ORIGINAL ARTICLES

Effect of Dietary Oat and Wheat Bran on Biochemical Changes in Rats Fed High Fat-High Cholesterol Diets

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ABSTRACT

The purpose of this study aims to examine the efficiency of using either oat or wheat bran (5 or 10%) on the prevention of hyperlipidemia, hypercholesterolemia induced in rats fed with High Fat-High Cholesterol (HF-HC) diets. Sixty adult male albino rats were divided into six groups: (G1) normal control rats fed with balanced diet and (G2) rats fed with hyperlipidemic-hypercholesterolemic which was supplemented with fat and cholesterol at a dose level of 20g and 1g/100g diet respectively. The other four groups of animals were fed with the same previous (HF-HC) diet supplemented with Oat (G3 & G4), while (G5 & G6) were supplemented with wheat bran at levels of 5 and 10% respectively for six weeks. The present study showed that 20% fat and 1% cholesterol administration cause a significant increase in total lipids, total cholesterol, triacylglycerol as well as Low Density Lipoprotein-Cholesterol (LDL-C), Very Low Density Lipoprotein-Cholesterol (VLDL-C), ratio of Low Density Lipoprotein-Cholesterol/High Density Lipoprotein-Cholesterol (LDL-C/HDL-C) and enzymes activities of Asparate Aminotransferase (AST) and Alanine Aminotransferase (ALT) accompanied with decreasing HDL-C compared to normal group. Cholesterol-enriched diet significantly increased serum malondialdehyde (MAD) and significantly decrease glutathione (GSH) content and erythrocyte superoxide dismutase (SOD) activity as compared with balanced diet group. Rats fed oat or wheat bran at tested doses resulted in a significant decrease in glucose, lipid parameters and a significant improve in antioxidants as well as enzymes activities of AST and ALT compared with those fed HF-HC diet. It was concluded that both Oat and wheat bran at dose 10% had anti-atherogenic hypolipidemic effect and reduced oxidative stress via inhibition of reactive oxygen species and lipid peroxidation as well as increment of antioxidant enzymes.

Key words: Dietary oat, Wheat bran, high fat, high cholesterol, Diets

Introduction

Increasing consumption of dietary fat and animal-based food products had led to the development of hyperlipidemic and abnormal lipid metabolism, such as increase in blood cholesterol, triacylglycerol and lipoproteins, which was considered to be a major factor (Tae-Youl et al., 2005 and David et al., 2008).

Epidemiological studies have strongly suggested that diet rich in cereals play a crucial role in the prevention of chronic disease such as cardiovascular disease and certain types of cancers (Slavin, 2000 and Aruoma, 2003).

The beneficial health effects derived from the intake of diets rich in cereals have been described to dietary fiber, or to some the components associated with the fiber including phenolic acids (Andreasen et al., 2001 and Zhao et al., 2003).

Several investigations were conducted to study antioxidant properties of wheat and wheat-based food products (Baublis et al., 2000 and Yu et al., 2003). It is widely accepted that phonolic compounds, including ferulic, vanillic, P. Coumaric, caffeic and chlorogenic acids, are rich in the bran portion of cereal kernels, and may contribute to total antioxidant activities of wheat (Yu et al., 2002 and Price et al., 2008). These hydroxycinnamic acids exhibit in vitro chemoprotective and antioxidant properties and are suggested to be mainly responsible to the beneficial effects of diet rich in cereal bran (Andreasen et al., 2001).

Wheat bran as an important by-product of the cereal industries are produced world wide in enormous quantities and recognized as a good source of dietary fiber. Ferulic acid, the main phenolic acid in wheat bran cell wall, was found to be conjugated with cell wall arabinoxylan (Hatfield et al., 1999). Feruloyl oligosaccharides were motivated by the enthusiasm to better understand the structure of the plant cell wall. Recently, interest in these oligosaccharides has been inspired by their biological activities and their potential niche application (Ohta et al., 1997; Lequart et al., 1999 and Katapodis et al., 2003).

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Oat (Avena Sativa L.) has long recognized as a healthful and nutritious food, containing high concentration of well balanced protein and soluble fiber (Welch, 1995). In addition, oat is a source of antioxidants, such as tocols (Peterson and Qureshi, 1993) and various phenolic compounds (Xing & White, 1997 and David, 2001). The antioxidant capacity of oat is largely due to the presence of tocopherol, tocotrienols, phytic acid, flavonoids and non-flavonoid phenolic compounds such as avenanthramides (Peterson, 1995). Oat antioxidants have been reported to inhibit low-density lipoprotein oxidation and promote scavenging of reactive oxygen species (Chen et al., 2004 and David et al., 2008).

