Ameliorative Effects of *Hibiscus sabdariffa* Extract against Carbon tetrachloride-induced Lipid Peroxidation, Oxidative Stress and Hepatic Damage in Rats

**ABSTRACT**

**Objective** *Hibiscus sabdariffa* is a medicinal plant associated with beneficial health effects. The leaves and flowers are used as traditional drinks and medicines in countries. The current study aimed to investigate *H. sabdariffa* L. methanolic extract ameliorative potential against carbon tetrachloride-induced lipid peroxidation, hepatic damage and oxidative stress.

**Methods** Adult male Wistar rats were administered 2.5 ml/kg body weight of CCl₄ by oral gavage to induce oxidative stress 48 hours before administration of 200, 600 to 1000 mg/kg doses of *H. sabdariffa* methanolic extract to group 3, 4 and 5, respectively for 10 days (n = 5). Group 1 was used as negative control while group 2 was used as positive-comparative control (2.5 ml/kg CCl₄). At the end of the experiment, serum glutathione (GSH), vitamin C and E, MDA, liver damage markers and antioxidant enzymes were analysed in all the groups.

**Results** Carbon tetrachloride-induced oxidative stress in experimental rats was evidenced by increase in malondialdehyde (MDA) and reduction in SOD, catalase and reduced glutathione (GSH). *H. sabdariffa* extract treatment at 600 and 1000 mg/kg doses resulted in significant modulation of antioxidant indices and alkaline phosphatase (p < 0.05), but failed to demonstrate significant effects in AST, ALT and MDA. There were significant increases (p < 0.05) in the serum vitamin C and E at 600 and 1000mg/kg doses of the extract.

**Conclusion** The overall results suggest that *H. sabdariffa* contains bioactive phytochemicals that may improve hepatic status and ameliorate oxidative damage at high doses in carbon tetrachloride intoxication.

**KEYWORDS** *Hibiscus sabdariffa*, hepatic damage, lipid peroxidation, oxidative stress, phytochemicals

**INTRODUCTION**

The oxidative properties of oxygen in diverse biological functions have been reported to play double-edged properties of either a decrease of cell antioxidant capacity or increased amount of reactive oxygen species (ROS) resulting in oxidative stress in organisms. The deleterious health effect is a matter of serious concern to biomedical research because several lines of evidence suggest that oxidative stress plays a key role in the initiation and development of chronic degenerative diseases including hypertension, insulin resistance, diabetes, cancer, atherosclerosis, inflammatory and neuro degenerative disorders. This imbalance between endogenous free radical production and antioxidant defense system in tissues produces lipid peroxidation resulting in structural degeneration of biomembrane with the release of cellular contents and formation of cytotoxic end-products, such as malondialdehyde. Lipid peroxidation is a process of radical attack and oxidative deterioration of poly-unsaturated fatty acids or fatty acyl chains, involving hydrogen abstraction from a bis-allylic position, formation of fatty acyl peroxyl radicals and subsequently hydroperoxides. The various toxic effects of CCl₄ in biological systems have been linked to decreased antioxidant...
status and increased lipid peroxidation leading to oxidative damage in body organs including the liver.\(^6\),\(^7\). However, carbon tetrachloride is a known hepatotoxicant that generates free radicals during metabolism to compromise hepatocellular integrity and functions.\(^8\). Hepatic cells are involved in metabolic events including biotransformation of drugs and xenobiotics; therefore protection from liver damage by protective/therapeutic agents is of paramount importance. Antioxidants prevent the organism from the harmful effects of free radicals by scavenging or inhibiting their formation\(^9\). The natural antioxidant defense system that neutralizes free radicals is overwhelmed in oxidative stress condition implicated in many pathological states.

A number of studies have reported that the supplementation of antioxidants from foods and natural remedies from traditional plants appear to play an essential role in the prevention of oxidative stress-related disorders and in the reduction of total mortality.\(^10\),\(^11\).

