Potential ameliorative effects of Sonchus oleraceus against hypercholesterolemic induced by high-fat diets in albino rats

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Abstract:

This study was conducted to find out the potential effect of Sonchus oleraceus on biological, biochemical, and histological changes of hypercholesterolemic rats induced by high fat diets. Therefore, Thirty-two Adult male albino rats Sprague Dawley strains, weighing 102±1.85 gm were used, and were divided into two groups; the first group (8 rats) fed on basal diet throughout the experimental periods (16 weeks) and served as a negative control group (G1). The second group was fed a high fat diet containing cholesterol, then this group (n=24 rats) was divided into three subgroups (8 rats per each) as follows: The first subgroup continued to be fed on hypercholesterolemic diet (G2), The second subgroup fed on hypercholesterolemic diet supplemented with Sonchus Oleraceus 5 % (G3). The third subgroup fed on hypercholesterolemic diet supplemented with 10% Sonchus oleraceus (G4). The results revealed that hypercholesterolemic diet rat groups showed a significant increase in body weight from positive control (G2). Also increase significantly levels of lipid profile, liver enzymes (AST, ALT and ALP) and cholesterol, except high-density lipoprotein cholesterol (HDL-c) compared to negative control group (G1). When feeding rats with a high hypercholesterolemic diet containing Sonchus oleraceus occur significant (P ≤ 0.05) decrease in body weight, liver enzymes (AST, ALT and ALP), kidney function and level of lipid profile (TC, TG, T. Lipid and LDL) and increase in the level of HDL. These results were confirmed with histopathological examination of liver, kidney, heart and brain. Therefore, we recommend using Sonchus oleraceus in moderate amount in our daily diets to benefit from its health benefits.

Keywords: Asteraceae family, hypercholesterolemia, liver functions, kidney functions, lipid profile.

Introduction

The World Health Organization (WHO) recently estimated that 46% of all fatalities in Egypt are caused by cardiovascular diseases. Atherosclerotic cardiovascular diseases (ASCVD) represent a major public health issue with significant social and
economic ramifications (Mach et al., 2020). Hypercholesterolemia is defined as the presence excessive levels of cholesterol in the blood, it is a condition of hyperlipidemia and consider one of the risk factors of cardiovascular diseases (CVD).

Research has demonstrated that 37% of the Egyptian population has elevated blood cholesterol levels (Farag et al., 2017). Cholesterol is a type of fat known as a sterol. It is one of three major kinds of lipids used by all animal cells to build their membranes. It also serves as a precursor for all steroid hormones, vitamin D, and bile acid. The bloodstream contains cholesterol (Vijayan et al., 2018).

Egypt has a high prevalence of CVD events, especially apparent in Cairo and urban communities, where unhealthy lifestyles and fast-food eating habits, increase cholesterol and triglyceride levels, and decrease HDL levels in the blood (Malloy and Kane, 2004).

Unconventional food plants are those that spread naturally, aren't handled, and can be seen growing among other agricultural crops and along highways, in the center of pastures, and in orchards (Leal et al., 2018). Sonchus oleraceus L. is a common annual herb, known as smooth sow-thistle, which is also referred to as lobbain in Upper Egypt because of the milky liquid it produces (Qureshi et al., 2002). Its belonging to the Asteraceae family. Elokda et al., (2022) the chemical composition moisture, ash, fat, protein, and fiber were 3.005, 16.709, 8.126, 27.373, 12.2 and 3.005 on dry weight basis % respectively. Also, S. oleraceus, an excellent source of minerals such as Na, K, Ca, Fe, Cu, Z and Mn by 5.62, 490.09, 83.26, 23.74, 0.13, 0.27 and 0.77 mg respectively (Filho et al., 2022) . S. oleraceus are rich in extractable antioxidants and may be able to protect humans’ cells from oxidative stress, the percent of antioxidant activity and polyphenol in plants depend on factors such as environment, location, and growing season (Howard et al., 2002). These components were steroids, terpenes, coumarins, and flavones,
which have an antitumor effect, cardiovascular therapy, and hepato-protective activity (Jiang et al., 2007). Nutrition experts around the world have demonstrated through their scientific studies that Sonchus species “S. oleraceus, S. asper, and S. arvensis” have far more nutritional and medicinal potential than any other leafy vegetables (Guil-Guerrero et al., 1998). Therefore, the study aimed to evaluate the potential protective effects of Sonchus oleraceus on hypercholesterolemic rats feeding on high-fat diets.