The purpose of this study aims to evaluate the potential natural dietary fibers present in oat or wheat bran (5 or 10%) for the improvement of some biochemical parameters which had changed in rats serum fed high fat-high cholesterol diet.

Materials and Methods

Materials:

Dietary Fibers:

There were carried out on cellulose as pure source. Cellulose as an insoluble fiber was used, wheat bran was brought from Agricultural Research Centre, Giza. Oats were obtained from local market.

Animals:

This study was carried out using sixty healthy adult albino rats (Sprague-Dawely) strain weighing 120 ±5g, supplied from breeding unit of the Egyptian Organization for Biological Product and Vaccines, Hellwan Egypt. Rats were housed of ten per cage under controlled environment conditions cycle. Rats fed experimental diet (Reeves et al., 1993) and were given tap water ad libitum throughout the experimental work.

Methods:

As experimental design, animals were randomly allocated into six groups: (G1) control group (balanced diet) and the (G2) rats were fed with hyperlipidemic-hypercholesterolemic which was supplemented with fat and cholesterol at a dose level of 20g and 1g/100g diet respectively. The other four groups of animal were fed with the same previous high fat-high cholesterol diet supplemented with oat (G3 & G4), while (G5 & G6) were supplemented with wheat bran at levels of 5 and 10% respectively. At the end of experiment period (6 weeks) and after over night fasting (12 hours), rats were scarified under anesthesia and blood samples were collected from hepatic portal vein in two centrifuge tubes, the first tube contained heparine for determination of superoxide dismutase (SOD) activity and reduced glutathione (GSH) according to Nishikimi et al., (1972) and Beutler (1982) respectively. In the second tube serum was separated by allowing blood samples left for 15 minutes at temperature of 25°C then centrifuged at 4000 r.p.m for 20 minutes by EBA8 centrifuge (Made in China), then kept in plastic vial at -20°C until analysis of glucose by method of Barham and Trinder (1972), total lipids by Zollner and Kirsch (1962), total cholesterol by Allian et al., (1974), HDL-C by Burstein et al., (1970), triacylglycerol by Fossati & Prencipe (1982), Calculation of LDL-C fraction and LDL-C/HDL-C ratio involves an equation developed by Friedewald et al., (1972), malondialdehyde (MAD) by Draper and Hadley (1990). Asparate aminotransferase (AST) and alanine aminotransferase (ALT) according to Henry et al., (1960).

Statistical Analysis:

The data of the biochemical measurements in blood and serum were subjected to statistical analysis using one-way classification lest. Values were considered statistically significant at P < 0.05 (Snedecor and Cochran, 1980).

Results:

Effect of tested dietary fiber on serum glucose and lipids profile:

The results tabulated in table (1 & 2) showed that the serum glucose level was 98.50 mg/dL in control group rats fed balanced diet, while rat fed HF-HC diet indicated that the mean value of serum glucose significantly (P<0.05) elevated to 174.00 mg/dL. The present results concluded that rats received dietary fiber either from oat or wheat bran at 5 or 10% significantly reduced the serum level of glucose. The means were
153.67 and 118.17 mg/dL for Oat while the values were 160.67 and 136.83 mg/dL for wheat bran respectively compared with those received HF-HC diet.

Moreover the statistical analysis indicated that the dietary treatment (High Fat-High Cholesterol) significantly increased in the total lipid, total cholesterol, triacylglycerol as well as LDL-C, VLDL-C and LDL/HDL ratio while decreased in the HDL-C for rats fed HF-HC compared with healthy group. The supplementation of diet with either Oat or wheat bran at the tested doses resulted in a significant decrease in the level of serum total lipid, total cholesterol, triacylglycerol, LDL-C, VLDL-C and LDL-C/HDL-C ratio with increased in the level of HDL-C compared with those fed HF-HC. It could be concluded that the supplementation with dietary fibers (Oat) dose up to 10% enhanced the level of glucose & total cholesterol while rats fed wheat bran at 10% improved serum total lipid and LDL-C/HDL-C ratio.