In the last 20 years in the United States, public frustration with the cost of medical prescriptions, combined with an interest in returning to natural remedies has led to an increase in herbal medicine use.\(^11\). The recent trend worldwide has been in favour of phytochemical therapeutics as they are economical, safe, effective, acceptable and largely free from adverse side effects. This has led to an increased interest in utilizing the therapeutic potential of naturally occurring dietary nutrients having free radical scavenging and/or antioxidant properties to counteract free radical-mediated toxicity.\(^12\). Studies have reported that they have multiple antioxidant activities due to phytochemicals in their phytoextracts evaluated in experimental models.\(^9\),\(^10\),\(^11\). Recently, the World Health Organization (WHO) appraised that 80% of people worldwide have faith on herbal medicines for some part of their primary health care. Phytochemical studies have shown that medicinal plants contain minerals, vitamins, flavonoids, polyphenols, thiocarbamate and quercetin glycosides, alkaloids and phenolic acids, and they are being employed for the treatment of different ailments in the native system of medicine.\(^8\),\(^9\),\(^10\),\(^11\),\(^12\), and one of such plants is \textit{H. sabdariffa} L.

The genus, \textit{Hibiscus}, which includes more than 300 species, \textit{H. sabdariffa} L. has been used traditionally as a food, in herbal drinks, in hot and cold beverages, as a flavouring agent in the food industry and as a herbal medicine.\(^13\). In China the seed is a source of oil and the plant is used for its medicinal properties; the West Africans use the leaves and seed powder in meals, while in Nigeria the aqueous calyx extract of \textit{H. sabdariffa} is commonly consumed as a local soft drink (popularly called Zobo), and the seed to enhance or induce lactation in cases of poor milk production.\(^14\). A wide spectrum of nutritional and therapeutic medicinal merits has been attributed to its seed, flowers, calyces and leaves.\(^15\),\(^16\),\(^17\). The various plant parts have been shown to have medicinal efficacy associated with bioactive antioxidant constituents of organic acids, anthocyanins, polysaccharides and flavonoids.\(^14\),\(^15\),\(^16\),\(^17\). In recent decades, the extracts of leaves, seeds, flowers and calyces of \textit{H. sabdariffa} have been studied for many potential uses including antipyretic, antiobesity, antispasmodic, anti-inflammatory, antifungal, antiparasitic antimicrobial, antioxidant, anti-diabetic, antihypertensive, antianæmic, hypolipidemic, hepatoprotective, and lactating activities. The development of standardized application of medicinal plant may be a novel strategy to enhance antioxidant status and thus prevent biochemical alterations and tissue damage. The present study is a scientific approach to reestablish the traditional uses of \textit{H. sabdariffa} and evaluates its ameliorative potential against carbon tetrachloride-induced lipid peroxidation, hepatic damage and oxidative stress in rats.

**MATERIALS AND METHODS**

**Plant material**

The dry calyces of \textit{H. sabdariffa} L were purchased at Ogbette market, Enugu State, Nigeria. Mr C. Okoli, a botanist at Renaissance University, Ugbawka, Enugu State identified the calyces as \textit{H. sabdariffa} L.

**Preparation of \textit{H. sabdariffa} crude extract**

The calyces were cleaned with distilled water. 100 g was ground with manual grinder and soaked in 80% methanol for 48 hours. The ground calyces were further extracted with five changes of 80% methanol. The pooled extract was filtered with Whatman no. 42 filter paper and the filtrate concentrated in an oven at 50°C and stored at −20°C until required. The percentage extract yield was around 3% of the dry weight of starting material. For the experiment described below, the extract was re-suspended in distilled water to the required concentration and administered by oral gavage.

**Phytochemical composition**

A preliminary phytochemical screening was done on the re-suspended aqueous extract with appropriate test reagents for the presence of oxalate, alkaloid, anthocyanin, saponin, phytate, polyphenol, ascorbic acid and tannin, using standard methods for quantitative determination.\(^20\),\(^21\). Each determination was done in triplicates and the mean value considered.

