Beneficial effects of garlic (Allium sativum Linn) on rats fed with diets containing cholesterol and either of the oil seeds, coconuts or groundnuts

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Feeding of 2% cholesterol diet increased lipid parameters in serum and tissues of rats during a period of one month. In addition to the above, lipid peroxidation also increased and activities of certain enzymes were significantly altered in the tissues. Similar changes were also observed to a greater extent with diets containing 40% by weight of coconut kernel or groundnut with and without 2% cholesterol. The enzymes studied were HMGCoA reductase, AST, ALT and ALP in tissues and serum as the case may be. In general the atherogenic effects were observed more with groundnut containing diets than those with coconut. Even though the oil from the former is mostly unsaturated and that from the latter is mostly saturated, these analytical criteria do not relate to their atherogenic effects. When 5% garlic was incorporated with any of the high fat diets, the lipid parameters, their peroxidation and alterations in enzyme activities were significantly decreased. These results show that garlic contains some principles that counteract the atherogenicity of the above oil seeds.

Coconut (CN) oil has been considered as an atherogenic oil as compared to groundnut (GN) oil as the former contains mostly saturated fats with very little unsaturated fatty acids. But coconut kernel (CK) is considered less harmful than its oil as the former contains very good fiber (7-8%), trienols and proteins (5-6%) that ameliorate the atherogenicity of the oil in it1. Keys proved that CN oil is not hypercholesterolemic3. However in a previous study from our laboratory we found that a diet containing 20% CN oil is hyperlipidemic in rats and that incorporation of garlic (Allium Sativum Linn) oil or garlic cake counteracted such deleterious effects.

Garlic (Allium Sativum Linn) has been claimed to have both hypocholesterolemic3,4 and hypolipidemic5 effects and very recently antioxidant properties have also been attributed to garlic principles6,7. The active principles in garlic are mainly sulphur rich compounds such as S-allyl cysteine sulphoxide and the compounds derived from it, viz. allicin, ajoene and polysulphides (components of garlic oil)8. In the west garlic is added in various dietary preparations as this vegetable is prophylactic in action against coronary heart disease (CHD), cancer and peptic ulcer.

Groundnut oil which is relatively unsaturated9 is surprisingly atherogenic for Rhesus monkeys, rats and rabbits and according to some workers arachidic and behnic acids present in groundnut oil (6.3%) may be responsible in part, for the greater atherogenic effect of that oil10. Another suggestion is that the atherogenicity of an oil is not due to the level of its saturated fatty acids (FAs) but rather due to its triglyceride structure11 i.e. the position of saturated and unsaturated fatty acid groups on the triglyceride. Randomisation of groundnut oil, which modifies its triglyceride structure, significantly reduces its atherogenicity12. Another possibility is that a lectin present in groundnut oil may be responsible for its atherogenicity13.

Rajmohan's study in humans15 showed that a 15% inclusion of coconut oil or its equivalent of kernel had no bad effects on serum cholesterol and lipoproteins as compared to that with groundnut oil. Further in the same study he showed that coconut oil and kernel together in a diet increased HDL cholesterol and decreased LDL cholesterol. These results influenced us to take up the present study, i.e., to compare the effects of groundnuts and coconuts with and without cholesterol in the diets and also to study whether
incorporation of garlic in the combined diet could ameliorate the bad effects of these oil seeds to any extent. The composition of CN oil consists of saturated FA, of short chain 15%, medium chain 64.2%, long chain 12.2% and monounsaturated oleic acid 6.8% and polyunsaturated linoleic acid 1.8%. The same for GN oil is saturated short chain and saturated FA of short chain 15%, medium chain 64.2%, long chain 18.8%, monounsaturated oleic acid 56% and palmitoleic acid 1.1% and polyunsaturated linoleic acid 24.1% as given by Sreekumar and Kurup.

Materials and Methods

The various general chemicals employed in the separation procedures and estimation were of analytical grade supplied by E.Merck, Germany, Biolab Diagnostics Ltd, etc. Garlic bought from local market was cleaned, sliced and dried in the sun and powdered for mixing with the ingredients of rat feed.