Table 1: Effect of supplementing Oat and wheat bran at the tested doses on serum glucose, total lipid, total cholesterol and triacylglycerol in (HF-HC) fed rats.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Glucose (mg/dL)</th>
<th>Total lipid (mg/dL)</th>
<th>Total cholesterol (mg/dL)</th>
<th>Triacylglycerol (mg/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1 (control)</td>
<td>98.50 ± 5.08</td>
<td>328.93 ± 0.35</td>
<td>89.16 ± 5.87</td>
<td>76.16 ± 3.43</td>
</tr>
<tr>
<td>G2 (HF + H-C)</td>
<td>174.00 ± 5.29</td>
<td>507.99 ± 9.16</td>
<td>108.66 ± 4.50</td>
<td>150.67 ± 10.28</td>
</tr>
<tr>
<td>G3 (HF – HC + 5% Oat)</td>
<td>153.67 ± 3.61</td>
<td>453.26 ± 7.22</td>
<td>86.66 ± 7.33</td>
<td>94.00 ± 3.34</td>
</tr>
<tr>
<td>G4 (HF – HC + 10% Oat)</td>
<td>118.17 ± 2.40</td>
<td>474.90 ± 9.78</td>
<td>69.66 ± 5.78</td>
<td>87.88 ± 10.11</td>
</tr>
<tr>
<td>G5 (HF – HC + 5% Wheat bran)</td>
<td>160.67 ± 7.60</td>
<td>289.94 ± 5.9</td>
<td>73.80 ± 9.49</td>
<td>79.66 ± 6.88</td>
</tr>
<tr>
<td>G6 (HF – HC + 10% Wheat bran)</td>
<td>136.83 ± 5.38</td>
<td>271.49 ± 8.64</td>
<td>69.66 ± 5.78</td>
<td>84.50 ± 4.67</td>
</tr>
</tbody>
</table>

L.S.D (P<0.05) 4.33 3.5 6.8 4.3

There was no significant difference between means have the same letters in the same column, each value represents the mean ± SD of six groups (ten rats in each group).

Table 2: Effect of supplementing Oat and wheat bran at the tested doses on Serum lipids profile in HF-HC fed rats.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>HDL-C mg/dL</th>
<th>LDL-C mg/dL</th>
<th>VLDL-C mg/dL</th>
<th>LDL/HDL Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1 (control)</td>
<td>21.50 ± 1.04</td>
<td>59.83 ± 7.57</td>
<td>14.23 ± 0.68</td>
<td>2.79 ± 0.45</td>
</tr>
<tr>
<td>G2 (HF + H-C)</td>
<td>17.83 ± 0.75</td>
<td>83.50 ± 5.85</td>
<td>30.13 ± 2.05</td>
<td>4.21 ± 0.32</td>
</tr>
<tr>
<td>G3 (HF – HC + 5% Oat)</td>
<td>22.33 ± 1.36</td>
<td>46.33 ± 3.72</td>
<td>18.80 ± 2.02</td>
<td>2.07 ± 0.14</td>
</tr>
<tr>
<td>G4 (HF – HC + 10% Oat)</td>
<td>23.83 ± 2.13</td>
<td>47.83 ± 2.99</td>
<td>17.56 ± 1.37</td>
<td>2.47 ± 0.19</td>
</tr>
<tr>
<td>G5 (HF – HC + 5% bran)</td>
<td>22.00 ± 1.09</td>
<td>31.83 ± 4.16</td>
<td>16.00 ± 1.04</td>
<td>1.51 ± 0.17</td>
</tr>
<tr>
<td>G6 (HF – HC + 10% bran)</td>
<td>23.00 ± 2.96</td>
<td>32.00 ± 1.54</td>
<td>16.91 ± 0.94</td>
<td>1.41 ± 0.19</td>
</tr>
</tbody>
</table>

L.S.D (P<0.05) 1.4 6.75 1.63 0.145

There was no significant difference between means have the same letters in the same column, each value represents the mean ± SD of six groups (ten rats in each group).

Effect of tested dietary fibers on serum MAD blood GSH and SOD:

The results in table (3) showed that feeding rats with HF-HC caused a significant increase in serum MAD to 5.99 n mol/ml and a significant depletion in values of whole blood GSH and SOD to become 30.09 mg/g Hb, 260.11 U/ml, respectively. Serum MAD was significantly decreased when rats fed diet supplemented with Oat or wheat bran (at 5% or 10%), while a significant increase observed in the level of GSH and SOD compared with those received HF-HC.