**Animals**

Adult male albino rats weighing 150–200 g of the Wistar strain were obtained from the experimental animal house, Department of Physiology, College of Medicine, University of Nigeria, Enugu Campus. They were maintained on standard pellet diet and tap water \textit{ad libitum} and kept in cages with wood chip beddings under a 12 hours light/dark cycle and room temperature 24–26°C. Rats were acclimatized for one week prior to experiment. The study was approved by the Animal Ethics Committee, University of Nigeria.
Effect of H. on CCl₄-induced hepatic damage

Experimental design

The albino rats were randomly divided into five groups (n = 5). In the control group, rats were given normal pellet diet and water. Animals in groups 2 to 5 were administered 2.5 ml/kg body weight CCl₄ orally to induce oxidative stress, while group 3 to 5 were treated with H. sabdariffa methanolic extract 200, 600 and 1000 mg/kg, by oral gavage 48 hours later, respectively. Malondialdehyde concentration, after 48 hours, was determined in group 2 and compared with the normal to confirm oxidative stress induction. All animals had free access to water and standard rat pellets. The experimental treatment lasted for 10 days. Animal welfare and experimental procedures were performed according to approved protocols of the Institutional Animal Care and Use Ethics Committee, University of Nigeria.

Sample collection and preparation

Twenty-four hours after the last treatment, the rats were anaesthetised with diethyl ether and blood collected via cardiac puncture into centrifugation tubes, kept at room temperature for one hour and centrifuged at 3000 rpm for 15 min. The serum obtained was kept at −20°C for biochemical assays.

Biochemical assays

Enzyme assay for liver damage

Serum enzyme markers for liver damage such as aspartate aminotransferase (AST), alanine aminotransferase (ALT) and alkaline phosphatase (ALP) were estimated spectrophotometrically, using enzymatic colorimetric assay kits (Randox Labs, UK) following standard methods.

Serum MDA estimation

Lipid peroxidation was determined spectrophotometrically by measuring the level of lipid peroxidation product, MDA in a reaction with thiobabituric acid, as described by Wallen et al.

Serum-reduced glutathione, superoxide dismutase and catalase activities

Serum-reduced glutathione (GSH), superoxide dismutase (SOD) and catalase (CAT) activities were determined according to the methods of Hissin and Hilf, Xin et al. and Aebi, respectively.

Serum antioxidant vitamins

Vitamin C and E were estimated by the colorimetric method of Natelson, and Baker and Frank respectively. All chemicals used were of analytical grades.

Statistical analysis

All the statistical analyses were performed using SPSS 16.0 software (SPSS Inc, Chicago, IL, USA). Statistical analyses were performed using the Student’s t test and one-way ANOVA. P < 0.05 was considered statistically significant. The results are presented as mean ± SD for the control and experimental rats.

RESULTS

Phytochemical analysis

The crude methanol extract of H. sabdariffa Linn. was qualitatively and quantitatively analysed for the phytochemicals, polyphenol, anthocyanin, tannins, alkaloids, saponin, flavonoids, oxalates and phytate and the results are given in Table 1. Vitamin A, C and E content of the extract were analysed and the results is shown in Fig. 1.

Table 1 Phytochemical analysis of methanolic extract of Hibiscus sabdariffa L.

<table>
<thead>
<tr>
<th>Phytochemical</th>
<th>Qualitative</th>
<th>Quantitative (mg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyphenols</td>
<td>++</td>
<td>1.20 ± 0.02</td>
</tr>
<tr>
<td>Anthocyanins</td>
<td>+</td>
<td>1.15 ± 0.02</td>
</tr>
<tr>
<td>Tannins</td>
<td>ND</td>
<td>0.04 ± 0.03</td>
</tr>
<tr>
<td>Alkaloids</td>
<td>+++</td>
<td>3.27 ± 0.01</td>
</tr>
<tr>
<td>Saponins</td>
<td>+++</td>
<td>2.19 ± 0.01</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>+++</td>
<td>5.28 ± 0.03</td>
</tr>
<tr>
<td>Oxalates</td>
<td>ND</td>
<td>0.54 ± 0.04</td>
</tr>
<tr>
<td>Phytate</td>
<td>++</td>
<td>1.72 ± 0.01</td>
</tr>
</tbody>
</table>

+++ : very high, ++ : high, + : moderate, ND: not detected.

Fig. 1 Concentrations of antioxidant vitamins in methanolic extract of Hibiscus sabdariffa Linn.
**Effect of H. sabdariffa extract on liver enzyme markers**

Table 2 presents the effect of *H. sabdariffa* extract on CCl₄-treated rats. In the CCl₄-intoxicated group, serum AST, ALT and ALP were significantly increased (p < 0.05) compared to the control group. Treatment with *H. sabdariffa* extract decreased AST and ALT activities in the serum, but not statistically significant (p > 0.05). The effect of the extract showed dose-dependent significant decreases (p < 0.05) from 200 to 1000 mg/kg *H. sabdariffa* extract on ALP activity compared to the CCl₄-intoxicated group.

