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Original Research Article

Investigating the Hepatoprotective Properties of Okra Seed Extract for Non-Alcoholic Fatty Liver Disease (NAFLD) Induced by Cholesterol in Rats Model

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Abstract: This investigation looked at the impacts of okra seed extract on cholesterol-induced fatty liver disease (CIFLD) in rats. In this study, thirty-two male rats were divided into four groups: G1 the control group, G2 cholesterol group, G3 300 mg/kg of cholesterol plus okra extract and G4 400 mg/kg of cholesterol plus okra extract. Four weeks post-experiment, blood samples were collected for lipid levels, oxidative stress indicators, and liver function tests. Table 1 shows the serum level of aspartate aminotransferase (AST) and alanine aminotransferase (ALT), which was significantly reduced in the okra extract treatment group (ALT: 200 mg/kg, 100.3 ± 8.6 U/l, 400 mg/kg, 70.5 ± 6.2 U/l), compared to the cholesterol group (ALT: 150.5 ± 10.4 U/l; AST: 120.3 ± 8.6 U/l). TG and TC levels were higher in cholesterol group (TG 150.5 ± 10.4 mg/dl; TC 200.3 ± 8.6 mg/dl) but significantly ($P < 0.0001$) lower (TG 100.3 ± 8.6 mg/dl and 70.5 ± 6.2 mg/dl for 200 mg/kg and 400 mg/kg respectively) in okra extract treated groups. Cholesterol group showed significantly ($p < 0.01$) higher malondialdehyde (MDA) (6.5 ± 0.3 nmol/ml) level, less superoxide dismutase (SOD) (3.2 ± 0.4 U/ml) and less glutathione (GSH) (1.5 ± 0.2 µmol/g tissue) than normal, which were all significantly ($p < 0.01$) improved by okra extract treatment (400 mg/kg) (MDA: 2.8 ± 0.2 nmol/ml, SOD: 7.0 ± 0.4 U/ml, GSH: 4.8 ± 0.3 µmol/ml). Histopathological analysis showed that severe steatosis and signs of inflammation observed in the cholesterol group were significantly less pronounced on okra-treated groups. We demonstrated that okra seed extract exhibited an effective hepatoprotective properties, which may be, at least in part, through antioxidant properties, the results of this study suggest that okra seed extract seen as a natural treatment option for fatty liver disease.

Keywords: Okra Seed Extract, liver disease, NAFLD, lipid profile.

INTRODUCTION

Non-alcoholic fatty liver disease (NAFLD) encompasses everything from simple steatosis to more extreme steatosis with accompanying cirrhosis, fibrosis, hepatitis, and sometimes hepatocellular cancer. The pathophysiology of most risk factors for the development of non-alcoholic fatty liver disease (NAFLD) is centred on a metabolic imbalance or insulin resistance [1, 2]. NAFLD, which is the most common chronic liver disease in the world [3], has liver manifestations that include non-alcoholic steatohepatitis (NASH), cirrhosis, fibrosis, and simple steatosis (also known as NAFL), with reported prevalences ranging from 6-33% depending on the populations studied. Of the components of MS, NAFLD is strongly associated with obesity and type 2 diabetes mellitus [4]. Nonalcoholic fatty liver disease (NAFLD) is when too much fat accumulates in the liver, without excessive alcohol consumption or other likely liver disease causes. At one end of the spectrum is simple steatosis, or fat accumulation in the liver. It progresses to steatosis with inflammation (nonalcoholic steatohepatitis, or NASH), which can lead to replacement of healthy liver cells with scar tissue (fibrosis). At the other end of the scale, cirrhosis, or severe fibrosis, and hepatocellular carcinoma denote a serious disease [6]. The key physiopathological mechanism of the progression of NAFLD is the insulin resistance and inflammation.