**Materials and Methods**

**Materials**

**Plant**

Sonchus oleraceus was obtained from the Governorate of Minia, Egypt. A sample of this plant was sent to Faculty of Agriculture, Minia University to be identified.

**Animals**

Thirty-two Adult male albino rats Sprague Dawley strains, weighing 102±1.85 gm were purchased and housed in the biological laboratory of the Chemistry Department, Faculty of Agriculture, Minia University.

**Chemicals**

Cholesterol diet and bile salts were purchased from Sigma Co., Cairo, Egypt. Kits for biochemical analyses were purchased from Bio Diagnostic Co., Dokki, Giza, Egypt. The rest of the chemicals, reagents and solvents were of analytical grade and purchased from El-Gomhoria Company for Trading Drug Chemicals and medicals, Cairo, Egypt. Basal diet constituents were obtained from Technogene Co., Dokki, Giza, Egypt.

**Methods**

**Draying of S. oleraceus**

S. oleraceus plants were washed thoroughly with tap water and dehydrated into an air-circulated oven at 40-50°C for 24 hrs. The dried samples were finely powdered by using a coffee
grinder, sieved with a sieve, and stored in polyethylene bags at -20°C until used.

**Experimental Design**

Thirty-two albino male rats were acclimatized for at least 2 weeks, with a condition (12 h light/12 h dark regular cycle and 25±2 °C temperature) and maintained on ad libitum for water and a standard rat chow diet which contains 17% protein. Animals were randomly divided into two main groups, the first group (Group 1, 8 rats) fed on a basal diet throughout the experimental periods (16 weeks) as a negative control (ve-) and the other main group (24 rats) was feed with high fat diet (HFD) contains (10% animal fats, 2% cholesterol and 0.3% bile salts) for 8 weeks to induced hypercholesterolemia, then classified into three subgroups as follow:

Group (2): fed on HFD and used as a positive control group (ve+).

Group (3): group infected with hypercholesterolemia and fed on HFD supplemented with 5 % dried *S. oleraceus*.

Group (4): group infected with hypercholesterolemia and fed on HFD supplemented with 10% dried *S. oleraceus*.

Biological experiments performed a complied with the rulings of the Institute of Laboratory Animal Resources, Commission on life Sciences, National Research Council (NRC, 1996)

Body weight gain (as a percent of initial weight) was assayed every week in rats.

**Blood and Tissues sampling**

At the end of the experiment (16 weeks) rats were fasted overnight before sacrificing and blood samples were taken from the retro-orbital plexus (*Schermer, 1967*) from all animals of each group after being anesthetized by diethyl ether. Each sample was centrifuged at 3000 rpm for 15 min and the obtained supernatant (serum) was kept at -20°C until used in biochemical analysis. Animals were dissected as quickly as possible and the liver, kidney, pancreas, spleen, heart and testis were excised, washed in ice-cold saline, wiped with filter paper and weighed.
Biochemical analyses

Serum levels of total cholesterol, HDL-c and TG were determined according to the methods of (Zollner and Kirsch, 1962; Tietz, 1976; Castelli et al., 1977; Vassault 1986) respectively. Low-density lipoprotein cholesterol and very low-density lipoprotein cholesterol are calculated according to (Friedewald, et al., 1972) as the following equation:

\[ \text{LDL-c} = \text{TC concentration} - \text{TG concentration}/5 - \text{HDL-c concentrate}. \]

Total protein, albumin, globulin and urea nitrogen were determined according to the methods of (Gornal et al., 1949; Doumas et al., 1971; Fawcett and Scott, 1960) respectively. Liver function as AST, ALT and ALP were measured with the colorimetric method according to (van and Sons, 1992; Henry, 1964; Belfield and Goldberg 1971) respectively. Lipid peroxide and nitric oxide were determined according to methods of (Ohkawa et al., 1979 ; Montgomery and Dymock 1961) respectively.

Histopathological studies

Small pieces of liver, kidney, heart, spleen and brain of each animal of control and treated groups were fixed in 10% formol saline solution for twenty-four hours. Washing was done using tap water then serial dilutions of absolute ethyl alcohol were used for dehydration. After routine processing, paraffin bees wax tissue blocks were prepared for sectioning at 4 microns thickness by slidge microtome. The obtained tissue sections were collected on glass slides, deparaffinized and stained by hematoxylin and eosin stain for histopathological examination through the light microscope (Banchroft et al., 1996).