Adult male albino rats (Sprague Dawley strain) 9-12 months old and weighing 170-240g were selected from the animal house of our institution. These rats were divided into 8 groups containing 6 rats in each group. Each group was maintained on a diet as prescribed below for one month. An average of 10g rat feed was consumed by each rat in a trial feeding experiment. Normal diet was Gold Mohur rat feed supplied by Brooke Bond Lipton India Ltd.

Group I: This group was given normal diet at a measured quantity of 10g/rat/day and water ad libitum. For each of other groups 60g rat feed was prepared and supplied as follows along with water ad libitum.

Group II: 98% normal rat feed mixed with 2% cholesterol i.e. 58.8g normal feed and 1.2g cholesterol.

Group III: 40% coconut kernel (CNK) and 60% normal rat feed i.e. 36g. normal feed and 24g. CNK powder.

Group IV: 40% groundnut (GN) and 60% normal rat feed i.e. 36g. normal feed+24g. GN powder.

Group V: 40% CNK, 2% cholesterol and 58% normal rat feed i.e. 34.8g. normal feed +24g. CNK powder+1.2g. cholesterol.

Group VI: 40% GN powder, 2% cholesterol and 58% normal rat feed, i.e. 34.8g. normal rat feed +24g. GN powder+1.2 g. cholesterol.

Group VII: 40% CNK, 53% normal rat feed, 2% cholesterol and 5% garlic, i.e. 31.8g. normal feed+1.2g. cholesterol+24g. CNK powder+3g. garlic powder.

Group VIII: 40% GN powder, 53% normal feed, 2% cholesterol and 5% garlic. i.e. 31.8g. normal feed+1.2g. cholesterol+24g. GN powder +3g. garlic powder.

The diet prepared as above for each group was mixed well and made into small balls with water. These were then dried in an oven and weighed again. Each group was given 60g. of feed daily in the morning between 9.30 to 10 A.M. The oil content in these diets is only 25%.

After one month feeding of each diet to the corresponding group, rats were sacrificed by decapitation after overnight fasting. Blood and various tissues were collected for different estimations. After cutting the jugular vein blood was collected in tubes, allowed to clot and subjected to centrifugation. The serum separated was used for the estimation of various enzymes and biochemical parameters. Liver, heart, aorta and kidney were the tissues specially analyzed. Standard procedures were used to estimate each enzyme or other parameters.

The activities of alkaline phosphatase (EC.3.1.3.1.)15, aspartate transaminase (EC.2.6.1.1.)16 and alanine transaminase (EC.2.6.1.2.)17 in serum and also the activities of certain of the above enzymes and HMGCoA reductase (EC.1.1.3.4)18 with a modification19 and lipid peroxidation i.e. thiobarbituric acid reacting systems 20 (TBARS) in various tissues and lipid parameters viz, total lipids21, cholesterol22 and triacylglycerol (TAG)23 in both serum and tissues were estimated. In addition to this serum HDL cholesterol was also estimated24. Their level of significance was calculated by using Student’s t-test. Tables are given under results.

Results

Serum lipids—Serum lipid profile of test and control rats are given in Table 1. In cholesterol and oil seed fed rats both separately and combined the serum total lipids increased significantly. The increase being in the order, groundnut+cholesterol>coconut+cholesterol>groundnut > coconut> cholesterol. Incorporation of garlic in the diet decreased the raised lipid levels very significantly to near normal values.
Cholesterol feeding alone however did not affect the serum triacylglycerol level. But on incorporation of the oil seeds separately and also in combination with cholesterol in the diet, the serum TAG level increased significantly and the corresponding values of cholesterol and oil seeds combined groups were also significantly higher than each of the oil seed groups. On incorporation of garlic in the diet the raised TAG levels in the combined groups were reduced significantly. The order of increase of the TAG levels is the same as in the previous case for total lipids.

With respect to the serum cholesterol level it increased significantly when cholesterol and oil seeds separately or in combination in the diet were fed to rats. The cholesterol values for the combined diet groups among different groups are shown in Table 1.

