SHORT COMMUNICATION

EFFECTS ON SERUM LIPIDS OF DIFFERENT DIETARY FATS ASSOCIATED WITH A HIGH SUCROSE DIET

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SUMMARY

1. Each of nine volunteers was fed three different diets. The percentage of total daily energy provided by fat, carbohydrate and protein remained constant, but the nature of the fat and carbohydrate was altered. The first diet contained ordinary amounts of sucrose and predominantly saturated fat. During the second dietary period, fat remained saturated, but the quantity of sucrose was increased at the expense of complex carbohydrate. In the third dietary period, the sucrose intake remained high, but fat was supplied chiefly in the polyunsaturated form.

2. A small but statistically significant increase of serum fasting cholesterol and triglyceride was observed during the second dietary period, but on the third diet levels of both lipids fell to concentrations not significantly different from those seen on the first diet.

Key words: sucrose, fat, serum lipids.

The effects on serum lipids of altering the nature of dietary carbohydrate has been extensively studied and reviewed (e.g. McGandy, Hegsted & Stare, 1967; Mann & Truswell, 1972). There is less information on the precise role which the nature of the dietary fat may have in the differences observed on diets of varying carbohydrate composition. Utilizing formula diets and short dietary periods, it has been shown that the serum triglyceride increase observed in response to dietary sucrose is influenced by the nature of the fat component of the formula (Macdonald, 1967). More recently and again using formula diets, Macdonald has shown that after 5 days, sunflower seed oil resulted in a fall in serum lipids regardless of the nature of the carbohydrate mixture of the formula (Macdonald, 1972).

The present series of dietary studies utilizing ordinary food substances has been carried out to study the effects on serum lipids of altering the saturated:polyunsaturated fat ratio during periods of high sucrose intake.

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SUBJECTS AND METHODS

Nine male volunteers aged 28–39 years participated in this study carried out in a metabolism ward. Seven suffered from chronic neurological disorders (one had cerebellar degeneration of unknown aetiology, four had neurological consequences of motor vehicle accidents, and two had hemiplegias following cerebrovascular accidents), but apart from their neurological signs, they had no other clinical or biochemical abnormalities. Two were ‘normal’ volunteers.

After admission to the metabolism ward, each volunteer was fed a basal diet for at least 2 weeks to establish his energy requirement and stabilize his weight. Three dietary periods followed, each of 2 weeks duration. Total energy and the percentage of it provided by fat, carbohydrate and protein remained constant for each subject, but the nature of the carbohydrate and fat was altered. Diet I was a continuation of the basal diet and was intended to represent a typical ‘Western’ diet with a sucrose intake of approximately 80 g per day and approximately half of the total daily fat intake of 77 g in the saturated form (butter, milk). Carbohydrate provided 54%, protein 16%, and fat 30% of total daily energy. In Diet II, the fat content remained unchanged, but the quantity of sucrose was doubled to approximately 34%, chiefly at the expense of complex carbohydrate. In the final diet period (III), carbohydrate was the same as during Diet II but polyunsaturated fat (sunflower seed oil, Flora margarine) comprised approximately 75% of the total fat. Each diet consisted of ordinary food substances and the diets were always given in the same sequence.

Volunteers were weighed daily and fasting blood samples were taken on days 0, 3, 6, 9, 12, 13 and 14 of each dietary period. Serum cholesterol (Abell, Levy, Brodie & Kendall, 1952) and triglyceride (Young & Eastman, 1963) estimations were carried out on each sample.

The Wilcoxon matched-pairs signed-ranks test was used to test for the statistical significance of observed differences.

RESULTS

Fasting serum lipid levels and body weight on each of the three diets are given in Table 1. Serum cholesterol and triglyceride levels increased significantly during the second dietary period ($P<0.05$). On Diet III, both lipid levels were significantly lower than during Diet II ($P<0.01$). Mean levels on Diet III are in fact lower than those observed on Diet I, but the differences do not attain statistical significance.

Body weights remained unchanged during the period of the study.