Ethical approval

All experiments for this study especially the biological experiments ones were ethically approved by Scientific Research Ethics Committee (SREC) Faculty of Specific Education, Minia University, Minia, Egypt
Statistical analysis

The data were analyzed using SPSS (Statistical Package for Social Sciences) version, 17.0, performed by one-way analysis of variance (ANOVA). The results were expressed as mean ± standard error and values of (P ≤ 0.05) were considered statistically significant.

Results and Discussion

The effect of feeding hypercholesterolemic rats on HFD containing (5 and 10%) of *S. oleraceus* on body weight was shown in Table (1). From such data it could be noticed that feeding of rats on HFD to induce hypercholesterolemia leads to an increase in the final body weight ratio than the control group. At the end of the experiment (16 weeks), rats of the hypercholesterolemic group recorded 235.01% of the control (normal) group for the BWG %. Feeding of (5 and 10%) *S. oleraceus* induced a significant P ≤ 0.05 decreasing on BWG% of the hypercholesterolemic rats which recorded 193.71 and 168.02 % respectively. This may be attributed to the therapeutic effect of antioxidant, anxiolytic, and antinociceptive of *S. oleraceus* against infections, inflammation, and also as a general tonic (*Kusum et al., 2022*).

Table (1): Effect of *S. oleraceus* on body weight gain (BWG, g) of hypercholesterolemic rats

<table>
<thead>
<tr>
<th>Groups</th>
<th>Initial body weight (g)</th>
<th>Final body weight (g)</th>
<th>BWG (g)</th>
<th>BWG %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (-)</td>
<td>103.17 ± 1.97</td>
<td>237.5 ± 6.35</td>
<td>134.32 ± 4.47</td>
<td>125.17 ± 11.21</td>
</tr>
<tr>
<td>Hypercholesterolemic groups</td>
<td>102.72 ± 2.12</td>
<td>342.52 ± 8.35</td>
<td>239.27 ± 8.35</td>
<td>235.01 ± 10.23</td>
</tr>
<tr>
<td>Control (+)</td>
<td>301.03 ± 6.95&lt;sup&gt;a&lt;/sup&gt;</td>
<td>198.52 ± 5.57&lt;sup&gt;a&lt;/sup&gt;</td>
<td>193.71 ± 3.66&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td><em>S. oleraceus</em> 5%</td>
<td>301.03 ± 6.95&lt;sup&gt;a&lt;/sup&gt;</td>
<td>198.52 ± 5.57&lt;sup&gt;a&lt;/sup&gt;</td>
<td>193.71 ± 3.66&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td><em>S. oleraceus</em> 10%</td>
<td>275.3 ± 8.42&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>172 ± 7.38&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>168.02 ± 6.92&lt;sup&gt;ab&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

Mean ±S.D of eight rats<sup>a</sup> significantly different from control group at P ≤ 0.05<sup>b</sup> significantly different from hypercholesterolemic groups at P ≤ 0.05.

Also, *S. Oleraceus* lipid extracts could partially prevent adipogenesis and reduce HFD-induced obesity and suggest that *S.*
oleraceus could use as a dietary supplement for protection against obesity (Chen et al., 2021).

From the data in Table (2), it could be indicated that rats fed on a hypercholesterolemic diet without supplementation (control positive) had significant $P \leq 0.05$ increase in liver and heart to body weight ratio compared with rats fed on a basal diet (control negative). Moreover, it could be observed that, liver and heart to body weight ratio had a significant decrease for all hypercholesterolemic rats administrated with different levels of S. oleraceus (5 and 10 %), the results are in agreement with a histological examination in organs. Meanwhile, weight to body weight ratio in the kidney, spleen, testes and brain did not appear to be any change in all groups.