**Table 1—Serum lipids and enzymes**

<table>
<thead>
<tr>
<th></th>
<th>Group I (Normal)</th>
<th>Group II (Chol.)</th>
<th>Group III (Coconut)</th>
<th>Group IV (Groundnut)</th>
<th>Group V (CN + Chol.)</th>
<th>Group VI (GN + Chol.)</th>
<th>Group VII (CN + Chol + Garlic)</th>
<th>Group VIII (GN + Chol + Garlic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total lipids (mg/dl)</td>
<td>62.98±8.13</td>
<td>90.5±18.0</td>
<td>137±20.25</td>
<td>144±18.65</td>
<td>175.3±21.7</td>
<td>185.0±24.8</td>
<td>64.0±8.07</td>
<td>66.7±8.10</td>
</tr>
<tr>
<td>TAG (mg/dl)</td>
<td>120±75±7.5</td>
<td>129.7±7.02</td>
<td>140.7±4.22</td>
<td>133.5±6.8</td>
<td>162.6±6.79</td>
<td>156.6±8.25</td>
<td>122.2±7.95</td>
<td>119.9±7.73</td>
</tr>
<tr>
<td>Total chol. (mg/dl)</td>
<td>68.5±4.5</td>
<td>77.5±4.3</td>
<td>80.16±5.8</td>
<td>82.24±5.8</td>
<td>112.6±4.5</td>
<td>120.0±5.3</td>
<td>77.5±4.3</td>
<td>78.0±4.3</td>
</tr>
<tr>
<td>HDL chol. (mg/dl)</td>
<td>34.4±3.1</td>
<td>50.5±4.1</td>
<td>55.5±4.2</td>
<td>58.12±3.9</td>
<td>65.5±3.2</td>
<td>68.8±3.0</td>
<td>50.6±2.75</td>
<td>51.6±3.38</td>
</tr>
<tr>
<td>ALP (IA units/L)</td>
<td>8.82±0.40</td>
<td>9.75±0.49</td>
<td>9.68±0.39</td>
<td>10.51±0.54</td>
<td>10.3±0.35</td>
<td>12.16±0.53</td>
<td>9.60±0.47</td>
<td>11.6±0.36</td>
</tr>
<tr>
<td>AST (IU/L)</td>
<td>21.6±1.77</td>
<td>29.17±1.56</td>
<td>26.92±1.35</td>
<td>31.43±5</td>
<td>29.4±1.78</td>
<td>40.33±1.53</td>
<td>24.0±1.44</td>
<td>27.1±2.6</td>
</tr>
<tr>
<td>ALT (IU/L)</td>
<td>20.88±1.2</td>
<td>26.09±1.48</td>
<td>26.67±1.97</td>
<td>30.9±1.26</td>
<td>32.24±1.46</td>
<td>34.12±1.35</td>
<td>24.1±1.45</td>
<td>25.12±1.54</td>
</tr>
</tbody>
</table>

Student's t-test: Group II, III & IV are compared with group I. a,b,c superscripts indicate level of significance. Groups V & VI are compared with group II. a,b,c lower scripts indicate level of significance. Groups V to VIII are compared with groups III to VI respectively. Superscripts indicate level of significance. N.S.(Non Significant) *P<0.05; **P<0.01; ***P<0.001.

