germany) at 25 °C with a gradient of acetonitrile (ACN) in water (0.1 % formic acid each) at 1 mL/min. The solvent gradient started with 5 % ACN for 8 min for column equilibration, followed by a gradient elution of 5–100 % ACN for 35 min. Compounds were detected at 254 nm.

2.4. Animals and treatments

Thirty-five (35) male Wistar Albino rats, approximately 1.5 months old, weighing 100–140 g were used. The rats were bred in the animal house of the Food Biochemistry Laboratory at the National School of Agro-Industrial Sciences at the University of Ngaoundéré. Rat conditioning took place under room temperature conditions and a 12-h by 12-h photoperiod. They had free access to water and food. The animal feed consisted of 60 % corn, 30 % fish, 6 % soybeans, 3.5 % bone meal and 0.5 % cooking salt and 0.11 % palm kernel meal. The experimental protocol was reviewed and approved by the Institutional Ethics Committee (Registration N°20/003/UN/DENS/CD-SV). Ethanol 90 % was provided by Polypharma SARL (Ngaoundere, Cameroon) and silymarin was supplied by Micro Labs Ltd (Husor, India).

The animals were divided into 7 groups of 5 rats each. Group 1 (normal control) received a normal diet. Group 2 (negative control) received only 10 % ethanol, group 3 (positive control) received 10 % ethanol and silymarin (50 mg/kg); group 4 (extract control) received 10 % alcohol and 50 mg/kg of the GT extract; group 5 received 10 % ethanol and 100 mg/kg of the GT extract; group 6 received 10 % ethanol and 200 mg/kg of the GT extract and the group 7 received only the GT extract at a dose of 200 mg/kg. Ethanol and aqueous GT extracts were co-administered orally at a daily dose for 28 days. The body mass of the animals was recorded daily. At the end of the treatment, the animals were fasted for 12 h and then sacrificed by decapitation under anesthesia with ethyl ether.

The blood was collected in the dry red-topped tubes, let clotted for 20 min at room temperature, and centrifuged at 1125 g for 15 min to obtain the serum [17] which was then stored at −20 °C for the study of the biochemical parameters. The livers were carefully removed and rinsed in 0.9 % NaCl and then weighed. Liver samples were stored in formalin (10 %) for histological study.

2.5. Biochemical analyses

The enzymatic activities of serum aspartate aminotransferase (AST), alanine aminotransferase (ALT), serum levels of triglycerides (TG), and total cholesterol (CT) were assayed using the DIALAB kits (Wiener Neudorf, Austria) following the manufacturer's instructions.

2.6. Histological sections

A piece of liver tissue fixed in 4 % paraformaldehyde has been embedded in paraffin and then cut into small sections of 5-μm thickness. These sections were stained with hematoxylin/eosin (HE), then dehydrated with ethanol 100° and xylene and used for microscopic observations.

2.7. Statistical analysis

Data were expressed as the mean ± standard error to mean (SEM). Comparisons were made using one-way analysis of variance (ANOVA) followed by Dunnett's post-hoc test using GraphPad Prism 5.03 software. The difference was considered statistically significant at $P < 0.05$.

3. Results

3.1. Effect of GT extract on weight changes of rats and the relative liver weight

Table 1 shows the effect of the GT extract on the rat's weight after 28 days of treatment and on the relative mass of the liver (liver weight/body weight). The results obtained showed that at the end of the

Table 1
Effect of GT extract on the rats weight changes and the relative liver weight.

Groups	Initial weight(g)	Final weight (g)	Weight variation (g)	Relative liver weight
Healthy control	129.6 ± 20.97	200.0 ± 19.75	70.40 ± 6.60	0.033 ± 0.001
Negative control	122.4 ± 6.33	189.6 ± 9.72	67.20 ± 3.51	0.035 ± 0.001
Sily. 50 mg/kg + EtOH	123.2 ± 5.26	199.4 ± 6.08	76.20 ± 5.75	0.031 ± 0.001
GT 50 mg/kg + EtOH	102.0 ± 2.85	171.8 ± 7.41	69.20 ± 8.68	0.033 ± 0.004
GT 100 mg/kg + EtOH	110.0 ± 17.13	172.2 ± 14.33	62.20 ± 8.68	0.03 ± 0.004
GT 200 mg/kg + EtOH	123.8 ± 14.89	185.6 ± 20.43	61.80 ± 6.16	0.03 ± 0.000
GT 200 mg/kg	126.2 ± 18.04	196.2 ± 20.32	70.00 ± 5.68	0.03 ± 0.000