**Table (2): Effect of Sonchus oleraceus on organs relative weight of hypercholesterolemic rats**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Control (-) Mean ± S.D</th>
<th>Hypercholesterolemic groups</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Control (+)</td>
<td>$S. \text{ oleraceus }$</td>
<td>$S. \text{ oleraceus }$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5%</td>
<td>10%</td>
</tr>
<tr>
<td>Liver (g)</td>
<td>6.71 ± 0.11</td>
<td>10.77 ± 0.21</td>
<td>8.70 ± 0.13</td>
<td>7.63 ± 0.07</td>
</tr>
<tr>
<td>Liver (%)</td>
<td>2.81 ± 0.04</td>
<td>3.15 ± 0.06$^a$</td>
<td>2.89 ± 0.03$^b$</td>
<td>2.77 ± 0.06$^b$</td>
</tr>
<tr>
<td>Heart (g)</td>
<td>0.82 ± 0.02</td>
<td>1.25 ± 0.02</td>
<td>0.97 ± 0.02</td>
<td>0.92 ± 0.02</td>
</tr>
<tr>
<td>Heart (%)</td>
<td>0.34 ± 0.02</td>
<td>0.36 ± 0.02$^a$</td>
<td>0.33 ± 0.01$^b$</td>
<td>0.33 ± 0.01$^b$</td>
</tr>
<tr>
<td>Spleen (g)</td>
<td>0.87 ± 0.01</td>
<td>1.14 ± 0.02</td>
<td>1.00 ± 0.01</td>
<td>0.97 ± 0.02</td>
</tr>
<tr>
<td>Spleen (%)</td>
<td>0.34 ± 0.005</td>
<td>0.33 ± 0.01</td>
<td>0.33 ± 0.006</td>
<td>0.34 ± 0.008</td>
</tr>
<tr>
<td>Kidney (g)</td>
<td>1.74 ± 0.02</td>
<td>2.38 ± 0.05</td>
<td>1.94 ± 0.21</td>
<td>1.85 ± 0.03</td>
</tr>
<tr>
<td>Kidney (%)</td>
<td>0.72 ± 0.01</td>
<td>0.71 ± 0.01</td>
<td>0.68 ± 0.02</td>
<td>0.68 ± 0.02</td>
</tr>
<tr>
<td>Tests (g)</td>
<td>2.58 ± 0.07</td>
<td>3.4 ± 0.1</td>
<td>3.02 ± 0.05</td>
<td>2.92 ± 0.03</td>
</tr>
<tr>
<td>Tests (%)</td>
<td>1.05 ± 0.02</td>
<td>1.03 ± 0.01</td>
<td>1.03 ± 0.01</td>
<td>1.04 ± 0.02</td>
</tr>
<tr>
<td>Brain (g)</td>
<td>1.36 ± 0.04</td>
<td>1.85 ± 0.02</td>
<td>172 ± 0.01</td>
<td>1.69 ± 0.01</td>
</tr>
<tr>
<td>Brain (%)</td>
<td>0.56 ± 0.03</td>
<td>0.55 ± 0.02</td>
<td>0.56 ± 0.01</td>
<td>0.56 ± 0.01</td>
</tr>
</tbody>
</table>

Mean ±S.D of eight rats$^a$ significantly different from control group at $P \leq 0.05$ $^b$ significantly different from hypercholesterolemic groups at $P \leq 0.05$. 

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The results are in agreement with results of (Hossin, 2009) who support the protective effects exhibited by pomegranate peels and it’s extract on the liver, kidney and spleen in obese hypercholesterolemic rats.

Table (3): Effect of *Sonchus oleraceus* on serum cholesterol and triglycerides of hypercholesterolemic rats

<table>
<thead>
<tr>
<th>Groups</th>
<th>TC (mg/dl)</th>
<th>TG (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (-)</td>
<td>146 ± 4.32</td>
<td>115 ± 5.05</td>
</tr>
<tr>
<td>Control (+)</td>
<td>248 ± 6.78(^a)</td>
<td>176 ± 5.10(^a)</td>
</tr>
<tr>
<td><em>S. oleraceus</em> 5%</td>
<td>193 ± 3.37(^{ab})</td>
<td>146 ± 4.35(^{ab})</td>
</tr>
<tr>
<td><em>S. oleraceus</em> 10%</td>
<td>150 ± 2.94(^b)</td>
<td>124 ± 4.4(^{ab})</td>
</tr>
</tbody>
</table>

Mean ±S.D of eight rats\(^a\) significantly different from control group at P ≤ 0.05 \(^b\) significantly different from hypercholesterolemic groups at P ≤ 0.05.

Table (3) shows the serum TC and TG levels in normal and hypercholesterolemic rats fed on HFDs with (5 and 10%) *S. oleraceus*. It was found that the control (+) group fed on HFD exhibited a significant increase in serum TC and TG concentrations as compared to the control (-) group fed on a basal diet. Feeding hypercholesterolemic rats on high dietary fibers diet, could decrease the levels content of total lipids, cholesterol and triglycerides to nearly normal levels (El-Sayed, 2013), that explain our result, that fed hypercholesterolemic rats with 5 and 10 % of *S. oleraceus* decreased serum concentrations of TC and TG in serum as compared to the control (+) group. hypercholesterolemic rats fed on 10% *S. oleraceus* were more effective in lowering TC from 248mg/dl in the positive group to nearly level of the normal group, and TG from 176mg/dl in the positive group to124mg/dl.