**Effects of methanol *H. sabdariffa* extract on antioxidant status markers**

The activities of superoxide dismutase, catalase and reduced glutathione are important diagnostic markers in the assessment of antioxidant status. These enzyme activities, as shown in Table 3, were decreased in CCl₄-intoxicated group. Treatment with the *H. sabdariffa* extract at different dosages abolished the decrease with significant increase in SOD at 600 and 1000 mg/kg, whereas GSH only had significant increase at 1000 mg/kg (p < 0.05); but with non-significant increase for catalase (p > 0.05). The results for serum antioxidant vitamins are shown in Table 3. Serum vitamin C level showed dose-dependent significant increases (p < 0.05) from 200 to 1000 mg/kg in the extract-treated rats (Fig. 1). However, there was a significant increase for vitamin E only at 1000 mg/kg dosage of the extract (Fig. 1).

**Effect of methanol extract of *H. sabdariffa* on MDA**

Oxidative stress was confirmed in the experimental rats by the significant increase (p < 0.05) in MDA level after 48 hours administration of CCl₄, compared to normal rats (Table 4). Treatment with the extract decreased the lipid peroxidation marker from 200 to 1000 mg/kg in a dose-dependent manner. However, at p < 0.05 these dose-dependent decreases in MDA were not significantly different when compared with the control.

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**Table 2** Effect of doses of methanol extract of *H. sabdariffa* on serum AST, ALT and ALP.

<table>
<thead>
<tr>
<th>Parameters (IU/L)</th>
<th>Group 1 control</th>
<th>Group 2 CCl₄ control</th>
<th>Group 3 CCl₄+200 mg/kg</th>
<th>Group 4 CCl₄+600 mg/kg</th>
<th>Group 5 CCl₄+1000 mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>AST</td>
<td>103.6 ± 1.7</td>
<td>128.8 ± 2.6ᵃ</td>
<td>126.0 ± 5.4</td>
<td>122.2 ± 5.1</td>
<td>115.4 ± 5.1</td>
</tr>
<tr>
<td>ALT</td>
<td>48.6 ± 2.7</td>
<td>54.6 ± 2.1ᵃ</td>
<td>53.8 ± 2.1</td>
<td>49.2 ± 2.6</td>
<td>48.4 ± 1.6</td>
</tr>
<tr>
<td>ALP</td>
<td>72.0 ± 3.4</td>
<td>79.4 ± 3.4ᵃ</td>
<td>72.0 ± 3.1ᵇ</td>
<td>68.4 ± 3.9ᵇ</td>
<td>63.2 ± 2.2ᵇ</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD, n = 5. ᵃ,ᵇStatistically significant (p < 0.05) compared to normal control (group 1) and CCl₄ control (group 2) respectively, in the same row.

**Table 3** Effect of doses of methanol extract of *H. sabdariffa* on the serum antioxidants.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group 1 control</th>
<th>Group 2 CCl₄</th>
<th>Group 3 CCl₄+200 mg/kg</th>
<th>Group 4 CCl₄+600 mg/kg</th>
<th>Group 5 CCl₄+1000 mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOD (IU/L)</td>
<td>13.83 ± 0.04</td>
<td>12.70 ± 1.03</td>
<td>12.13 ± 1.05</td>
<td>20.84 ± 1.26ᵇ</td>
<td>20.76 ± 1.09ᵃ</td>
</tr>
<tr>
<td>CAT (IU/L)</td>
<td>1.23 ± 0.05</td>
<td>1.19 ± 0.23</td>
<td>1.33 ± 0.10</td>
<td>1.37 ± 0.02</td>
<td>1.35 ± 0.03</td>
</tr>
<tr>
<td>Vitamin C (mg/dl)</td>
<td>8.00 ± 0.41</td>
<td>5.16 ± 0.47ᵃ</td>
<td>7.32 ± 0.74ᵇ</td>
<td>8.00 ± 0.24ᵇ</td>
<td>8.09 ± 0.01ᵇ</td>
</tr>
<tr>
<td>Vitamin E (mg/dl)</td>
<td>0.61 ± 0.02</td>
<td>0.48 ± 0.05ᵃ</td>
<td>0.58 ± 0.03</td>
<td>0.57 ± 0.03</td>
<td>0.59 ± 0.04ᵇ</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD, n = 5. ᵃ,ᵇStatistically significant (p < 0.05) compared to normal control (group 1) and CCl₄ control (group 2) respectively, in the same row.