**Table 2—Liver lipids and enzymes**

<table>
<thead>
<tr>
<th></th>
<th>Group I (Normal)</th>
<th>Group II (Chol.)</th>
<th>Group III (Coconut)</th>
<th>Group IV (Groundnut)</th>
<th>Group V (CN + Chol.)</th>
<th>Group VI (GN + Chol.)</th>
<th>Group VII (CN + Chol + Garlic)</th>
<th>Group VIII (GN + Chol + Garlic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total lipids (mg/100g)</td>
<td>7.24±0.43</td>
<td>8.22±0.27</td>
<td>8.64±0.24</td>
<td>9.16±0.53</td>
<td>9.55±0.21</td>
<td>10.37±0.46</td>
<td>5.27±0.46</td>
<td>7.24±0.29</td>
</tr>
<tr>
<td>Total chol. (g/100g)</td>
<td>0.51±0.19</td>
<td>2.89±0.37</td>
<td>3.17±0.73</td>
<td>5.79±0.33</td>
<td>6.17±0.24</td>
<td>7.17±0.25</td>
<td>4.49±0.19</td>
<td>3.67±0.17</td>
</tr>
<tr>
<td>TAG (g/100g)</td>
<td>0.5±0.015</td>
<td>1.04±0.057</td>
<td>1.25±0.33</td>
<td>1.14±0.30</td>
<td>1.65±0.34</td>
<td>17.43±0.46</td>
<td>7.46±0.25</td>
<td>6.34±0.27</td>
</tr>
<tr>
<td>TBARS (μMolMDA/g)</td>
<td>6.5±0.42</td>
<td>11.4±0.55</td>
<td>12.17±0.44</td>
<td>11.24±0.36</td>
<td>12.53±0.37</td>
<td>12.86±0.54</td>
<td>8.83±0.52</td>
<td>7.5±0.21</td>
</tr>
<tr>
<td>HMGCoA reductase*</td>
<td>0.33±0.013</td>
<td>0.22±0.016</td>
<td>0.56±0.005</td>
<td>0.35±0.005</td>
<td>0.62±0.006</td>
<td>0.71±0.008</td>
<td>0.28±0.003</td>
<td>0.32±0.008</td>
</tr>
<tr>
<td>AST (IU/g)</td>
<td>0.42±0.02</td>
<td>0.47±0.006</td>
<td>0.41±0.010 (N.S)</td>
<td>0.56±0.007</td>
<td>0.47±0.005</td>
<td>0.69±0.006</td>
<td>0.46±0.004</td>
<td>0.47±0.007</td>
</tr>
<tr>
<td>ALT (IU/g)</td>
<td>0.40±0.006</td>
<td>0.74±0.026</td>
<td>0.38±0.03</td>
<td>0.64±0.034</td>
<td>0.51±0.004</td>
<td>0.84±0.006</td>
<td>0.49±0.003</td>
<td>0.76±0.006</td>
</tr>
</tbody>
</table>

Student's t-test. Comparisons between the groups are made and level of significance is noted for the corresponding groups as in Table 1. *P<0.05 **P<0.01 N.S.(Non significant)
*HMGCoA reductase=Mevalonate/HMGCoA ratio.
groups were also significantly higher than that of the oil seed diet groups. The order of increase of serum cholesterol is the same as for total lipids. On incorporation of garlic in the combined diets, cholesterol levels reduced significantly. Further, feeding of cholesterol and oil seeds separately or in combination, significantly raised the serum HDL cholesterol and the same for the combined diet groups were also significantly higher than that of the oil seed groups. The order of increase of serum HDL is the same as for total cholesterol for the above groups. On incorporation of garlic in the combined diets, serum HDL cholesterol decreased very significantly and that too only in parallel with serum total cholesterol, but only the former remained far above normal.

*Serum enzymes*—The effects of various dietary preparations shown above on the stimulation of different enzyme activities, viz. ALP, AST and ALT increased in the following order, groundnut + cholesterol > coconut + cholesterol > groundnut > coconut

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**Table 3—Heart tissue and aorta lipids and enzymes from heart**