treatment, no significant variation in rat weight was noted between groups. Although a slight increase in the relative liver weight was found in the ethanol-treated group compared to the untreated group, there were no significant variations between both groups and other test groups.

3.2. GT aqueous extract significantly decreased serum transaminases activity

As shown by Fig. 1a, ethanol administration significantly increased ($P < 0.01$) the AST activity compared to the normal control (34.61 ± 3.22 vs 12.07 ± 3.27 U/L). However, treatment of rats with GT extract at 50 mg/kg (14.25 ± 3.02 U/L) and 100 mg/kg (18.32 ± 2.13 U/L) showed a significant decrease in the AST activity as compared with the negative control. However, there was not a significant reduction of AST with silymarin at the dose of 50 mg/kg. GT extract also did not show any increase in AST activity as compared to the normal control. Likewise, ALT activity was found to increase by ethanol administration (Fig. 1b), but silymarin (9.88 ± 2.57 U/L), GT extract at 50 mg/kg (10.35 ± 2.13 U/L) and 100 mg/kg (9.07 ± 2.63 U/L) respectively have significantly reduced ALT activity as compared to the ethanol-treated group (28.50 ± 1.87 U/L).

3.3. GT aqueous extract at 200 mg/kg significantly reduced serum TG and TC levels in ethanol-treated rats

The effect of GT extract on markers of the serum lipid profile is displayed in Table 2. As evidenced by the table, ethanol administration significantly increased ($P < 0.01$) TG levels (1.42 ± 0.35 g/dL) compared to the normal control (0.46 ± 0.07 g/dL). Silymarin and GT extract at 50, 100, and 200 mg/kg significantly reduced serum TG levels compared to the negative control. As far as TC is concerned, a significant increase ($P < 0.01$) in TC levels was observed in ethanol-treated rats (80.62 ± 12.20 g/dL) compared to the normal control (48.90 ± 5.47 g/dL). However, Silymarin and GT extract at 50, and 100 mg/kg showed a decrease in the TC contents although non-significant. Nevertheless, GT extract at 200 mg/kg significantly ($P < 0.05$) reduced the serum TC levels (53.23 ± 4.75 g/dL) compared to the negative control.

3.4. GT extract reduced hepatic cytolysis, lipid accumulation, and leukocyte infiltration in hepatic tissue

As shown by Fig. 2, histological analysis of photomicrographs of the liver of normal controls revealed a normal architecture of the hepatic parenchyma, presenting a portal space (consisting of the portal vein, bile canaliculus and hepatic artery), sinusoid capillaries and well distinct hepatocytes. Compared with the normal control, histopathological abnormalities marked by the presence of hepatic cytolysis (HC), an increased number of lipid droplets (LD), and massive infiltration of leukocyte cells in the hepatic parenchyma, have been observed in the ethanol-treated rats. Conversely, the GT extract dose-dependently reduced these abnormalities in the microstructure of the liver, especially at 100 and 200 mg/kg, relative to the negative control. Also, Silymarin at 50 mg/kg exhibited a protective effect against ethanol-induced liver injury.

3.5. Phytochemical analysis of the GT aqueous leaf extract

Qualitative phytochemical screening of the GT aqueous leaf extract

Table 2
Ameliorating effects of GT aqueous leaf extract on serum lipids.

Groups	Triglycerides (g/dL)	Total Cholesterol (g/dL)
Healthy control	0.46 ± 0.07**	48.90 ± 5.47**
Negative control	1.42 ± 0.35	80.62 ± 12.20
Sily. 50 mg/kg + EtOH	0.43 ± 0.18**	58.85 ± 6.09
GT 50 mg/kg + EtOH	0.21 ± 0.06***	67.34 ± 3.30
GT 100 mg/kg + EtOH	0.37 ± 0.08**	57.13 ± 3.95
GT 200 mg/kg + EtOH	0.18 ± 0.05***	53.23 ± 4.75*

Values are mean ± SEM (n = 5), *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$ when compared to the negative control. EtOH: Ethanol, GT: Gardenia ternifolia.