In healthy people, glucose is absorbed by skeletal muscle for glycogenesis, and free fatty acids go to adipose tissue to be stored as triglycerides. Adipose tissue and skeletal muscle, on the other hand, develop insulin resistance in conditions of excessive nutrient intake. This leads to decreased glycogenesis and increased lipolysis in skeletal muscle and decreased lipogenesis in adipose tissue, which diverts excess substrate to the liver for storage as triglycerides [7]. Okra is an annual shrub that is grown primarily in tropical and subtropical climates worldwide. It is a common crop for gardens and farms. It is a popular food crop that is grown all over the world for its flavor. Okra's young green pods are typically eaten as vegetables, but the pod extract is also used to increase the viscosity of many soup and sauce recipes. [9]. Okra pods have been used historically as astringents, food additives, appetite enhancers, and aphrodisiacs. Additionally, okra pods have been suggested as a remedy for urinary problems, gonorrhea, and diarrhea. While the seeds of this plant have been shown to have fungicidal and anticancer effects, extracts of immature okra pods have also been shown to exhibit moisturizing and diuretic qualities [10]. Nonalcoholic fatty liver disease (NAFLD) is a degenerative condition characterized by the buildup of fat in the liver (in more than 5% of hepatocytes) without the use of alcohol, viral infections, or drugs that can cause steatosis. The broad category of nonalcoholic fatty liver disease (NAFLD) includes cirrhosis, hepatocellular carcinoma, liver fibrosis, simple steatosis, and nonalcoholic steatohepatitis (NASH). Lipid peroxidation, cell damage, and the activation of pro-inflammatory pathways are all possible outcomes of reactive oxygen species (ROS) [11]. Consequently, agents capable of scavenging free radicals and minimizing oxidative stress are especially significant in the management of liver diseases [12]. Here, a rat model of cholesterol-induced fatty liver was employed to assess the hepatoprotective potentials of okra seed extract. This study aims to clarify the protective response of okra seed extract in preventing cholesterol-induced hepatotoxicity by investigating liver function parameters, histological alterations, and oxidative stress level. Still, this study could lead the way to the natural treatment approaches to combat NAFLD, as well as to improving liver health.

MATERIALS AND METHODS

1.1. Preparation of Okra Seed Extract

Okra seeds (*Abelmoschus esculentus*) were obtained from a nearby market and the seeds were dried in the air and crushed into a fine powder. The extraction was conducted utilizing a soxhlet apparatus with ethanol serving as the solvent. A rotary evaporator was used to condense the extract, which was then kept at 4°C in a dark glass container until it was needed.

1.2. Animals

Thirty two male rats, weighing between 220 and 250 grams, were obtained for this experiment from the Animal House at Al-Qasim Green University. The animals had unrestricted access to food and water and were housed in standard laboratory conditions with a 12-hour light/dark cycle. Throughout the study, they were kept in an air-conditioned room with standard settings (temperature: 22±2℃; relative humidity: 50±10%; 12-hour light/dark cycle). The study protocol was approved by the Institutional Animal Ethics Committee (IAEC).

2. Experimental Design

2.1. Induction of Fatty Liver

The rats were randomly assigned to four food groups (n = 8 per group) following a week of acclimation. However, rats in the other three groups were fed a high-cholesterol diet (G2), cholesterol group (G3), cholesterol + okra extract administration of (200 mg/kg), and cholesterol + okra extract administration of (400 mg/kg). Rats in the normal control (CON) group (G1) were given normal saline and rodent chow. Lipid levels, oxidative stress indicators, and liver function tests were conducted four weeks after the experiment ended.

2.2. Treatment Protocol

Using a feeding tube, okra seed extract was taken orally. The animals were put to death by carbon dioxide asphyxiation following a four-week course of treatment.

3. Biochemical Analysis

3.1. Blood Sample Collection

Cardiac punctures were used to draw blood, which was then left to clot for half an hour at room temperature. Centrifugation was used for 10 minutes at 3000 rpm to separate the serum, which was then kept at -20°C until additional analysis.

3.2. LFTs and lipids profile analysis

Serum levels of liver enzymes, alanine aminotransferase (ALT) and aspartate aminotransferase (AST) and lipids profile that included of total cholesterol (TC), triglycerides (TG), low-density lipoprotein-cholesterol (LDL), and high-density lipoprotein-cholesterol (HDL), and oxidative stress parameters such MDA, SOD, and GSH levels were determined using commercial kits and spectrophotometric analysis.