The treatments of HFD-induced obese rats with *S. oleraceus* (0.3 mg/g of BW per rat) for a month, exhibited a significant decrease in weight gain, fat accumulation and blood triglyceride (Chen *et al*., 2021).
Table (4): Effect of *S. oleraceus* on serum lipoproteins of hypercholesterolemic rats

<table>
<thead>
<tr>
<th>Groups</th>
<th>HDL-c (mg/dl)</th>
<th>LDL-c (mg/dl)</th>
<th>VLDL-c (mg/dl)</th>
<th>TC/ HDL ratio</th>
<th>TC/ LDL ratio</th>
<th>LDL/ HDL ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (-)</td>
<td>66.45 ± 0.82</td>
<td>56.37 ± 3.75</td>
<td>23.18 ± 1.01</td>
<td>2.2 ± 0.56</td>
<td>2.61 ± 0.11</td>
<td>0.85 ± 0.05</td>
</tr>
<tr>
<td>Hypercholesterolemic groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (+)</td>
<td>45.48 ± 1.01a</td>
<td>167.25 ± 6.88a</td>
<td>35.27 ± 1.02a</td>
<td>5.48 ± 0.17a</td>
<td>1.48 ± 0.02a</td>
<td>3.7 ± 0.17a</td>
</tr>
<tr>
<td><em>S. oleraceus</em> 5%</td>
<td>61.76 ± 0.92ab</td>
<td>102.06 ± 3.13ab</td>
<td>29.27 ± 8.7ab</td>
<td>3.13 ± 0.05ab</td>
<td>1.9 ± 0.03ab</td>
<td>1.66 ± 0.05ab</td>
</tr>
<tr>
<td><em>S. oleraceus</em> 10%</td>
<td>65.7 ± 0.62b</td>
<td>59.13 ± 2.8b</td>
<td>24.86 ± 0.89ab</td>
<td>2.28 ± 0.02b</td>
<td>2.55 ± 0.06b</td>
<td>0.89 ± 0.03b</td>
</tr>
</tbody>
</table>

Mean ±S.D of eight rats a significantly different from control group at P ≤ 0.05 b significantly different from hypercholesterolemic groups at P ≤ 0.05.

Cholesterol is not soluble in water; it is carried in the blood plasma by protein particles (lipoproteins). Lipoproteins are divided into four types based on their density: VLDL, IDL, LDL, and HDL. Although all lipoproteins include cholesterol, excessive levels of lipoproteins other than HDL, especially LDL-c, are linked to a higher risk of atherosclerosis and CVD. High levels of LDL in the blood can be caused by a poor diet, obesity, or the presence of another condition such as diabetes (Vijayan et al., 2018). The effect of two levels (5 and 10%) of *S. oleraceus* on HDL-c, LDL-c, and VLDL-c of hypercholesterolemic rats are presented in Table (4). Results indicate that the control (+) group had an elevated significantly (P ≤ 0.05) in LDL-c as compared to the control negative (167.25 mg/dl vs 56.37 mg/dl); in contrast, HDL-c decreased significantly (P ≤ 0.05) (45.48 mg/dl vs 66.45 mg/dl), respectively. Supplementation diets with 5 and 10% of *S. oleraceus* led to a significant increase (P ≤ 0.05) in HDL-c, while this addition caused significant decrease (P ≤ 0.05) in LDL-c & VLDL-c, as compared to the control positive group. This may be attributed to a high fiber content of *S. oleraceus*.

There was a relationship between increased dietary fiber intakes and increase in HDL cholesterol and decreased in LDL (Zhou et al., 2015). The TC/HDL-c ratio complements cholesterol
markers such as non-HDL-c and LDL-c and should consider for further risk assessment in the prevention programs, especially among high-risk patients such as diabetics. Individuals with low LDL-c or non-HDL-c levels may be at risk of ASCVD if their TC/HDL-c ratio is discordantly higher (Quispe et al., 2020). In the same table, the ratios of TC/HDL-c, TC/LDL-c and LDL/HDL were calculated for all groups. The results indicated that, the positive group had a ratio of TC/HDL-c (5.48), which was about twice the ratio of negative group. In contrast TC/LDL-c recorded the lowest ratio (1.48). The ratio of LDL/HDL in normal rats accounted for a value of (0.85), this ratio increased to (3.7) in the positive group. Supplementation diets with (5 & 10%) of S. oleraceus led to improvement in the TC/HDL-c and TC/LDL-c ratios.