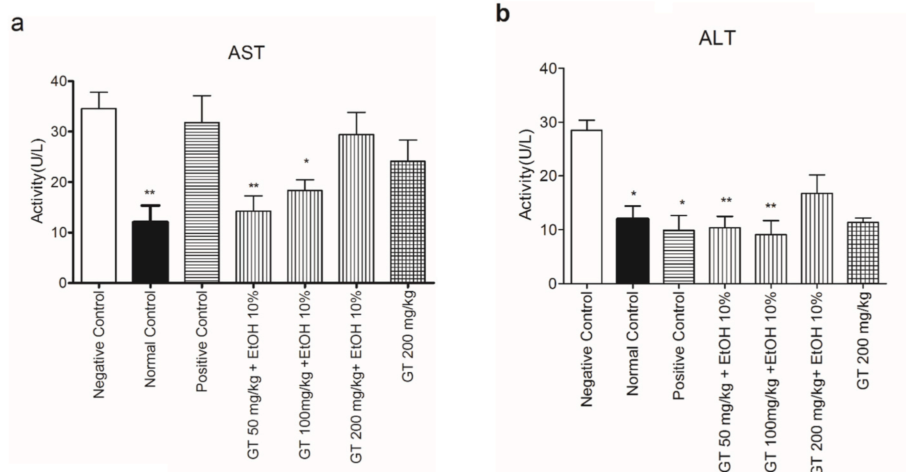

Fig. 1. Effects of GT aqueous extracts on serum AST (a) and ALT (b) activities in ethanol-induced liver injury. Values are mean ± SEM (n = 5), *$P < 0.05$; **$P < 0.01$ when compared to the negative control. AST Aspartate aminotransferase, ALT Alanine aminotransferase, GT: *Gardenia ternifolia.*