<table>
<thead>
<tr>
<th>Heart tissue Parameters</th>
<th>Group I (Normal)</th>
<th>Group II (Chol.)</th>
<th>Group III (Coconut)</th>
<th>Group IV (Groundnut)</th>
<th>Group V (CN + Chol.)</th>
<th>Group VI (GN + Chol)</th>
<th>Group VII (GN + Chol + Garlic)</th>
<th>Group VIII (CN + Chol + Garlic)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total lipids</strong> (mg/g)</td>
<td>7.2 ± 0.340</td>
<td>12.52 ± 1.46</td>
<td>17.01 ± 1.24</td>
<td>17.02 ± 1.36</td>
<td>18.04 ± 1.87</td>
<td>21.57 ± 1.82</td>
<td>7.92 ± 0.28</td>
<td>8.84 ± 0.38</td>
</tr>
<tr>
<td><strong>Triacyl glycerol</strong> (mg/g)</td>
<td>0.48 ± 0.080</td>
<td>0.66 ± 0.09</td>
<td>0.93 ± 0.10</td>
<td>0.835 ± 0.07</td>
<td>1.15 ± 0.07</td>
<td>0.90 ± 0.11</td>
<td>0.527 ± 0.06</td>
<td>0.42 ± 0.08</td>
</tr>
<tr>
<td><strong>Total Chol.</strong> (mg/g)</td>
<td>1.06 ± 0.195</td>
<td>1.65 ± 0.15</td>
<td>1.35 ± 0.08</td>
<td>1.35 ± 0.35</td>
<td>3.35 ± 0.15</td>
<td>3.25 ± 0.35</td>
<td>4.9 ± 0.65</td>
<td>2.31 ± 0.35</td>
</tr>
<tr>
<td><strong>HMGCoA reductase</strong></td>
<td>0.55 ± 0.072</td>
<td>0.419 ± 0.05</td>
<td>0.835 ± 0.07</td>
<td>0.757 ± 0.04</td>
<td>0.722 ± 0.03</td>
<td>0.786 ± 0.08</td>
<td>0.567 ± 0.01</td>
<td>0.68 ± 0.12</td>
</tr>
<tr>
<td><strong>AST</strong> (IU/g)</td>
<td>0.44 ± 0.030</td>
<td>0.447 ± 0.04</td>
<td>0.324 ± 0.04</td>
<td>0.332 ± 0.02</td>
<td>0.428 ± 0.02</td>
<td>0.432 ± 0.02</td>
<td>0.209 ± 0.01</td>
<td>0.357 ± 0.04</td>
</tr>
<tr>
<td><strong>ALT</strong> (IU/g)</td>
<td>0.29 ± 0.032</td>
<td>0.361 ± 0.05</td>
<td>0.184 ± 0.02</td>
<td>0.549 ± 0.04</td>
<td>0.220 ± 0.02</td>
<td>0.572 ± 0.01</td>
<td>0.316 ± 0.02</td>
<td>0.317 ± 0.03</td>
</tr>
<tr>
<td><strong>ALP</strong> (KU/g)</td>
<td>1.01 ± 0.065</td>
<td>1.36 ± 0.26</td>
<td>2.13 ± 0.37</td>
<td>2.14 ± 0.32</td>
<td>2.25 ± 0.11</td>
<td>2.14 ± 0.38</td>
<td>0.828 ± 0.05</td>
<td>0.825 ± 0.05</td>
</tr>
<tr>
<td><strong>(Aorta lipids)</strong></td>
<td>0.526 ± 0.072</td>
<td>0.419 ± 0.05</td>
<td>0.835 ± 0.07</td>
<td>0.757 ± 0.04</td>
<td>0.722 ± 0.03</td>
<td>0.786 ± 0.08</td>
<td>0.567 ± 0.01</td>
<td>0.68 ± 0.12</td>
</tr>
<tr>
<td><strong>Total lipids</strong> (mg/g)</td>
<td>1.7 ± 0.35</td>
<td>2.2 ± 0.38</td>
<td>2.8 ± 0.33</td>
<td>3.0 ± 0.40</td>
<td>3.6 ± 0.37</td>
<td>3.8 ± 0.30</td>
<td>1.5 ± 0.30</td>
<td>1.6 ± 0.20</td>
</tr>
<tr>
<td><strong>Triacyl glycerol</strong> (mg/g)</td>
<td>6.9 ± 0.30</td>
<td>10.1 ± 0.32</td>
<td>13.9 ± 0.50</td>
<td>15.2 ± 0.40</td>
<td>16.8 ± 0.4</td>
<td>18.6 ± 0.7</td>
<td>8.1 ± 0.5</td>
<td>10.1 ± 0.4</td>
</tr>
</tbody>
</table>

Student’s t-test: Comparisons between the groups are made and level of significance is noted for the corresponding groups as in Table 1.

*Ratio of Mevalonate/HMGCoA gives a direct measurement of the activity of HMGCoA reductase. *P < 0.05, *P < 0.01, *P < 0.001

