Dietary Persimmon Improves Lipid Metabolism in Rats Fed Diets Containing Cholesterol

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ABSTRACT The effect of dietary persimmon (Pers, 7.0%) on lipid metabolism and antioxidant activity was investigated in 40 male Wistar rats adapted to cholesterol-free or 1% cholesterol diets. The rats were divided in four groups of 10. The basal diet contained wheat starch, casein, soybean oil, and mineral and vitamin mixtures. The control group (C) consumed the basal diet. To the basal diet were added 7 g/100 g dry persimmon (Pers), 1 g/100 g cholesterol (Chol), or both (Chol/Pers). The experiment lasted 4 wk. Plasma total cholesterol (TC), LDL cholesterol (LDL-C), HDL cholesterol (HDL-C), triglycerides (TG), total phospholipids (TPH), HDL phospholipids (HDL-PH), lipid peroxides (LP) and liver TC concentrations were measured. Groups did not differ before the experiment. In the Chol/Pers vs. Chol group, the persimmon-supplemented diet significantly (P < 0.05) lessened the rise in plasma lipids due to dietary cholesterol: TC (3.88 vs. 4.88 mmol/L; −20%), LDL-C (2.24 vs. 3.27 mmol/L; −25%), TG (0.72 vs. 0.88 mmol/L; −19%), LP (2.20 vs. 3.25 mmol/L; −25%) and TC in liver (32.8 vs. 49.9 μmol/g; −34%), (P < 0.001). The Chol/Pers diet significantly reduced the decrease in HDL-PH due to dietary cholesterol (0.73 vs. 0.58 mmol/L; −25.6%, P < 0.001) and decreased the level of TPH (1.32 vs. 1.73 mmol/L; −23%, P < 0.001). Persimmon in rats fed the basal diet without cholesterol did not significantly affect the variables measured. These results demonstrate that persimmon possesses hypolipidemic and antioxidant properties that are evident when persimmon is added to the diet of rats fed cholesterol. These properties are attributed to its water-soluble dietary fiber, carotenoids and polyphenols. J. Nutr. 128: 2023–2027, 1998.

KEY WORDS: persimmon lipoproteins phospholipids lipid peroxides rats
1977, Young and How 1986). A high concentration of antioxidants such as ascorbic acid (up to 7.5 mg), carotenoids (particularly \( \beta \)-cryptoxanthin, zeaxanthin and \( \beta \)-carotene), polyphenols and a specific group of polyphenols (tannins) were found in persimmon (Gorinstein et al. 1994, Gross 1987, Uchida et al. 1989). The dry residue of persimmon includes the following (g/100 g): polyphenols, 0.16–0.25; carotenoids, 0.002; and soluble and nonsoluble proteins, 0.64–1.3 (Daoed et al. 1992, Gorinstein et al. 1994, Gross 1987, Pirretti 1991). Some components of persimmon show special activities (Uchida et al. 1989). Persimmon tannins prolonged life and reduced the incidence of stroke in hypertensive rats (Uchida et al. 1989, Uchida et al. 1992, Gorinstein et al. 1994, Gross 1987, Pirretti 1991). This effect was attributed to the fact that persimmon tannins are 20 times more potent than antioxidant vitamin E. However, the effect of a persimmon-supplemented diet on lipid metabolism has not been examined.

The aim of this study, therefore, was to investigate the possible influence of this diet on lipid metabolism and antioxidant activity in rats fed cholesterol-containing and cholesterol-free diets.

MATERIALS AND METHODS

Rats and diets. The Animal Care Committee of Warsaw Agricultural University approved this study. The Institute of Animal Physiology and Nutrition of Polish Academy of Sciences (Jabłonna, Poland) provided 6-mo-old male Wistar rats (n = 40) with a mean weight of 120 g. They were housed individually in stainless steel metabolic cages and were divided into four groups of 10. All four groups were fed a basal diet that included wheat starch, casein, soybean oil, and mineral and vitamin mixtures. The rats of the control (C) group were fed only the basal diet. The persimmon (Pers) group received the basal diet supplemented with 7 g/100 g dry persimmon (Pers). The cholesterol (Chol) group received the basal diet plus 1% nonoxidized cholesterol, whereas the cholesterol/persimmon (Chol/Pers) group received the basal diet supplemented with 1% nonoxidized cholesterol and 7 g/100 g dry persimmon. The experiment lasted 4 wk. Total cholesterol (TC), LDL-C, HDL cholesterol (HDL-C), triglycerides (TG), total phospholipids (TPh), HDL phospholipids (HDL-PH), lipid peroxides (LP) in plasma and TC concentration in liver were measured.