Table (5): Changes in serum urea, protein, albumin, and globulin levels in hypercholesterolemic rats

<table>
<thead>
<tr>
<th>Groups</th>
<th>Protein (g/dl)</th>
<th>Albumin (g/dl)</th>
<th>Globulin (g/dl)</th>
<th>Alb/Glu</th>
<th>Urea (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (-)</td>
<td>6.67 ± 0.22</td>
<td>4.03 ± 0.12</td>
<td>2.36 ± 0.28</td>
<td>1.85 ± 0.25</td>
<td>40.79 ± 0.86</td>
</tr>
<tr>
<td>Hypercholesterolemic groups</td>
<td>Control (+)</td>
<td>7.76 ± 0.04</td>
<td>4.65 ± 0.09</td>
<td>3.13 ± 0.13</td>
<td>1.48 ± 0.06</td>
</tr>
<tr>
<td>S. oleraceus 5%</td>
<td>7.24 ± 0.14</td>
<td>4.09 ± 0.12</td>
<td>3.15 ± 0.03</td>
<td>1.30 ± 0.03</td>
<td>44.61 ± 0.51</td>
</tr>
<tr>
<td>S. oleraceus 10%</td>
<td>6.81 ± 0.17</td>
<td>4.48 ± 0.18</td>
<td>2.33 ± 0.20</td>
<td>1.94 ± 0.22</td>
<td>41.61 ± 0.68</td>
</tr>
</tbody>
</table>

Mean ±S.D of eight rats a significantly different from control group at P ≤ 0.05 b significantly different from hypercholesterolemic groups at P ≤ 0.05.

Effect of S. oleraceus on total protein, albumin and globulin (g/dl) of hypercholesterolemic rats. Data in Table (5) indicated an elevation of total protein, albumin and globulin in hypercholesterolemic rats of about 16%, 15% and 32% respectively, compared to normal control. Rats fed on high cholesterol diet (control +ve) had a significant increase in the concentration of total protein, albumin and Globulin which
recorded 7.76 ± 0.04, 4.65 ± 0.09 and 3.13 ± 0.13 respectively compared to the control (–ve) group which recorded 6.67 ± 0.22, 4.03 ± 0.12 and 2.36 ± 0.28. Meanwhile, supplementation of S. oleraceus to hypercholesterolemia rats restored these parameters to normal levels. Our results are in agreement with the results obtained by (Elhassaneen, et al., 2020) reported that the coconut fruits and coconut milk decreased albumin and total protein of hypercholesterolemic rats.

On other hand, hypercholesterolemic diets caused a significant (P ≤ 0.05) increase in serum urea about 21.5 % compared to normal control. Meanwhile, treatment with S. oleraceus 5% ameliorated the urea level to near normal while S. oleraceus 10 % restored this level to normal.

Hypercholesterolemic diets induced oxidative stress in rat liver was evaluated by assessing lipid peroxide and nitric oxide levels. As shown in Table (6) hypercholesterolemic diets significantly (P ≤ 0.05) increased lipid peroxide and nitric oxide levels by about 51 and 16% respectively compared to normal control. These results in accordance with many authors (Mahmoud et al., 2013; Abdel –Rahim et al., 2013; Wang et al., 2011 and Setorki et al., 2011). S. oleraceus at two doses return this elevation to normal levels.

Table (6) Effect of S. oleraceus on oxidative stress in hypercholesterolemic rat

<table>
<thead>
<tr>
<th>Groups</th>
<th>Lipid peroxide</th>
<th>Nitric oxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (–)</td>
<td>22.17 ± 0.68</td>
<td>6.61 ± 0.30</td>
</tr>
<tr>
<td>Hypercholesterolemic groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (+)</td>
<td>25.82 ± 0.31(^a)</td>
<td>9.98 ± 0.34(^a)</td>
</tr>
<tr>
<td>S. oleraceus 5%</td>
<td>22.5 ± 0.23(^b)</td>
<td>6.81 ± 0.25(^b)</td>
</tr>
<tr>
<td>S. oleraceus 10%</td>
<td>22.02 ± 0.56(^b)</td>
<td>6.81 ± 0.22(^b)</td>
</tr>
</tbody>
</table>

Mean ±S.D of eight rats \(^a\) significantly different from control group at P ≤ 0.05 \(^b\) significantly different from hypercholesterolemic groups at P ≤ 0.05.
Table (7) Effect of *S. oleraceus* on liver function activity in Hypercholesterolemic Rats