**Table 4—Lipid profile, peroxidation and HMGCoA reductase activity in kidney**

<table>
<thead>
<tr>
<th>Lipid profile</th>
<th>Group I (Normal)</th>
<th>Group II (Chol.)</th>
<th>Group III (Coconut)</th>
<th>Group IV (Groundnut)</th>
<th>Group V (CN + Chol.)</th>
<th>Group VI (GN + Chol)</th>
<th>Group VII (GN + Chol + Garlic)</th>
<th>Group VIII (CN + Chol + Garlic)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total lipids</strong> (mg/g)</td>
<td>7.47 ± 0.98</td>
<td>11.54 ± 1.03</td>
<td>16.25 ± 1.99</td>
<td>21.42 ± 3.85</td>
<td>20.33 ± 1.26</td>
<td>22.83 ± 2.04</td>
<td>7.97 ± 1.15</td>
<td>9.36 ± 0.78</td>
</tr>
<tr>
<td><strong>Triacyl glycerol</strong> (mg/g)</td>
<td>4.19 ± 0.22</td>
<td>8.54 ± 0.98</td>
<td>12.51 ± 1.35</td>
<td>9.92 ± 1.13</td>
<td>14.35 ± 1.54</td>
<td>12.64 ± 0.91</td>
<td>6.7 ± 2.18</td>
<td>6.09 ± 1.81</td>
</tr>
<tr>
<td><strong>Total chol.</strong> (mg/g)</td>
<td>2.81 ± 0.26</td>
<td>3.16 ± 1.09</td>
<td>4.11 ± 0.57</td>
<td>8.09 ± 0.89</td>
<td>4.88 ± 0.13</td>
<td>8.93 ± 0.69</td>
<td>3.32 ± 0.46</td>
<td>3.91 ± 0.69</td>
</tr>
<tr>
<td><strong>TBARS</strong> (μmol MDA/g)</td>
<td>0.57 ± 0.6</td>
<td>1.81 ± 0.9</td>
<td>2.22 ± 0.8</td>
<td>26.06 ± 0.9</td>
<td>25.50 ± 0.8</td>
<td>25.17 ± 0.6</td>
<td>14.5 ± 1.0</td>
<td>18.2 ± 1.2</td>
</tr>
<tr>
<td><strong>HMGCoA reductase</strong></td>
<td>0.38 ± 0.021</td>
<td>0.314 ± 0.035</td>
<td>0.485 ± 0.026</td>
<td>0.516 ± 0.028</td>
<td>0.066 ± 0.11</td>
<td>0.091 ± 0.12</td>
<td>0.31 ± 0.10</td>
<td>0.33 ± 0.03</td>
</tr>
</tbody>
</table>

Student’s t-test. Comparisons between the groups are made and level of significance is noted for the corresponding groups as in Table 1.

*P < 0.05, *P < 0.01, *P < 0.001

*HMGCoA reductase=Mevalonate/ HMGCoA ratio.
Cholesterol. However between cholesterol and coconut groups there is not much difference in the activity of ALP. Cholesterol and oil seed combinations have significantly increased the activities of these enzymes as compared to the oil seed control groups. On incorporation of garlic in the diets the deleterious effects of cholesterol and oil seeds were significantly reduced.

Liver lipids and lipid peroxidation—The liver lipid profile and enzyme activities of various groups of rats are given in Table 2. In cholesterol and oil seed fed rats both separately and in combination the liver total lipids increased significantly. The increase is being in the same order as for total lipids. Each group has a significant rise over its control. On incorporation of garlic in the diets the raised lipid levels decreased very significantly to near or below normal levels.

Total cholesterol, TAG levels and the index of lipid peroxidation i.e. TBARS also increased in parallel with the rise of total lipids as stated above and also more or less in the same order and level of significance between groups from I to VII. The deleterious effects of cholesterol and oil seeds in the diets were significantly reduced by incorporation of garlic in these diets.

Liver enzymes HMGCoA reductase (EC.1.1.1.34), AST (EC.2.6.1.1) and ALT (EC.2.6.1.2)

With respect to enzyme activities, HMGCoA reductase decreased with cholesterol containing diet and it increased more with CN diet than that with GN diet. With combined diets of cholesterol and oil seeds, the activities of these enzymes increased further and that too significantly as compared to each control. Incorporation of garlic in these diets significantly reduced the deleterious effects of cholesterol and oil seeds. AST activity increased more significantly with groundnut containing diet than that with cholesterol. Coconut containing diet has no such effect. On incorporation of cholesterol and oil seeds in the diet the enzyme activity increased significantly further over each control value and such deleterious effects were significantly reduced on incorporation of garlic into these diets.

A similar pattern of activity is seen with ALT on feeding various preparations of the diets and the effects between the groups are also significant except that for group III viz; the coconut diet group. Incorporation of garlic in the diets containing cholesterol and oil seeds significantly reduced their deleterious effects.

Heart and aorta lipids and enzymes—The heart and aorta tissue lipid profile and enzyme activities of heart determined in this study are presented in Table 3.