Table 3: Effect of supplementing Oat and wheat bran at tested doses on serum MAD, blood GSH and erythrocyte superoxide dismutase in HF-HC fed Rats.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>MDA (n mol/ml)</th>
<th>GSH (mg/gHb)</th>
<th>SOD (U/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1 (control)</td>
<td>3.16 ± 0.08</td>
<td>44.66 ± 0.04</td>
<td>321.19 ± 0.04</td>
</tr>
<tr>
<td>G2 (HF + H-C)</td>
<td>5.99 ± 0.15</td>
<td>30.09 ± 0.03</td>
<td>250.11 ± 0.03</td>
</tr>
<tr>
<td>G3 (HF – HC + 5% Oat)</td>
<td>3.28 ± 0.08</td>
<td>46.99 ± 0.04</td>
<td>320.12 ± 0.04</td>
</tr>
<tr>
<td>G4 (HF – HC + 10% Oat)</td>
<td>3.48 ± 0.07</td>
<td>46.11 ± 0.08</td>
<td>322.11 ± 0.08</td>
</tr>
<tr>
<td>G5 (HF – HC + 5% bran)</td>
<td>3.01 ± 0.03</td>
<td>47.14 ± 0.20</td>
<td>321.88 ± 0.20</td>
</tr>
<tr>
<td>G6 (HF – HC + 10% bran)</td>
<td>2.99 ± 0.09</td>
<td>47.88 ± 0.04</td>
<td>324.99 ± 0.04</td>
</tr>
</tbody>
</table>

L.S.D (P<0.05) 0.12 1.21 1.22

There was no significant difference between means have the same letters in the same column, each value represents the mean ± SD of six groups (ten rats in each group).

Effect of tested dietary fibers on serum AST and ALT activity:

The result presented in table (4) showed the levels of AST 118.00 U/ml and 50.16 U/ml of ALT in serum of rats fed balanced diet. Meanwhile, rats fed HF-HC showed a significant (P<0.05) increase in the levels of serum enzymes activities became 185.0 U/ml for AST and 87.83 U/ml for ALT. With respect to AST and ALT
activities statistical analysis exhibited a significant decrease in the levels of these enzymes activities due to the supplementation diet with Oat or wheat bran (5 or 10%) compared with those fed HF-HC.

With respect to the result in tables (3 and 4) it could be concluded that, rats fed dietary fiber wheat bran reached up to 10%. The statistical analysis exhibited the higher elevation in SOD & GSH, reduction in MAD as well as AST & ALT activities.

Table 4: Effect of supplementing Oat and wheat bran at tested doses on serum asparate aminotransferase (AST) and alanine aminotransferase (ALT) in HF-HC fed rats.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Parameters</th>
<th>AST (U/ml)</th>
<th>ALT (U/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1 (control)</td>
<td>118.00 ± 14.81</td>
<td>50.16 ± 7.13</td>
<td></td>
</tr>
<tr>
<td>G2 (HF + H-C)</td>
<td>185.00 ± 4.28</td>
<td>87.83 ± 4.35</td>
<td></td>
</tr>
<tr>
<td>G3 (HF – HC + 5% Oat)</td>
<td>172.67 ± 4.50</td>
<td>62.00 ± 7.21</td>
<td></td>
</tr>
<tr>
<td>G4 (HF – HC + 10% Oat)</td>
<td>150.33 ± 4.03</td>
<td>67.00 ± 7.68</td>
<td></td>
</tr>
<tr>
<td>G5 (HF – HC + 5% wheat bran)</td>
<td>156.00 ± 5.69</td>
<td>74.16 ± 4.99</td>
<td></td>
</tr>
<tr>
<td>G6 (HC + 10% wheat bran)</td>
<td>144.33 ± 5.98</td>
<td>68.66 ± 9.89</td>
<td></td>
</tr>
<tr>
<td>L.S.D (P &lt; 0.05)</td>
<td>4.5</td>
<td>5.3</td>
<td></td>
</tr>
</tbody>
</table>

There was no significant difference between means have the same letters in the same column, each value represents the mean ± SD of six groups (ten rats in each group).

Discussion:

Hyperlipidemia including hypercholesterolemic and hypertriglyceridemia, is a major risk for the development of cardiovascular diseases (Kyung-Hee et al., 2006 and David et al., 2008).

In the present study results reached a significant (P< 0.05) increased in the blood serum glucose for rats fed HF-HC diet compared with those received balanced diet. Furthermore, supplement diet fed rats with Oat or wheat bran (5 or 10%) led to a significant reduction in the serum glucose levels compared with those fed HF-HC diet. These results are similar to the results of (Madhujith and Shahidi, 2007). They found that significant reduction of the increase in postprandial serum glucose and insulin values after meals that include soluble fibers.

