Hyperlipidaemia is considered a risk factor involved in the development of cardiovascular disease (Frishman, 1998; Smith et al., 2004). The search for new drugs capable of reducing and regulating serum cholesterol and triglyceride levels has gained momentum over the years, resulting in numerous reports on significant activities of natural agents (Jahromi et al., 1993). People are now well aware of the need to lower cholesterol levels in order to lower the risk of heart attacks and strokes. Besides dietary improvement, the search is underway to identify natural foods having a cholesterol reducing effect such as fish oil or oat bran. *Spirulina* is one of these foods (Nayaka et al., 1988). *Spirulina* (family Oscillatoriaceae), a cyanobacteria, grows naturally in lakes and has been used for over a thousand years as a source of food because of its high protein content and good amino acid composition (Hayashi et al., 1994). These blue green microalgae used in daily diets in natives in Africa and America have found to be a good source of carotenoids, micronutrients, tocopherols, beta-carotetene, polyunsaturat-ed fatty acid in the form of linoleic acid and gamma-linole-ic acid (GLA) and dietary fibre (Miranda et al., 1998). It was shown that the IgA antibody level was significantly enhanced by *Spirulina* treatment (Hayashi et al., 1998). *Spirulina* is commercially produced in some tropical and subtropical climatic regions of the world (Venkataraman and Becker, 1985, Henrikson, 1989, Bonnin, 1982). Commercial production of *Spirulina* have also been producing in Bangladesh (Jahan et al., 1999). A number of clinical studies has been done by using *Spirulina* (Trisha, et al., 2001). Researchers in West Germany had previously demonstrated cholesterol reduction in mice using diet supplemented with...
Spirulina (Devi and Venkataraman, 1983). The Japanese research showed lower cholesterol reduction was related to weight loss. Spirulina was chosen because it previously lowered serum cholesterol in rats (Devi and Venkataraman, 1983, Kato and Takemoto, 1984, Begum et al. 1993). Some of the scientists have investigated the hypocholesterolaemic effects of Spirulina. Further studies are hereby necessary to reproduce the validity and consistency of hypolipidemic effects of Spirulina. On the basis of this information an attempt has been made to study the effect of Spirulina on lipid profile in Long Evan rats.

Materials and Methods

Long Evans rats were given various feeds supplemented with Spirulina platensis powder for 28 days as shown in Table I.

### Table I. Types of feed given to different groups of rats. (Each group contains six rats)

<table>
<thead>
<tr>
<th>No. of diets groups</th>
<th>No. of the treatments</th>
<th>Types of feed supplied</th>
<th>Spirulina platensis powder supplied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet-1</td>
<td>Group A (Control-01)</td>
<td>High fat and high sugar</td>
<td>nil</td>
</tr>
<tr>
<td></td>
<td>Group B (low dose)</td>
<td>High fat and high sugar</td>
<td>0.5% Spirulina of total diet</td>
</tr>
<tr>
<td></td>
<td>Group C (high dose)</td>
<td>High fat and high sugar</td>
<td>2.5% Spirulina of total diet</td>
</tr>
<tr>
<td>Diet-2</td>
<td>Group D (Control-02)</td>
<td>Laboratory Diet</td>
<td>nil</td>
</tr>
<tr>
<td></td>
<td>Group E</td>
<td>Laboratory Diet</td>
<td>150mg/kg body weight.</td>
</tr>
</tbody>
</table>

Plant material

Spirulina platensis was supplied from Bangladesh Council of Scientific and Industrial Research (BCSIR) Laboratories, Dhaka as a powder form. The collected Spirulina powder were dried up by sunlight and kept at a room temperature of about 25 °C for future use.

Animals

Thirty Long Evans rats of sex, aged 3-4 months, and weighed 135 to 200g were supplied by Institute of Food Science and Technology (IFST), Animal Research House, BCSIR, Dhaka, used in this study. They were kept in cages and maintained at 25°C room temperature under conditions of natural light and dark schedule.

Preparation of diet

Two types of diet were supplied to rats. First type included high fat and high sugar diet contained animal fat (10%), vegetable fat (10%), carboxy methyl cellulose (CMC) (10%), starch (20%), sugar (50%) and multi vitamin (1%) (ACI Limited) available in the market. Second type was laboratory diet containing wheat mash (23%), rice polish (23%), oil cake (8.6%), dried fish or fish meal (8.6%), wheat (29%), oil (2.9%), salt (1.45%), molasses (2.9%) and multi vitamin (0.5%) (ACI Limited) available in the market. In both the cases constituents were mixed thoroughly.