4. Histopathological Analysis

After collection of blood, liver tissues were harvested and fixed in 10% formalin. The tissues were sectioned at 5 µm depth, and were embedded in paraffin and stained with hematoxylin and eosin (H&E) for histological analysis. The tissue sections were observed for any histological changes characteristic of fatty liver by light microscope.

5. Statistical Analysis

Standard deviation (SD) ± mean was used to express the data. Tukey's post hoc test was used after a one-way ANOVA for statistical analysis. P-values less than 0.05 were regarded as statistically significant. GraphPad Prism software was used for all analyses.

RESULTS

1. Effect of Okra Seed Extract on Liver Function Tests

Table 1 summarizes the serum levels of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) in the different treatment groups. The cholesterol group showed a significant increase in both ALT and AST levels compared to the control group, indicating liver damage. However, treatment with okra seed extract resulted in a dose-dependent reduction in ALT and AST levels.

Table 1: Effect of Okra Seed Extract on Liver Function Tests

Groups	ALT(U/l)	AST(U/i)
Control	30.32±3.2	32±4.1
Cho	100.3±5.5***	95±6.3***
Cho+OKRA 200mg/kg	65.2±4.8**	70.3±5.2**
Cho+OKRA 400mg/kg	45.1±3.9*	50.8±4.5*

***Values are expressed as mean ± SD (n=8). *p < 0.05, **p < 0.01, ***p < 0.001 compared to Control.**

2. Effect on Lipid Profile

Serum triglyceride levels were significantly elevated in the cholesterol group compared to the control group (**Figure 1**). Triglyceride levels were significantly lowered after treatment with okra seed extract, especially at the higher dosage.

Table 2: Effect of Okra Seed Extract on Lipid Profile

Groups	TG (mg/dl)	TC (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)	HDL (mg/dl)
Control	50.2±4.1	120.5±5.2	45±3.5	10±0.8	55±3
Cho	150.5±10.4***	200.3±8.6***	100.2±7.8***	30.1±2.1***	30±2.5***
Cho+OKRA 200 mg/kg	100.3±8.6**	160.2±6.5**	60.3±5.2**	20.1±1.7**	45±3.2**
Cho+OKRA 400mg/kg	70.5±6.2**	140.1±5.3*	45±4.1*	14.1±1.2*	50±3.8*

***Values are expressed as mean ± SD (n=8). *p < 0.05, **p < 0.01, ***p < 0.001 compared to Control**.

Table 3 shown that Malondialdehyde (MDA) levels, a marker of lipid peroxidation and oxidative stress, were significantly elevated in the cholesterol group, indicating increased oxidative damage. Treatment with both doses of okra seed extract reduced MDA levels compared to the cholesterol group, with the 400 mg/kg dose showing levels similar to the control group, suggesting effective antioxidant activity.

Also, the Superoxide Dismutase (SOD) activity, an important antioxidant enzyme, was significantly decreased in the cholesterol group, reflecting diminished antioxidant defense. In contrast, both doses of okra seed extract improved SOD activity, with the higher dose approaching control levels, indicating enhanced antioxidant capacity.

Furthermore, the Glutathione (GSH) levels, a critical antioxidant in the body, were markedly reduced in the cholesterol group. Treatment with okra seed extract significantly restored GSH levels in a dose-dependent manner, with the higher dose showing levels closer to those in the control group.