**Table 4** Effect of doses of methanolic extract of *H. sabdariffa* on malondialdehyde.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group 1 control</th>
<th>Group 2 CCl₄</th>
<th>Group 3 CCl₄+200 mg/kg</th>
<th>Group 4 CCl₄+600 mg/kg</th>
<th>Group 5 CCl₄+1000 mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDA after 48 hours</td>
<td>19.25 ± 0.96</td>
<td>24.28 ± 0.86</td>
<td>24.42 ± 0.42</td>
<td>24.18 ± 0.45</td>
<td>24.13 ± 1.30</td>
</tr>
<tr>
<td>MDA after 10 days</td>
<td>19.30 ± 0.59</td>
<td>24.40 ± 0.96</td>
<td>21.42 ± 1.07ᵃ</td>
<td>20.45 ± 1.27ᵃ</td>
<td>20.30 ± 1.04ᵃ</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD, n = 5. ᵃStatistically non-significant (p > 0.05) compared to MDA level before *H. sabdariffa* treatment (after 48 hours) in the same column.
**DISCUSSION**

Antioxidant phytochemicals in medicinal plants are of increasing interest to consumers and biomedical researchers because of their promising roles in the treatment of many pathologies and maintenance of human health. The antioxidants are metabolic inhibitors of free radical-associated damage, even in relatively small concentrations and therefore, have a pretty diversified physiological role in biological system. Antioxidant constituents of plants are free radical predators to ameliorate metabolic oxidative stress\(^\text{12}\). Toxic challenge to tissues or cells is associated with increased generation of free radicals, and antioxidant supplementation by natural plant phytochemicals may help to ameliorate cytotoxicity and lipid peroxidation. The liver can particularly affect; or be affected by, chemicals ingested orally or administered intraperitoneally because it is the first organ perfused by blood containing the chemical. Carbon tetrachloride is a known toxicant that shows damage to hepatic mitochondria and endoplasmic reticulum during metabolism\(^\text{37}\).

In this study, the crude methanol extract of *H. sabdariffa* calyces was analysed qualitatively and quantitatively for the presence of polyphenols, anthocyanins, tannins, alkaloids, saponins, flavonoids, oxalates and phytoflavonoids. Flavonoids, alkaloids and saponins were found to be present in abundance compared to other constituents analysed in the extract. This was corroborated by the quantitative estimation, with flavonoids showing the highest concentration (Table 1). These data are in agreement with earlier studies\(^\text{16,33}\). In recent studies, the flavonoid, protocatechuic acid has been shown to have antioxidant potentials in the protection of liver against chemically-induced peroxidative liver damage\(^\text{14}\). However, alkaloids have been associated with medicinal efficacy; one of their common biological properties is their cytotoxicity\(^\text{15}\).

In the present study, our single administration of CCl\(_4\) was found to cause hepatic damage and oxidative stress as evidenced by increased serum AST, ALT and ALP activities, associated with reduced antioxidant status. This indicates liver damage by CCl\(_4\) metabolic generation of reactive trichloromethyl free radicals and consequent peroxidative degradation of lipid membrane, leading to leakage of marker enzymes from the hepatocytes and decrease in antioxidant status markers\(^\text{7}\). From our results in this study, *H. sabdariffa* extract treatment stimulated hepatoprotective effects against hepatocellular injury as shown by decrease in serum AST, ALT and ALP activities in agreement with previous studies\(^\text{16,14}\). Although it was found that only ALP activity decreased significantly for every dose administered in this study (Table 2). This result suggests a repair mechanism in the parenchymal and mitochondrial sites where the enzymes are located in the liver. AST and ALT decreases were not significant relative to control within the experimental period. It may be as a result of slow recovery of particular hepatocytes involved in the management of these enzymes.