Experimental design

The experiment was carried out in 5 groups of rats supplemented with diets for 28 days. Each group contained six rats. The body weights (b.w) of the rats were measured before starting each experiment and also at weekly interval. Selected diet with or without Spirulina was given to each group of rats according to the group distribution of Table A.
lipoprotein-cholesterol) in serum were assayed by Spectrophotometer (Thermo Spectronic, England) and with the corresponding commercial kits (CHRONOLAB AG Switzerland).

**Statistical analyses**

The collected data were analyzed statistically and the mean, standard deviation and other calculations are evaluated considering 5% level of significance. For comparing means of different lipid profiles for diet-1, Analysis of Variance (ANOVA) and for comparing two groups means for diet-2, Student's t-test were used since sample size is small. All statistical analysis were done by a computer package programme called SPASS(Statistical Package for Social Science) of version 12, now frequently being used to analyze all sort of data and this version was developed by SPSS Inc.

**Results and Discussion**

Findings of the present investigation have been depicted in Fig.1 and Tables II-III.

**Effect of diets on body weight**

During the period of investigation it was found that feed intake in high fat and high sugar intake rats of group A, B and C decreased in from 10th, 14th and 18th days, respectively. Rats of group A became sick from 14th day and group B and C became sick from the day of 22nd. Amount of feed intake of these three groups rat had decreased from 15g to 11g/rat. Though the amount of feed intake reduced but body weight of the above groups' rats increased up to 7th day. In case of high fat and high sugar diet group A (control-01) rats weight was increased up to 14th and then decreased at 28th day. Rats of group B with Spirulina 0.5% also loose their weight

![Fig. 1. Effect of diet on body weight after taking feed from 0-28 days. Values are expressed as mean of six rats per group](image-url)
but not like that of control group A. It was interestingly observed that rats of group C (with *Spirulina* 2.5%) loose their weight at 14th day and increased at 22th day, then again reduced at 28th day (Fig. 1). It was also observed that along with the reducing weight in group A rats, body hairs also dropped out after 14th day. Body hair of group B and C rats did not drop out though their weight reduced to some extents. On the other hand, 2nd type laboratory diet apparently increased the body weight of the group D (Control -02) rats. Rats of group E (with *Spirulina* 150mg/kg b.w) reduced minimum level at 28th day (Fig. 1). Feed intake of these groups’ rat increased from 15g to 19g/rat. After increasing diet, the belonging groups did not become sick.

### Effects of diets on serum lipid profile

The effects of diets on serum lipids of rats of groups A, B and C have been summarized in Table I. The mean of TC in serum was reduced maximum in group B (55.60mg/dl) than in group C (58.85 mg/dl) compared to control group A (68.62mg/dl). TG of serum increased 68.18 mg/dl and 54.36 mg/dl in group B and group C rats respectively than control group A (43.84 mg/dl). LDL-C decreased 13.55mg/dl in group B and C uniformly in respect to control group A (36.97mg/dl). HDL-C of serum was increased accordingly in group C (34.43 mg/dl) and in group B (28.40 mg/dl) than control group A (22.87mg/dl). It was found that after administration of 0.5% and 2.5% *Spirulina* powder of total diet no statistical difference were found in rats of groups B, C than A in case of TC (p= 0.040), TG (p=0.038) and LDL (p=0.006), but was varied in HDL (p=0.149). From Table II it was evident that the mean of Group E having laboratory diet with *Spirulina* showed better result than Group D (control -02) diet with *Spirulina* powder were found to be significant in TG (p= 0.235), LDL (p= 0.303) and HDL (p= 0.323) and was insignificant in TC (p= 0.012) rats of E.