Table 3: Effect on Oxidative Stress Markers

Groups	MDA (nmol/l)	SOD (U/l)	GSH (µmol/l)
Control	2.1±0.2	8.5±0.5	5.8±0.4
Cho	6.55±0.3***	3.2±0.4***	1.5±0.2***
Cho+OKRA 200mg/kg	4.2±0.3**	5±0.3**	3.2±0.3**
Cho+OKRA 400mg/kg	2.8±0.2*	7±0.4*	4.8±0.3*

***Values are expressed as mean ± SD (n=8). *p < 0.05, **p < 0.01, ***p < 0.001 compared to Control**.

4. Histopathological Observations

Histopathological analysis of liver tissues showed notable variations between the treatment groups figures [1, 2, 3 and 4]. In the control group, the liver structure looked normal, featuring distinct portal tracts, central veins, and hepatocytes that showed no evidence of steatosis or inflammation. The cholesterol group exhibited pronounced steatosis characterized by extensive macrovesicular fat accumulation in the hepatocytes. The presence of inflammatory infiltrates

and ballooning degeneration of hepatocytes indicates liver injury and dysfunction. We found that the liver tissue of the Cholesterol + Okra Extract (200 mg/kg) group had less fat accumulation compared with the cholesterol group. Even though moderate steatosis was still present, inflammatory cell infiltration and hepatocyte ballooning were reduced, suggesting the okra seed extract may have hepatoprotective effects. Liver tissues were slightly steatosic and nearly normal in structure in the Cholesterol + Okra Extract (400 mg/kg) group. A clear reduction in infiltration of inflammatory cells (Figures 3A and 3B) was observed, and there were indications of preserved health of hepatocytes, which demonstrates a strong protective effect of the highest dose of okra seed extract tested against cholesterol-induced liver injury.

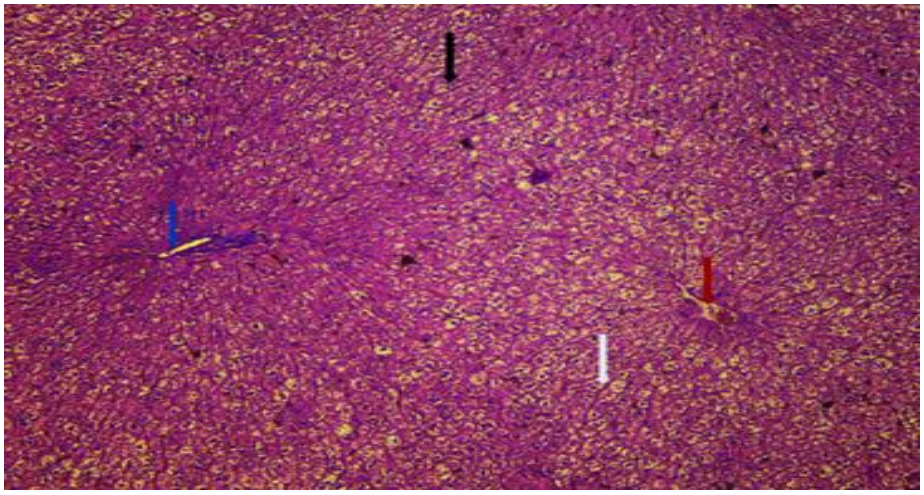

Figure 1: In the Control Group's Liver Section, the Portal Area (Blue Arrow), Central Vein (Red Arrow), Hepatocytes (White Arrow), and Canaliculi (Black Arrow) All Exhibit Typical Patterns. X10 H & E

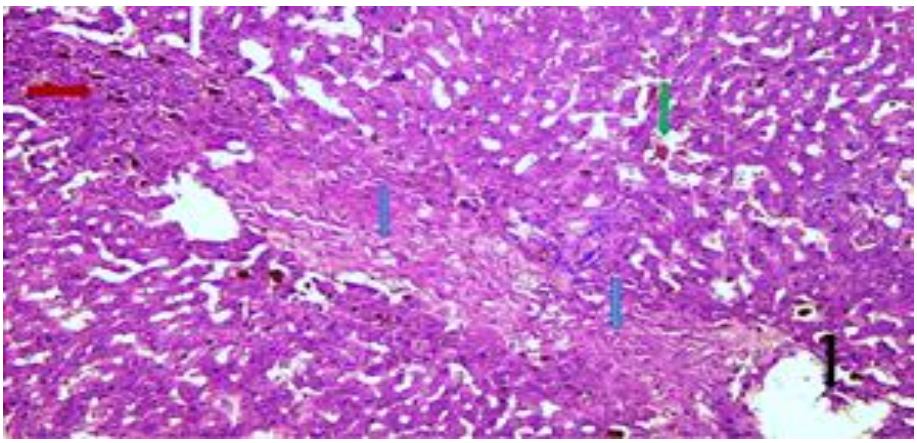

Figure 2: The Cholesterol Group Exhibited Pronounced Steatosis Characterized by Extensive Macrovesicular Fat Accumulation in the Hepatocytes. X100 H & E