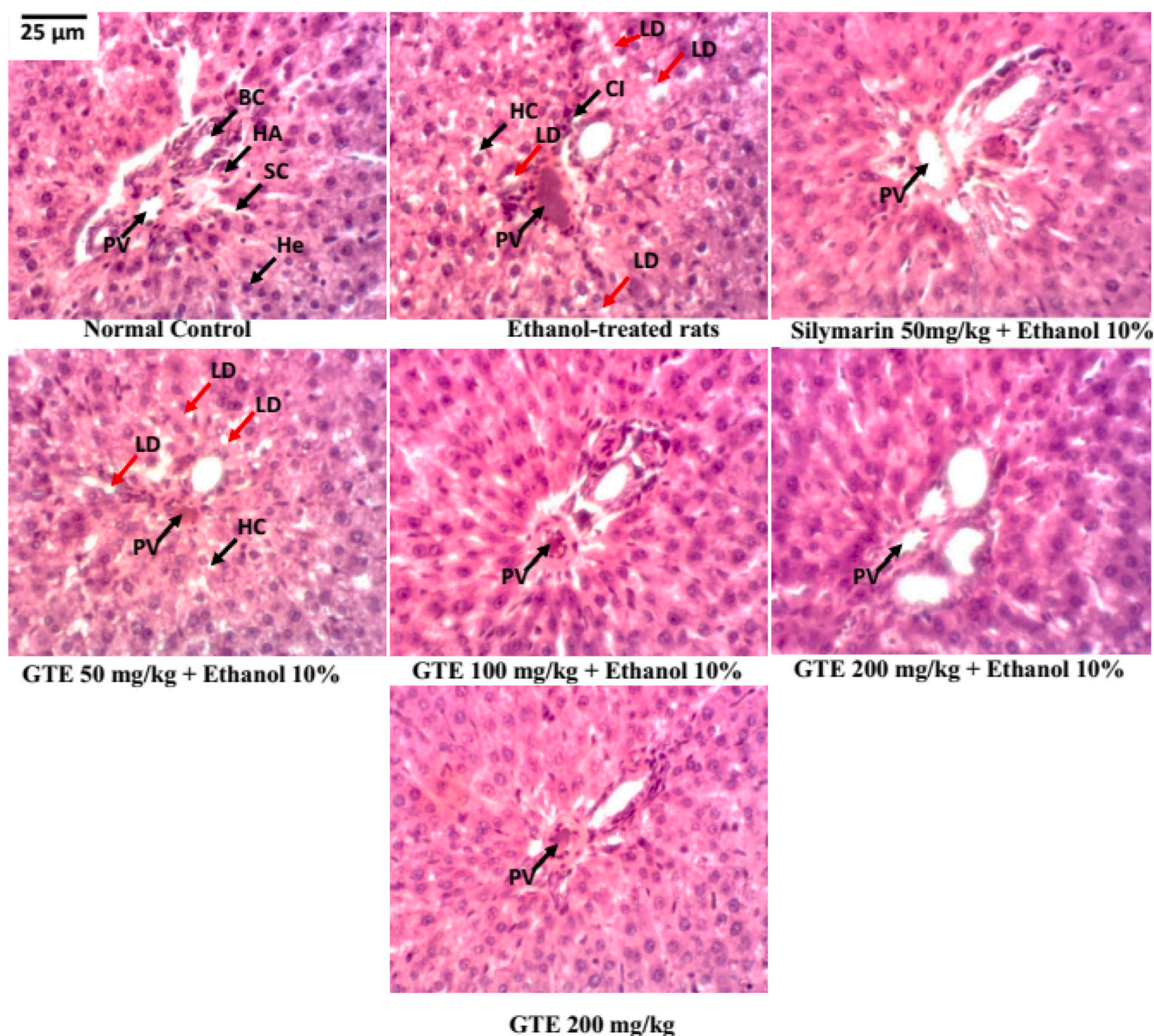

Fig. 2. Photomicrographs (Hematoxylin and Eosin, Magnification ×200) showing the effects of different doses of GT leaf aqueous extract on liver tissue lesions induced by ethanol. PV: portal vein; **He**: Hépatocyte; **SC**: Sinusoidal capillary; **HA:** Hepatic artery; **BC**: Biliary canaliculi; **HC**: Hepatic cytolysis; **LD**:Lipid droplets; **CI:** cell infiltrate.

Table 3
Phytochemical constituents of the GT aqueous leaf extract.

Phytoconstituents	Observations
Flavonoïds	–
Tannins	+
Phenolic acids	+
Saponins	+

(Table 3) revealed the presence of condensed tannins, phenolic acids, and saponins but flavonoids were not found (Supplementary material). The HPLC/UV profile also confirmed that GT extract remained a mixture of compounds with no epicatechin-, coumarin-, and naringenin-corresponding peaks (Fig. 3).

4. Discussion

Gardenia ternifolia is a plant used in traditional medicine for the treatment of many diseases including malaria, hypertension, asthma, leprosy, diabetes, rickets, fever, constipation, and cancer [18]. In this study, we aimed to evaluate the effects of the aqueous extract of the leaf of this plant on alcoholic liver disease induced in rats. Our results showed that the GT extract exhibited a hepatoprotective effect. The first analyses carried out demonstrated that the administration of ethanol did not significantly increase the hepatic mass index, although GT extract decreased this index compared to the negative control as shown in Table 1. This result testifies to low hepatomegaly induced by ethanol and therefore probably too low steatosis. The data obtained are consistent with those found by Yoo et al. (2014) who showed that liquid food mixed with alcohol alone or with alcohol and *Crepidiastrum denticulatum* extract for 28 days did not cause a significant change in liver mass index [19].