<table>
<thead>
<tr>
<th>Groups</th>
<th>AST</th>
<th>ALT</th>
<th>ALP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (-)</td>
<td>33.05 ± 2.45</td>
<td>10.44 ± 0.85</td>
<td>97.5 ± 2.08</td>
</tr>
<tr>
<td>Hypercholesterolemic groups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (+)</td>
<td>67.56 ± 1.82&lt;sup&gt;a&lt;/sup&gt;</td>
<td>35.61 ± 3.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>141.75 ± 2.75&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><em>S. oleraceus</em> 5%</td>
<td>46.77 ± 1.29&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>22.13 ± 1.01&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>118.75 ± 2.22&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td><em>S. oleraceus</em> 10%</td>
<td>35.81 ± 1.08&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.97 ± 0.86&lt;sup&gt;b&lt;/sup&gt;</td>
<td>101.25 ± 2.75&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Mean ± S.D of eight rats <sup>a</sup> significantly different from control group at P ≤ 0.05 <sup>b</sup> significantly different from hypercholesterolemic groups at P ≤ 0.05.

Hypercholesterolemia diets resulted in considerable hepatic injury as assessed by significant (P ≤ 0.05) elevations in serum transaminases and alkaline phosphatase. The elevation of ALT, AST and ALP in hypercholesterolemic rats was about 104%, 241% and 45% respectively compared to normal control. Meanwhile, supplementation of *S. oleraceus* to hypercholesterolemic rats restored these parameters to normal levels. Our results are in agreement with the results obtained by (Elokda *et al.*, 2022) who reported the effect of treating acute liver disease rats with two levels (2% and 4%) of *S. oleraceus* led to a significant decrease in liver enzymes, as compared to the positive control group. The high level from *S. oleraceus* achieved the best results in decreasing the mean value of serum (AST, ALT, and ALP enzymes). On the other side (Akhlaghi, 2016) reported that flavonoids present in *S. oleraceus* prevent hepatosteatosis by increasing fatty acid oxidation in the liver.

**Histological examination**

The results of the histological study support the results of biochemical parameters. The microscopic examination of liver tissues in the control group showed a normal histological structure of the hepatic lobule (Fig.1G1). On the other hand, hypercholestereremia rats showed a fatty change of centrolobular and cholangitis hepatocytes associated with inflammatory cells.
infiltration (Fig.1G2). Whereas the group treated with hypercholesteremic plus S. oleraceus 5% showed a fatty change of centrilobular hepatocytes (Fig.1G3) meanwhile, hypercholesteremic plus S. oleraceus 10% restored these changes to normal (Fig.1 G4).

Fig. (1): Photomicrograph of the cross-section in the liver cortex of control (G1), hypercholesterolemia (G2), hypercholesterolemia + S. oleraceus 5% (G3), and hypercholesterolemia S. oleraceus + 10 % (G4) (H & E x 400).

Heart of control rats revealed normal histopathologic structure. On contrary, the examined sections of hypercholesterolemic rats showed focal myocarditis and intermuscular oedema associated with inflammatory cell infiltration (Fig.2G2). Whereas the group treated with hypercholesterolemic plus S. oleraceus 5% improved heart structure, one slit showed focal myocarditis and others exhibited no histopathological changes (Fig.2G3) while high dose (S. oleraceus 10%) restored heart tissue to the normal structure (Fig.2G4).
Fig. (2): Photomicrograph of the cross-section in the heart cortex of control (G1), hypercholesterolemia (G2), hypercholesterolemia + S. oleraceus 5% (G3), and hypercholesterolemia S. oleraceus + 10 % (G4) (H & E x 400).

Sections taken from hypercholesterolemic rat's kidney showed glomerulitis, protein cast in the lumen of renal tubules and congestion of intratubular blood vessels (Fig.3G2).

Fig. (3): Photomicrograph of the cross-section in the kidney cortex of control (G1), hypercholesterolemia (G2), hypercholesterolemia + S. oleraceus 5% (G3), and hypercholesterolemia S. oleraceus + 10 % (G4) (H & E x 400).
Nevertheless, these findings were ameliorated by treatment with S. oleraceus which showed moderate congestion of intratubular blood vessels at a low dose (Fig.3G3) while a high dose showed slight congestion of glomerular tufts and other sections exhibited no histopathological changes (Fig.3G4).

Fig. (4): Photomicrograph of the cross-section in the brain cortex of control (G1), hypercholesterolemia (G2), hypercholesterolemia + S. oleraceus 5% (G3), and hypercholesterolemia S. oleraceus + 10 % (G4) (H & E x 400).