Lipid levels—On administration of cholesterol and oil seeds both separately and in combination as parts of rat feed, total lipids, total cholesterol and triacylglycerol increased significantly in heart tissue and aorta. The order of increases of total lipids and total cholesterol is the same as given below for the different diet groups. i.e., cholesterol+groundnut > cholesterol+coconut > groundnut > coconut > cholesterol. Incorporation of garlic in the combined diets ameliorated the deleterious effects of oil seeds and cholesterol.

In the case of TAG in heart the order of increase for various diet groups is as follows.

Cholesterol + coconut > coconut > cholesterol + ground > groundnut > cholesterol. However between combined diet groups and their control there are no significant differences. On incorporation of garlic in the combined diets the deleterious effects of both cholesterol and oil seeds were prevented significantly. The TAG level was significantly reduced towards normal values. In general the deleterious effects of the diets on heart and aorta are almost in the same pattern.

TAG level in aorta increased in the same order as for total lipids shown earlier for various groups. On incorporation of garlic in the combined diets the deleterious effects of cholesterol and oil seeds were reduced significantly.

Enzyme activities in heart

HMGCoA reductase (EC.1.1.1.34)—On administration of cholesterol containing diet to rats the activity of HMGCoA reductase in heart decreased significantly. However in oil seed fed and combined diet fed groups, the activity of this enzyme increased significantly. On combination of cholesterol and oil seeds in the diets the enzyme activity decreased significantly only for coconut+cholesterol group and not for groundnut+cholesterol group. Further on incorporation of garlic in the above diets the activity of this enzyme decreased very significantly for coconut combined group and just significantly for the groundnut combined group. The order of the stimulatory effects of the diets on this enzyme is coconut > groundnut+cholesterol > groundnut > coconut + cholesterol.
AST (EC.2.6.1.1)—With respect to the activity of AST in heart tissue, cholesterol diet did not alter it, but both the oil seeds on incorporation in the diet decreased the activity of this enzyme very significantly. On addition of cholesterol and oil seeds in the diet the activity of this enzyme increased significantly towards normal level as compared to the oil seed control groups. On incorporation of garlic in the combined diets the activity of this enzyme decreased very significantly for the coconut group and just significantly for the groundnut group. In general the various combination of diets only decreased the activity of the enzyme or just maintained the normal level.

ALT (EC.2.6.1.2)—In contrast to the effects of cholesterol diet on AST, the same diet significantly increased the activity of ALT in the heart tissue of rats. While incorporation of coconut in the diet significantly decreased the activity of the enzyme, that with groundnut, only raised it significantly.

Incorporation of cholesterol with coconut in the diet decreased the enzyme activity significantly with respect to the cholesterol control. However the corresponding value obtained with cholesterol+groundnut diet was significantly higher over its control. Any how the enzyme activity in the combined diet groups was not significantly different from that in the oil seed control groups. If there was any deleterious effect of cholesterol or oil seeds it was corrected very significantly on incorporation of garlic in the combined diets. The order of adverse effects of the diets on enzyme is groundnut+cholesterol > groundnut > cholesterol > coconut+cholesterol > coconut.

ALP (EC.3.1.3.1)—On feeding cholesterol and oil seeds containing diets separately the activity of ALP in heart tissue increased significantly to various levels. Addition of cholesterol to the oil seeds in the diet also increased further the activity of the enzyme to a significant level. On incorporation of garlic in the combined diets the deleterious effects of both cholesterol and oil seeds on the enzyme activity were reduced significantly. The adverse effects of the diets are in the order, coconut+cholesterol > groundnut+cholesterol > coconut > groundnut > cholesterol.

Lipid profile, peroxidation and HMGCoA reductase in kidney

The lipid profile, lipid peroxidation level and HMGCoA reductase activity of kidney of the rats from various groups are presented in Table 4.

Lipids and lipid peroxidation—Total lipids increased significantly on feeding cholesterol and oil seeds containing diets separately and also in combination as compared to the corresponding control values. However on comparison between the groups only the coconut+cholesterol combination and not the groundnut+cholesterol combination that has a significant hyperlipidemic effect. On incorporation of garlic in the combined diets the deleterious effects of oil seeds and cholesterol were effectively reduced.