To understand the extent of the changes caused by prolonged alcohol consumption, certain biochemical parameters were analyzed. Here, exposure to ethanol resulted in significantly increased levels of ALT, and AST. On the other hand, treatment with GT extract significantly reduced the activity of these enzymes (Fig. 1). AST and ALT are intrahepatic enzymes that act as transaminases in the metabolism of amino acids. Their serum level generally regulated around a threshold can be suggestive of liver damage if it comes to be very high. Our results showed that doses of 50, 100, and 200 mg/kg significantly protect the liver from these alterations. Similar findings were reported by Yunana and Dahiru (2015) who evaluated the hepatoprotective effect of GT leaf on carbon tetrachloride (CCL4)-induced hepatotoxicity in rats [15]. The effects exerted by the GT extract are similar to those of silymarin whose hepatoprotective activity is often associated with the ability to scavenge

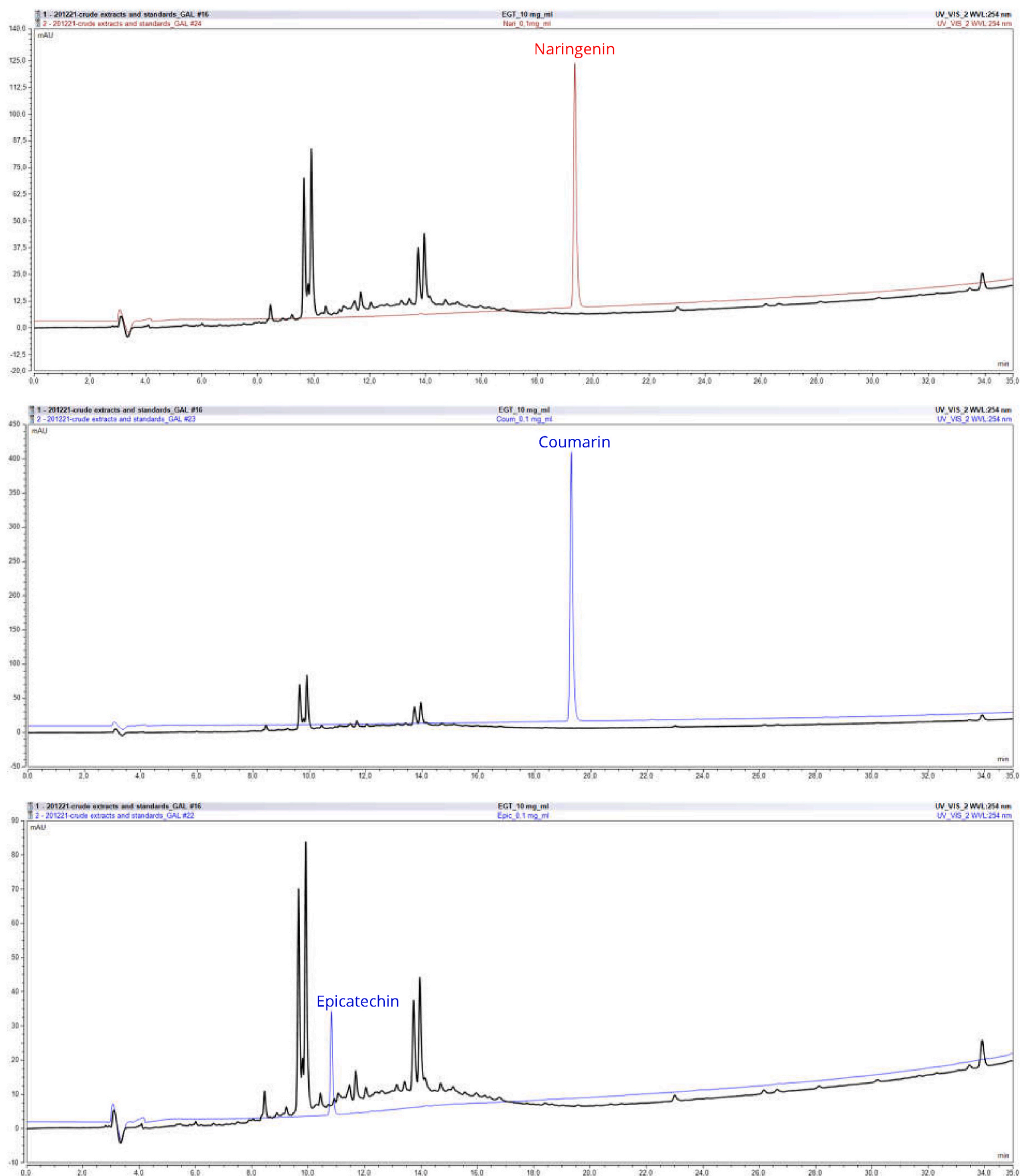

Fig. 3. HPLC/UV chromatograms of the GT leaf aqueous extract in comparison to those of Naringenin, Coumarin & Epicatechin.