The microscopic examination of brain tissue in the control group showed normal histological (Fig.4 G1). On the other hand hypercholesteremia rats showed focal hemorrhage and necrosis of neurons (Fig.4G2). Whereas the group treated with hypercholesterolemic plus S. oleraceus 5% showing necrosis of
neurons (Fig.4G3) meanwhile, hypercholesterolemic plus *S. oleraceus* 10% restored these changes to normal (Fig.4G4).

**Conclusion**

This study has shown that *Sonchus Oleraceus* contains several bioactive compounds capable of mitigating the harmful effects of high cholesterol and inhibiting hypercholesterolemia in rats. Therefore, we recommend using *Sonchus Oleraceus* in moderate amount in our daily diets to benefit from its health benefits.

**Acknowledgement**

The authors wish to thank Dr. Magda E. Mahmoud professor of chemistry and the staff of the Agricultural chemistry Dep, Faculty of Agriculture, Minia University for her trustful help. And Dr. Kawkab A. Ahmed professor, Department of Pathology, College of Veterinary Medicine, Cairo University, Egypt, for her great assistance in histopathological examinations.

**References**


المجلة البحثية في مجالات التربية النوعية

التأثيرات التحسينية المحتملة للجعضيض ضد ارتفاع مستوى الكوليسترول الدم الناجم عن الأنظمة الغذائية عالية الدهون في الفئران البيضاء

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المستخلص

أجريت هذه الدراسة لمعرفة تأثير الجعضيض على التغييرات البيولوجية والكيميائية والنسيجية للفئران المصاببة بارتفاع مستوى كوليسترول الدم. لذلك تم استخدام 32 من ذكور الفئران البيضاء وزنها 102±1.85 جم. تم تقسيم ذكور الفئران البالغة إلى مجموعتين رئيستين الأولي مكونو من 8 فئران و التي تغذت على نظام غذائي طبيعي طوال فترة التجربة (G1) المجموعة الضابطة السالبة - أما المجموعة الثانية الرئيسية والتي تغذت على نظام غذائي يحتوي على دهون حيوانية و كولسترول وكان عددها 24 فازا قسمت إلى ثلاثة مجموعات فرعية وهي مجموعه G2 (16 أسبوعا) وهي مجموعه G1) المجموعة الضابطة السالبة C - أما المجموعة الثانية الرئيسية والتي تغذت على نظام غذائي يحتوي على دهون حيوانية و كولسترول وكان عددها 24 فازا قسمت إلى ثلاثة مجموعات فرعية وهي مجموعه G2 (16 أسبوعا) وهي مجموعه G1) المجموعة الضابطة السالبة - أما المجموعة الثانية الرئيسية والتي تغذت على نظام غذائي يحتوي على دهون حيوانية و كولسترول كان عددًا 42 فازًا و قسمت إلى ثلاثة مجموعات فرعية مجموعات جعاضضة، و التي تغذت على نظام غذائي عالي الدهون والكولسترول طوال فترة التجربة ومجموعه G3) والتي تغذت على نظام غذائي عالي الدهون والكولسترول بالإضافة إلى 5% جعاضض، مجموعه G4) والتي تغذت على نظام غذائي عالي الدهون والكولسترول بالإضافة إلى 10% جعاضض. وقد أظهرت النتائج وجود زيادة ملحوظة في كل من وزن الجسم ومستوى الدهون والكوليسترول والكوليسترول الضار (LDL) بالإضافة إلى الكهرباء وانتظام الكبد و الكولسترول باستثناء الكوليسترول المفيد عالية الكثافة (HDL-C) لدى المجموعة الضابطة الجعاضضة G2 مقارنةً بالمجموعة الضابطة السالبة G1. بينما كان هناك انخفاضاً ملحوظاً في المجموعتين اللتين تغذياً على الجعاضض في كل من وزن الجسم ومستوى الدهون والكوليسترول والكوليسترول الضار (LDL) والكوليسترول، بينما كان هناك ارتفاع ملحوظ في مستوي الكوليسترول المفيد (HDL-C). 

وقد أكد ذلك الفحص النسيجي للكبد والكلي والقلب والمخ. لذلك، نوصي باستخدام الجعاضض بكميات معتدلة في وجباتنا الغذائية اليومية للاستفادة من فوائده الصحية.

الكلمات المفتاحية: عائلة النجمية، فط كوليسترول الدم، وظائف الكبد، وظائف الكلي، مستوي الدهون.