Cholesterol-enriched diet resulted in a significant increase in total lipids, total cholesterol, triacylglycerol, LDL-C, VLDL-C and LDL/HDL ratio accompanied with decrease in HDL-C, thus providing to a model for dietary hyperlipidemia. The increase of lipid parameters has been shown to be a strong risk factor for coronary heart diseases in many populations (Makni et al., 2008). The raise in total cholesterol in serum may be due increased uptake of exogenous cholesterol and subsequent deposition and decrease cholesterol catabolism as evidenced by reduction in bile acid production and turnover the bile acid (Vijaimohan et al., 2006).

In the present investigation the use of dose 10% of dietary fiber oat is recommended to enhance the level of glucose and total cholesterol. This can be due to the oat containing β–glucan (David et al., 2008).

Our results indicated that both Oat and wheat bran at dose 10% had Potential hypolipidemic, hypotriglyceridemic and hypcholesterolemic effect in serum of normocholestermic and hypercholesterolemic rats with a reduction of serum LDL-C, VLDL-C as well as LDL/HDL-C ratio as well. However, the decrease in LDL-C/HDL-C ratio had markedly a significant decrease in groups fed diet supplemented with wheat bran (10%) . In this connection (Chen et al., 2006), reported that dietary factors are effective in lowering serum total cholesterol, such as fibers sources containing high amount of soluble dietary fiber. Also, it was recorded that the reduction of lipides levels in serum may be due to increase fecal lipid excretion when rats fed dietary fibers (Zhou et al., 2006). The low total cholesterol content in the livers of rats fed dietary fibers diet could be attributed to reduce synthesis of cholesterol or an increase loss of steroids compounds (Topping et al., 1990 and Ylitalo et al., 2002).

In this study, the level of oxidative stress biomarker MAD was significantly increased while another antioxidants GSH and SOD decreased in blood from rats fed HF-HC were compared with those fed control diet. Oxidative stress has been defined as a disturbance to the equilibrium status of peroxidant and antioxidant systems in favor of prooxidation due to excess formation of free radicals and decreased activity of antioxidant defense systems. Excess reactive oxygen species (ROS) are toxic as they could attack and damage cellular constituents, such as DNA, protein, carbohydrates, nucleic acid and membrane lipids leading to tissue injury and cell death. Oxidative stress and ROS have been associated with a variety of chronic health problems such as cardiovascular diseases and cancers (Lotito & Frei, 2006 and Hajiani et al., 2008). These results of the supplementation diet fed rats with Oat or wheat bran (5 or 10%) exhibited a significant decreased in the level oxidative stress biomarker MAD with increasing the levels of antioxidants GSH and SOD rats compared with those received HF-HC.

However, it is widely believed that phenolic acids are group of natural products commonly found in many cereal grains. Higher concentrations of these compounds are found in the outer layers of the kernel which constitute the bran (Baublis et al., 2002 and Kyung-Hee et al., 2006). These phenolic acids may vary in structure due to difference in number and position of the hydroxyl group on the aromatic ring. These naturally occurring
compounds have been found to be strong antioxidants against free radicals and other reactive oxygen species, the major cause of many chronic human disease such as cancer and cardiovascular diseases (Price et al., 2008).

The feruloyl oligosaccharides (FOS) can be released from wheat bran protect normal rat erythrocytes against in Vitro oxidative damage and enhance the level of antioxidative activity in rat plasma in Vivo (Jing et al., 2010).

Our results had significantly showed increase in the levels of enzymes activities for AST and ALT in rats serum after fed HF-HC diet compared with those received balanced diet. Moreover, results reached improved in these levels enzymes activities due to dietary fibers tested in this study were supplemented to feed rats diet compared with those fed HF-HIC. This can be attributed to feeding dietary fibers containing natural antioxidants (David, 2001).

In the present investigation, statistical analysis exhibited more significant effect for oat at dose 10% supplemented with fed rats in the reducing of postprandial glucose and total cholesterol. Many studies focused on β-glucan as the component mainly tended to be efficient in reducing insulin resistance and improvement of glucose tolerance. In addition, soluble dietary fiber increased the intestinal viscosity and thus decreased the absorption of cholesterol and reabsorption of bile acids (Vijaimohan et al., 2006). Whereas, supplemented diet wheat bran 10% for fed rats, the results obtained raised more the effectiveness in the ameliorate oxidative stress and enzyme activities.

In Conclusion, natural dietary fiber namely Oat and wheat bran were efficient in lowering the blood glucose and had potential effect to reduce hypercholesterolemia and lipid peroxidation through increasing antioxidants. The hypolipidemic mechanism represented in Oat and wheat bran at a level of 10% may reduce absorption of dietary fat and cholesterol as well as the increment of antioxidant enzyme.

References