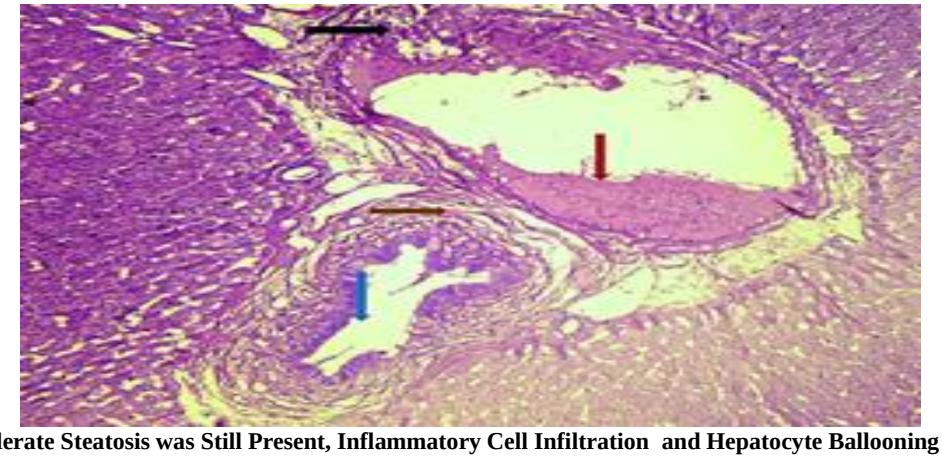

Figure 3: Moderate Steatosis was Still Present, Inflammatory Cell Infiltration and Hepatocyte Ballooning (X100 H & E)

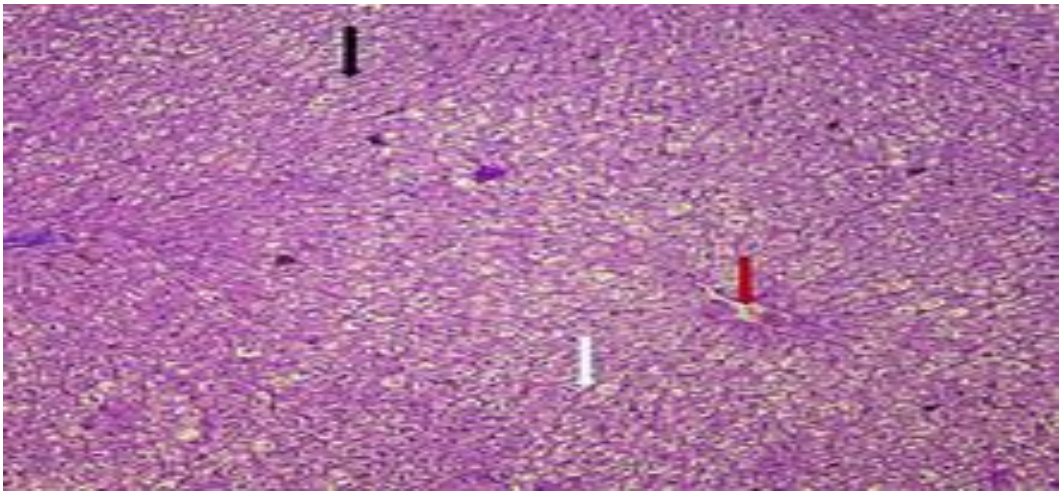

Figure 4: The Liver Tissue of the Cholesterol + Okra Extract (200 Mg/Kg) Group Had Less Fat Accumulation Compared with the Cholesterol Group (X10 H & E)