To prepare persimmon for use in this experiment, whole fruits of the seedless Triumph variety were dried at 40°C, powdered and mixed with the basal diet before the rats were fed. Cholesterol of analytical grade (USP) was obtained from Sigma Chemical, St. Louis, MO. The cholesterol batches were mixed carefully with the basal diet (1:999) just before the diets were offered to the rats. The dietary cholesterol was checked according to the HPLC method of Ansari et al. (1979) and was found not to contain cholesterol oxides. Total dietary fiber was determined according to Prosky et al. (1992). We have determined that persimmon contains (g/100 g of dry persimmon) 3.50 g of total dietary fiber, 1.75 g of soluble dietary fiber, and 1.70 g of insoluble dietary fiber. The fiber concentration of persimmon-containing diets was 2.20 and 5.51 g/100 g soluble and insoluble dietary fiber, respectively. The dietary fiber was determined using diethyl ether; blood samples were taken from the left atrium of the heart. Plasma was prepared and used for laboratory tests. After anesthesia, the abdomen was opened to take samples of the liver for determination of TC. The weight gain of the rats was recorded on a weekly basis. TC, LDL-C, TPH, HDL-PH and TG were determined enzymatically. TC and TG were measured as described by Trinder and Webster (1984) with kits (PAP 100, #6.122.4 and #6.123.6, respectively); TPH was measured according to a combined enzymatic method using phospholipase D, choline oxidase and peroxidase (Takayama et al. 1977) with a kit (#6.149.1) from Bio Merieux (Marcy l’Etoile, France). HDL-C and HDL-PH were determined by the same enzymatic methods after the precipitation of LDL-C and VLDL cholesterol (VLDL-C) fractions with phosphotungstic acid in the presence of magnesium ions with kit (# 1.619.1) from Bio Merieux. LP was determined colorimetrically (Tateishi et al. 1987) in a direct reaction between methylene blue derivatives (MCDP, 10-N-methylcarbamoyl-3,7-dimethylamino-10H-phenothiazine) catalyzed by hemoglobin using kit (9+CC-004) from Kamiya Biomedical (Seattle, WA). LDL-C was calculated according to the Friedewald formula (Friedewald et al. 1972). TC in liver was measured according to Mazur et al. (1990).

Data analysis. Values are given as the means ± SEM; where appropriate, data were tested by two-way ANOVA (Chol × Pers) using GraphPad Prism, version 2.0 (GraphPad Software, San Diego, CA) followed by Duncan’s new multiple range test (Duncan 1955) to assess differences between group means. Differences of P < 0.05 were considered significant.

RESULTS

The addition of persimmon or cholesterol to the diets did not affect food intake, body weight gain or feed efficiencies (data not shown). At baseline, the four groups did not differ from one another in plasma lipid concentrations (data not shown). After the experiment, the concentrations of TC and LDL-C in both the Chol and Chol/Pers groups were greater than in the C and Pers groups (Table 2), and in Chol rats, TC and LDL-C were significantly greater than in the Chol/Pers group (P < 0.001). Therefore, the persimmon-supplemented diet significantly hindered the cholesterol-induced increase in plasma TC (20%, P < 0.001) and LDL-C (31%, P < 0.001). The HDL-C/TC ratio was lower in both the Chol/Pers and Chol groups than in the C and Pers groups (0.42 ± 0.03 and 0.32 ± 0.03 vs. 0.56 ± 0.04 and 0.56 ± 0.04, respectively, and the ratio in the Chol/Pers group was significantly greater than that in the Chol group (P < 0.025). The TG concentration was greater in the Chol group than in the other three groups.