Similarly triacylglycerol and total cholesterol values and lipid peroxidation also increased significantly in parallel with the total lipids on feeding the rats with cholesterol and oil seeds containing diets separately or in combination.

However on comparison between the groups only the triacylglycerol values increased significantly in the combined diet groups as compared to the oil seed groups. On incorporation of garlic in the combined diets the deleterious effects of cholesterol and oil seeds were significantly reduced.

HMGCoA reductase (EC.1.1.1.34)—The activity of HMGCoA reductase decreased in the cholesterol diet fed rats very significantly, but on the incorporation of oil seeds separately or in combination with cholesterol, the activity of the enzyme increased significantly as compared to the cholesterol fed control. The increases in the activity of the enzyme in the combined diet groups were also significant as compared to the oil seeds control groups. On incorporation of garlic in the diets the deleterious effects of oil seeds and cholesterol combinations on the enzyme were significantly reduced and the activity of the enzyme remained below normal.

Discussion

On a perusal of the results, it is found that with respect to the increase of serum and tissue cholesterol, groundnut containing diet is more atherogenic than coconut containing diet when used with or without cholesterol. A higher atherogenic effect of groundnut may be due to the fact that the oil in it contains more long chain saturated fatty acids (19%) than that is present in the oil of coconuts (12%). In addition the latter oil is made up of both short chain (15%) and medium chain fatty acids (64%) together with some unsaturated fatty acids (8.6%) as compared to 57% monounsaturated and 24% polyunsaturated fatty acids present in the former. The short chain fatty acids in coconut have an advantage that they may be easily
absorbed and metabolized and that they are hypocholesterolemic in action\(^2^\). These factors may explain why coconuts traditionally used in Kerala and many parts of South East Asia are not very harmful if used minimally and that groundnut diets used at the level of coconuts as in this study is more harmful than the latter.

The TAG levels in serum and tissues are higher with coconut fed groups than with groundnuts. This may be because of the presence of a lower degree of unsaturation (8.6\%) with the FAs of former than that with the latter (81\%). This means that while coconut diet is less hypercholesterolemic, groundnut diet is less hyperlipidemic in nature. As expected HMGCoA reductase in liver, heart and kidney of rats fed cholesterol diet was decreased as a result of feed back inhibition by cholesterol. The activity of this enzyme in tissues was increased more with coconut containing diet than that with groundnut containing diets. However on cholesterol combination groundnut containing diets produced a greater activity of this enzyme than that with coconut containing diet. Therefore the action of coconut and groundnut are different in the absence and presence of cholesterol in the diet. This may be some how related to the metabolic impacts of cholesterol and fatty acid components of the oil seeds in it. The enzymes of serum in general are increased both with coconut and groundnut containing diets with or without cholesterol. All these derangements were corrected on the addition of garlic to each combined diet. This means that the active principles in garlic somehow helped the metabolism of cholesterol and fatty acid components of the oil so that all their bad impacts on the enzymes could be curtailed.

With regards to the level of enzymes other than HMGCoA reductase, viz; AST, ALT and ALP in tissues, all of them in general were increased on cholesterol diet. HMGCoA reductase on the other hand was inhibited. However all of the enzymes in general and lipid peroxidation in particular were increased on incorporation of oil seeds with or without cholesterol. The deleterious effects of these diets were ameliorated on addition of garlic to them. These and similar results mentioned above support the claim that garlic could function as a strong antiatherogenic agent in a diet\(^2^6\) that contains high fats and cholesterol and which eventually could derange the lipid metabolism and enzyme levels. The benefits of garlic may be attributed to its active principles, viz. sulfoxide derivatives of cysteine and their degradation products like alllicin and polysulphides including ajeno which act as antioxidant\(^5\), antidiabetic and hypocholesterolemic\(^4,8\), and inhibitors of HMGCoA reductase\(^27\), cholesterol synthesis\(^28\) and fatty acid synthetase\(^29\). These compounds and cysteine and methionine rich protein in garlic may have a great biological role as reported by our team\(^1,26\) and each of them warrants a thorough investigation for their individual and the combined action. Based on our results from the past and present and also because many people got very many benefits by the regular use of garlic\(^1,3,2\), we recommend a regular use of 5-10g garlic in our diet especially for those who are above the age of thirty.

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