DISCUSSION

In this study, the hepatoprotective and antioxidant activity of okra seed extract is comparable to conventional feeds. This was further confirmed by histopathological examination of the liver sections. Okra seed extract: You may be able to prevent chemically induced non-fatty liver disease (NAFLD) with okra seed extract due to its strong antioxidant properties. Elevated serum protein levels of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) are commonly associated with liver injury and dysfunction [13]. In our study, both enzyme levels were significantly higher in the cholesterol group, indicating liver injury. In contrast, okra seed extract 200 and 400 mg/kg significantly decreased ALT and AST levels in a dose-dependent manner, indicating a protective effect of okra seed extract on liver function. Lipid profile analysis further corroborated these results. Participants in the cholesterol group had significantly higher levels of triglycerides (TG) and total cholesterol (TC), both clinical risk markers for nonalcoholic fatty liver disease (NAFLD) [14]. Okra polysaccharides for example improved blood glucose (BG), body weight, glucose tolerance and lipid profile. Moreover, the antioxidants present in the okra such as isoquercitrin and quercetin 3-o-gentiobioside reduced dyslipidemia symptoms, hyperglycemia and body weight [15,16]. Oxidative stress injures the liver by modifying pathways that regulate normal physiological processes and by inducing permanent changes in lipid, protein, and DNA composition. Toxicity of reactive oxidative stress is believed to be one of the pathological mechanisms associated with the development and progression of several liver diseases, including alcoholic liver diseases, non-alcoholic steatohepatitis, and chronic viral hepatitis, because such pathways influence gene transcription, protein expression, and cellular apoptosis, and the activation of the hepatic stellate cell [17]. In addition, this review attempts to demonstrate the benefits of okra-based nutraceuticals and their application, highlighting the nutraceutical potential of Abelmoschus esculentus for diverse therapeutic purposes such as antioxidant agent as well as potential therapeutic effects of okra's phytochemicals on several chronic diseases i.e. type-2 diabetes, heart disease and digestive ones, and its antifatigue, liver detoxifying, antibacterial and chemopreventive effects have also been explored [18]. Of the included studies, one examined the effect of okra on blood TG levels in both animal and human type 2 diabetic models; others found that okra significantly reduced TG levels [19]. Research by Moradi et al. have demonstrated positive effects of 10 g of okra powder in humans [20].

In other studies suggested that okra might not significantly improve TG levels and blood TG levels were unaffected by the addition of dose of 200 mg/kg okra seed and 1% okra pod polysaccharides [21]. Okra extracts supplementation significantly reduced TC in fructose-induced hypertensive rats, stressed diabetic mice, and cholesterol oil-fed rabbits based on the findings of a study done by Doreddula *et al*. in 2014. [22]. Huang *et al*. (2018) found that giving 200 mg/kg of cooked and roasted okra, 5 and 10 mg/kg of quercetin, and 100, 200, and 400 mg/kg of total flavone glycoside from okra extract significantly decreased the TC of STZ-induced diabetic rats [23]. Moreover, Kzar *et al*., 2019 showed that okra extract supplementation at the doses of 100, 200, and 300 mg/kg for diabetic rats and 0.5 g/kg for rabbits provided them with cholesterol oil significantly led to the reduction of level of LDL-C (24). After diabetes induction, Alblihd *et al*., 2023 mention that the oral okra extract administration may lessen and even reverse these negative effects. Overall, using a diabetic rat model, our study highlights the potential advantages of okra in lowering blood glucose levels and reversing histopathological changes in splenic tissues by enhancing CD8+ T cells and NF-kβ expression [25]. In Wister Albino rats, a significant increase in HDL-C was recorded with oral administration of okra powder (100 and 200 mg/kg) [26]. Moreover, Okra's ability to lower

blood sugar and liver MDA in rats with diabetes induced by streptozotocin (STZ) [27].

CONCLUSION

Finally, This finding suggested that the antioxidant activity of okra seed extract was the benefactor of an improvement of hypolipidemic effects and effects on lipids profile5 in addition to fibers, polysaccharides and so much chemicals found in okra seeds. It is likely the phytochemical compounds present in the okra seed extract that are the pivotal factor for cardioprotective effects.

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