radicals, thus protecting membrane permeability [20]. Likewise, we may think that GT protects hepatocyte membranes from oxidation induced by free radicals generated by alcohol metabolism. Indeed, earlier reports with flavonoids aglycones isolated from surface exudates of the GT leaf highlighted *in vitro* antioxidant activities against, 1-diphenyl-2-picrylhydrazyl (DPPH) [21]. Similarly, other authors demonstrated that the methanol extract of fruits from *Gardenia gummifera* (Rubiaceae) exerted hepatoprotective activities through antioxidant mechanisms including anti-radical effects on DPPH and nitric oxide [22]. Therefore, a deep investigation of the antioxidant properties of GT in the liver would be an advantage in understanding the hepatoprotective effects.

Considering that membrane integrity alteration is mostly due to lipid peroxidation, we became interested in the effects of ethanol on lipid metabolism. Based on the results presented in Table 2, exposure to ethanol resulted in a significant increase in serum TG and TC, which were reduced by the different doses of GT. This result suggests that the hepatoprotective activity of GT is linked to the improvement of serum lipid markers. Previous studies have documented the effect of alcohol on lipid metabolism by indicating that exposure to ethanol increased the activation of the sterol regulatory element binding protein-1 (SREBP-1) transcription factor involved in the expression of lipogenic enzymes, increased fatty acid uptake, increased hepatic lipid export and decreased fatty acid oxidation [23]. Therefore, the lipid-decreasing effect of GT leaf extract might be due either to the inhibition of the SREBP-1 factor, or the increase of fatty acid oxidation and a reduced export of VLDL from the liver. These results correlate with that of Yunana and Dahiru (2015) who stated the reducing effects of GT extract on serum TG might be

attributed to an inhibitory effect of the lipase activity. However, further studies are still needed to verify the effect of GT extract on the mechanisms of lipogenic pathways.

Exposure of the liver to ethanol produced changes in liver architecture characterized by leukocyte infiltration, an increased number of lipid droplets, and hepatic cytolysis as evidenced by Fig. 2. The administration of GT leaf extracts corrected these ultrastructural changes, suggesting that the extract might exert both *anti*-steatotic and anti-inflammatory activities in severe alcoholic steatohepatitis. These findings are consistent with data found in Table 2 and with previous studies that showed that GT leaf may exhibit lipid-lowering effects [15] and inhibit inflammation by suppressing the *in vitro* cyclooxygenase-1 activity with an effect of 98 % at 4 μg/mL concentration [24].