### Table II. Total Lipid profile in Long Evan rats after feeding high fat and high sugar with different doses *Spirulina platensis*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group A (Control-01) (n=6)</th>
<th>Group B (0.5% Spirulina of total diet) (n=6)</th>
<th>Group C (2.5% Spirulina of total diet) (n=6)</th>
<th>Significance Value (p value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC (mg/dl)</td>
<td>68.62 ±12.22</td>
<td>55.60 ±7.08 (18.97% ↓)</td>
<td>58.85 ±2.36(14.23% ↓)</td>
<td>0.040</td>
</tr>
<tr>
<td>TG (mg/dl)</td>
<td>43.84 ±7.10</td>
<td>68.18 ±22.45(55.52%↑)</td>
<td>54.36 ±9.85 (23.99 %↑)</td>
<td>0.038</td>
</tr>
<tr>
<td>LDL-C (mg/dl)</td>
<td>36.97 ±17.64</td>
<td>13.55 ±8.83 (63.34% ↓)</td>
<td>13.55 ±7.54 (63.34% ↓)</td>
<td>0.006</td>
</tr>
<tr>
<td>HDL-C (mg/dl)</td>
<td>22.87 ±12.03</td>
<td>28.40 ±7.94 (24.18% ↑)</td>
<td>34.43 ±8.3 (50.54% ↑)</td>
<td>0.149</td>
</tr>
</tbody>
</table>

### Table III. Total lipid profile in Long Evan rats after feeding Laboratory diet an Laboratory diet with *Spirulina platensis*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group D (control-02) (n=6)</th>
<th>Group E (Spirulina150mg/kg/body weight) (n=6)</th>
<th>Significance Value (p value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC (mg/dl)</td>
<td>96.21 ±26.32</td>
<td>77.72 ± 6.44 (19.21% ↓)</td>
<td>0.012</td>
</tr>
<tr>
<td>TG (mg/dl)</td>
<td>40.96 ± 5.51</td>
<td>42.57 ± 6.64 (3.93%↑ )</td>
<td>0.235</td>
</tr>
<tr>
<td>LDL-C (mg/dl)</td>
<td>57.49 ±30.80</td>
<td>31.01 ± 18.89 (46.06%↓)</td>
<td>0.303</td>
</tr>
<tr>
<td>HDL-C (mg/dl)</td>
<td>30.54 ±12.00</td>
<td>38.17 ± 18.22 (24.98%↑)</td>
<td>0.323</td>
</tr>
</tbody>
</table>
(43.84 mg/dl) showed lower serum cholesterol, triglyceride and LDL (undesirable fat) after eating Spirulina for 8 weeks. The group consumed 4.2g (about 8 tablets) daily for a period of four weeks (from 244 to 233).

The other group stopped consumption of Spirulina after four weeks, and recorded a return of serum cholesterol to original level after initial decrease with the use. It was found that triglyceride (TG) decreased slightly and LDL cholesterol level reduced by a significant level of 6.1% within four weeks. (Nayaka, et al, 1988). In the present study, the hyperlipidaemic activity of Spirulina was evaluated among the hypercholesterolaemic rats. Above findings are corresponding to the present study. Rats fed with 0.5% Spirulina were more effective in decreasing TC level and 2.5% positively effective in increasing HDL-C level. But effect of 0.5% and 2.5% Spirulina were same in dropping LDL-C level (Table - 01). In case of group D (control-02) with laboratory diet and group E having laboratory diet with Spirulina have also shown promising results on reducing cholesterol of serum (Table-02). TC, LDL-C and HDL-C decreased 19.21%, 46.06% and 24.98% respectively in Spirulina enriched laboratory feed than group D (control- 02). It was notified that TG of serum increased in group B (18.97%), group C (14.23%) and in group E (3.93%) than both control groups. It may be the presence of high fat and high sugar in diets that was responsible for the increase of TG in these groups. Further study on this aspect is solicited.

Conclusion

The present study indicated that the high concentration LDL-C in hypercholesterolaemic rats was significantly reduced by the administration of Spirulina. Therefore, Spirulina might constitute a good candidate for the treatment of atherosclerosis by lowering serum LDL-C level. In conclusion, the present study clearly specify the anti-hypercholesterolaemic and anti-hyperlipidaemic effects of Spirulina in animal models with undetected side effects. Spirulina have significant role on reducing the LDL/HDL ratio mainly through decreasing the serum level of LDL. This may lead to isolation and structure elucidation of some of the bioactive constituents followed by establishing the most probable mechanism of action for each of the characterized compounds.

References


*Received : March 19, 2009; Accepted : January 06, 2010*