Oxidative stress induced due to the generation of trichloromethylperoxyl radicals and/or decreased antioxidant level in the serum has been suggested to play a pivotal role in hepatic fibrogenesis\(^\text{7}\), metabolic disorders\(^\text{16}\), and carcinogenesis\(^\text{47}\). SOD is the first antioxidant enzyme to deal with oxygen radicals by accelerating the dismutation of superoxide to hydrogen peroxide, while CAT is a peroxisomal hemoprotein that catalyses the removal of hydrogen peroxide formed during the reaction catalyzed by SOD. Thus, SOD and CAT are supportive antioxidative enzymes, which provide protective defense against reactive oxygen species\(^\text{37}\). In our study, *H. sabdariffa* increased the serum activities of SOD, CAT, and non-enzymatic antioxidants, GSH, vitamin C and E. However, there were no significant differences observed for catalase activities, which might be due to the overall metabolic use from free radicals. Vitamin E significantly increased at a dose of 1000 mg/kg. Although a number of studies have reported significant improvement in antioxidant enzymes for varieties of *H. sabdariffa*, it is conceivable that these effects may largely be due to its antioxidant activity. Reports have associated *H. sabdariffa* with elevation in antioxidant status and/or reduced oxidative stress in experimental studies\(^\text{38}\). The medicinal potentials of this plant improve SOD, CAT, GSH and glutathione peroxidase and consequently control the generation of free radicals. The mechanism of such protection of oral administration of *H. sabdariffa* may be due to detoxification of oxygen radicals through augmentation of cellular antioxidants such as SOD, CAT and GSH\(^\text{38}\). Protection against oxidative stress through this mechanism may be one of the effective therapeutic approaches. It appears in our study that high dose or concentration of *H. sabdariffa* could effectively enhance antioxidant defense system. For instance, although the antioxidant indices increased with doses from 200 to 1000 mg/kg, vitamin E and GSH only had significant increase at 1000 mg/kg. In two human studies on the potential of *H. sabdariffa* to lower serum cholesterol level as reviewed by Da-Costa-Rocha et al.\(^\text{16}\), that administration of *H. sabdariffa* at a dose of 3 g/day for 30 days had a significant cholesterol-lowering effect as against non-significant effect in 1 g/day for 90 days. The possible explanation is that high dose of *H. sabdariffa* may be associated/or important for medicinal health benefits of *H. sabdariffa*, which our results also suggest although in CCl\(_4\) intoxication.

MDA is one of the end-products of polyunsaturated fatty acid peroxidation and is a good indicator of the degree of lipid peroxidation\(^\text{16}\). In the present study, a significant increase observed in MDA level of CCl\(_4\)-intoxicated rats was reduced by treatment with extract of *H. sabdariffa* calyx, indicating its potential to break the chain reaction of lipid peroxidation. The decrease was dose-dependent; suggesting a higher beneficial effect at higher doses above 1000 mg/kg used in this study. This may not readily pose toxicity because some studies have reported acute toxicity LD\(_{50}\) to be above 3000 mg/kg body weight of rats\(^\text{33}\). According to a study by
Onyenekwe et al.\textsuperscript{39}, no deaths were observed in Albino mice after 14 days administration (i.p.) at doses of 1000–5000 mg/kg b.w./d, thus the calculated LD50 of \textit{H. sabdariffa} calyx aqueous extract was >5000 mg/kg bw. In this study however, it appears that the dose at 1000 mg/kg withstood the oxidative stress associated with CCl\textsubscript{4}-induced hepatotoxicity, although a study reported a lower dose against oxidative stress in an in-vivo ischemic reperfusion injury\textsuperscript{38}. Taken together, therefore, our findings suggest that \textit{H. sabdariffa} calyx crude extract has potentials to ameliorate chemically-induced oxidative stress and acute liver damage in rats. The favourable dose-dependent decreases in non-significant parameters may be suggestive of effective beneficial role of the extract at high doses. The antioxidant properties are attributable to the ability of its phenolic phytochemicals to quench ROS and upregulate natural antioxidant defense system. The data in this study support the existing medicinal efficacy associated with \textit{H. sabdariffa} in previous studies in promoting its use in prevention and treatment of some hepatic disorders.

REFERENCES


Effect of H. on CCl₄-induced hepatic damage