The activity of our extract could be explained by its main groups of secondary metabolites, known to exert different biological activities. The phytochemical investigation of the GT leaf aqueous extract revealed the presence of condensed tannins, phenolic acids, and saponins, but flavonoids were not detected. Previous studies on the GT leaves reported similar metabolites with other compounds like terpenoids [25,26], or only flavonoids and triterpenoids as shown by a Kenyan study [21] (Table 4). According to Yunana and Dahiru (2015), the hepatoprotective effects of GT leaves aqueous extract could be due to a high quantity of saponins (12 %) and tannins (10 %) and a low level of flavonoids (2.25 %) and terpenoids (1.28 %) [15]. Previous research found saponins extracted from *Panax notoginseng* leaves [27] and *Platycodon grandiflorum* root [28] to be protective against ALD. Saponins have antioxidant effects on ALD via downregulating CYP2E1 and activating the Nrf-2 factor. They also possess anti-inflammatory properties by improving gut-derived endotoxin-mediated inflammation through the inhibition of TLR-4 and CD14 expression [27,28]. Our results are close to those of Agbodjento et al. (2018) who showed that GT leaves are full of tannins, flavonoids, and alkaloids [18], and those of Yununa and Dahiru (2015) who detected saponins, tannins, flavonoids, phenols, terpenoids, and alkaloids in GT leaf extract in Nigeria [15]. They also support findings from Ouattara et al. (2023), who only found polyphenols and catechic tannins in the GT leaf aqueous extract [29]. Aside from regulating hepatic steatosis and oxidative stress, polyphenols in general also upregulate genes involved in bile acid synthesis, unsaturated fatty acid elongation, and tetrahydrofolate production, as well as iron metabolism in ALD [30]. A prior phytochemical investigation of the GT stems and roots in the Ivory Coast reported steroids, terpenoids, and diverse categories of polyphenols such as flavonoids, coumarins, and tannins; however, alkaloids were not found in these plant parts [29] (Table 4). As a result, the content of the plant extract may differ depending on the plant part obtained, the location, and the time of collection. Other studies suggest that in cousin species like *Gardenia jasminoides*, compounds like geniposide, genipin, gardenoside, crocin, and iridoids are particularly abundant and represent one of the most bioactive components [31]. We could hypothesize that similar constituents might be found in the GT leaf extract. Some natural alkaloids have been shown to possess immunosuppressive effects against T-cell proliferation and activation of liver macrophages [32] while others like berberine were found to exert antioxidant properties in ALD, indicated by a normalization of CYP 2E1 expression in the liver or a rise in glutathione levels [33]. Regarding terpenoids, their use against liver disease has mostly been related to the treatment of non-alcoholic fatty liver disease. Terpenoid therapy primarily targets the AMPK to inhibit lipogenesis, PPARs to promote β-fatty acid oxidation, Nrf-2 to activate antioxidant enzyme expression, and SIRT 1 pathways [34]. Recently, a study by Yin et al. (2023) demonstrated the effect of a diterpenoid against ALD [35]. Furthermore, their effects on liver cancer have been thoroughly investigated [36]. Although terpenoids and alkaloids could not be investigated in our GT sample, previous evidences suggest their potential contribution to the GT hepatoprotective effects. Synergistic effects of these metabolites must be considered to understand the bioactivity of this plant extract.

Table 4
Phytochemical constituents of the *Gardenia ternifolia* according to the literature

Plant parts	Phytoconstituents	References
Leaves	Flavonoids: 3,5,3′-trihydroxy-7,4′-dimethoxyflavone; 3,5,7- trihydroxy-4′-methoxyflavone; 5,7-dihydroxy-3,4′-dimethoxyflavone; 4′-dihydroxy-7- methoxyflavanone Tritepenoids; β-sitosterol, stigmasterol	[21]
	Flavonoids, terpenoids, saponins, tannins, phenols, alkaloids	[25]
	Polyphenols, alkaloids, sterols-polyterpenes, leucoanthocyanins, mucilage, tannins	[26]
Aerial parts	Naringenin-7-*O*-methyl ether; Kaempferol-7-*O*-methyl ether; Naringenin-4,7-*O*-dimethyl-ether; Quercetin-4,7-*O*-dimethyl ether; β-sitosterol, 4,5-Dihydroxy-6,7-dimethoxyflavanone	[37]
Stems	Polyphenols, flavonoids, coumarins, sterols and terpenes, saponins, tannins, phenolics acids	[29]
	Anthocyanins	[11]
	Polyphenols, alkaloids, sterols-polyterpenes, leucoanthocyanins, mucilage, tannins, coumarins	[26]
Roots	Polyphenols, flavonoids, coumarins, sterols and terpenes, saponins, tannins	[29]
	Flavonoids, polyphenols	[38]

5. Conclusion

Aqueous extracts of *G. ternifolia* leaf have the potential to protect against chronic alcoholic liver damage by decreasing inflammation in the liver architecture and regulating parameters of the lipid profile. The hepatoprotective effect of this plant is attributed to the concomitant presence of various secondary metabolites which deserve to be fully characterized to elucidate their mechanisms of action in further studies. Therefore, current findings support the use of *G. ternifolia* leaf for the management of liver disease.

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Declaration of competing interest

The authors have no conflict of interests to disclose on this publication.

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