**Table 1**

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Control</th>
<th>Chol</th>
<th>Pers</th>
<th>Chol/Pers</th>
</tr>
</thead>
<tbody>
<tr>
<td>g/kg diet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cassein</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>180</td>
</tr>
<tr>
<td>Soybean oil</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Wheat starch</td>
<td>690</td>
<td>690</td>
<td>690</td>
<td>690</td>
</tr>
<tr>
<td>Dry persimmon</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vitamin mixture</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Mineral mixture</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
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<tr>
<td>Total fiber</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Soluble fiber</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Insoluble fiber</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

1 Control and cholesterol diets were fiber free.

2 Dry persimmon was prepared and supplied by the Department of Pharmaceutical Chemistry (see Materials and Methods).

3 Sigma Chemical (St. Louis, MO).

4 Vitamins (per kg of diet): thiamin, 20 mg; riboflavin, 15 mg; pyridoxin, 10 mg; nicotinamide, 100 mg; calcium panthenolate, 70 mg; folic acid, 5 mg; biotin, 0.3 mg; cyanocobalamin, 0.05 mg; retinyl palmitate, 1.5 mg; dl-α-tocopheryl acetate, 125 mg; cholecalciferol, 0.15 mg; menadione, 1.5 mg; ascorbic acid, 50 mg; myo-inositol, 100 mg; carrier, wheat starch; 1.36 g.

5 Minerals (per kg of diet): CaHPO₄, 15.0 g; KH₂PO₄, 2.5 g; KCl, 5 g; NaCl, 5 g; MgCl₂, 2.5 g; Fe₃O₄, 2.5 mg; MnSO₄, 0.2 mg; CuSO₄·5H₂O, 0.2 mg; ZnSO₄·7H₂O, 100 mg; KIO₃, 0.4 mg.

6 MCDP, 10-N-methylcarbamoyl-3,7-dimethylamino-10H-phenothiazine.
TABLE 2

Plasma lipids and total cholesterol concentration in liver of rats fed diets with and without 1% cholesterol (Chol) and with and without 7% persimmon (Pers) 1,2

<table>
<thead>
<tr>
<th>Diet</th>
<th>Plasma lipids</th>
<th>Liver</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TC (mmol/L)</td>
<td>LDL-C (mmol/L)</td>
</tr>
<tr>
<td>Control</td>
<td>2.85 ± 0.14c</td>
<td>1.25 ± 0.06c</td>
</tr>
<tr>
<td>Pers3</td>
<td>2.73 ± 0.12c</td>
<td>1.13 ± 0.05c</td>
</tr>
<tr>
<td>Chol</td>
<td>4.88 ± 0.24a</td>
<td>3.27 ± 0.15a</td>
</tr>
<tr>
<td>Chol/Pers</td>
<td>3.88 ± 0.19b</td>
<td>2.24 ± 0.11b</td>
</tr>
<tr>
<td>ANOVA (P-value)</td>
<td>Pers 0.01</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Chol &lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Pers × Chol  &lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

1 Values are means ± SEM, n = 10.
2 Means without letters in common differ significantly (P < 0.05).
3 Abbreviations used: Chol, nonoxidized cholesterol; HDL-C, HDL cholesterol; HDL-PH, HDL phospholipids; LDL-C, LDL cholesterol; NS, not significant (P ≥ 0.05); TC, total cholesterol; TG, triglycerides; TPH, total phospholipids.

DISCUSSION

Some authors have claimed that a diet rich in vegetables and fruits can prevent atherosclerosis (Lorgeril et al. 1994, Partiff et al. 1994). At present, the markets of Europe and North America offer many tropical fruits such as persimmon, guava, wax apple, lichi, rambutan, mango and pineapple (Brekke 1992). Based on recent investigations (Gorinstein et al. 1993 and 1994), the main object of this study was to evaluate persimmon's ability to prevent atherosclerosis. The major classical risk factor for atherosclerosis, hyperlipidemia, remains a foundation of this disease (Faggiotto et al. 1984, Faggiotto and Ross 1984). The fight against hyperlipidemia and other classical risk factors, including hypertension, cigarette smoking and diabetes mellitus, is the basis for the prevention of atherosclerosis. Indeed, intensive reduction of the above-mentioned risk factors has a beneficial effect, i.e., the disease regression in the risk reduction group is twice as frequent as in control group (Haskell et al. 1995). Since the work of Anitschkow (1913), it has been known that a proper diet is a very important measure in preventing hyperlipidemia. Dietary fiber can exercise a favorable effect on lipid metabolism...
2026  

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