DISCUSSION

The results of recently published studies suggest that sucrose, fed in quantities usually eaten (around 20% of dietary energy), does not result in elevation of fasting serum lipid levels when compared with other dietary carbohydrates (Dunnigan, Fife, McKiddie & Crosbie, 1970; Mann & Truswell, 1972). A hyperlipidaemic effect of sucrose has only been demonstrated in male volunteers when this carbohydrate has been fed at levels which are usually regarded as unphysiological (Macdonald & Braithwaite, 1964; Macdonald, 1965; Antar & Ohlson, 1965; Hodges, Krehl, Stone & Lopes, 1967; Szanto & Yudkin, 1969; Akinyanju, Qureshi, Salter & Yudkin, 1968; Nestel, Carrol & Havenstein, 1970). It has, however, been suggested that at
TABLE 1. Fasting serum cholesterol and triglyceride levels and body weight in each of the three
diets. The values given for each subject are the means of the last three days on each diet (days
12, 13 and 14)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Cholesterol (mg/100 ml)</th>
<th>Triglyceride (mg/100 ml)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I  II  III</td>
<td>I  II  III</td>
<td>I  II  III</td>
</tr>
<tr>
<td>1</td>
<td>148 163 136</td>
<td>115 116 107</td>
<td>51.8 51.0 51.5</td>
</tr>
<tr>
<td>2</td>
<td>281 287 230</td>
<td>126 153 127</td>
<td>40.8 40.7 40.3</td>
</tr>
<tr>
<td>3</td>
<td>276 311 302</td>
<td>139 187 147</td>
<td>51.3 51.5 51.3</td>
</tr>
<tr>
<td>4</td>
<td>299 325 303</td>
<td>105 130 103</td>
<td>55.7 56.0 56.5</td>
</tr>
<tr>
<td>5</td>
<td>243 262 227</td>
<td>120 142 126</td>
<td>55.3 55.3 56.0</td>
</tr>
<tr>
<td>6</td>
<td>235 245 216</td>
<td>115 110 90</td>
<td>69.5 68.7 68.5</td>
</tr>
<tr>
<td>7</td>
<td>317 300 308</td>
<td>264 282 207</td>
<td>77.0 77.0 77.5</td>
</tr>
<tr>
<td>8</td>
<td>234 232 229</td>
<td>182 181 150</td>
<td>69.0 70.5 70.0</td>
</tr>
<tr>
<td>9</td>
<td>255 279 230</td>
<td>160 163 137</td>
<td>49.7 49.5 49.3</td>
</tr>
<tr>
<td>Mean</td>
<td>254.2 267.1 242.3</td>
<td>147.3 162.7 132.7</td>
<td>57.8 57.8 57.8</td>
</tr>
</tbody>
</table>

least some free living individuals in the United Kingdom have a daily dietary sucrose intake of
400 g (Szanto & Yudkin, 1969; Yudkin, 1972).

The findings of the present investigation are relevant to people eating larger than usual
amounts of sucrose, since the diets given in this study comprised ordinary food substances
and meals were prepared in the conventional way. The hyperlipidaemia induced during a high
sucrose predominantly saturated fat diet was reversed when polyunsaturated fat was increased
to 75% of the total fat intake.

Possible mechanisms for the hypertriglyceridaemic effect of sucrose have been considered.
Endogenous synthesis of triglyceride by the liver may be more rapid when sucrose is the
principal carbohydrate source, since fructose is more rapidly converted into the precursors of
triglyceride than of glucose (Heinz, Lamprecht & Kirsch, 1968). Delayed clearing of tri-
glyceride from the serum may also be a possible mechanism. The insulin response to meals
containing sucrose rather than polymers of glucose tends to be low (Mann, Truswell & Pim-
stone, 1971; Mann & Truswell, 1972). Insulin-stimulated lipoprotein lipase is responsible for
the removal from the serum of exogenous and endogenous triglyceride (Nikkilä, 1969) and a
decreased lipoprotein lipase activity could result in impaired triglyceride clearing on diets with
a high sucrose content.

We were able to find no evidence in the literature which satisfactorily explains the mechan-
ism of the synergistic hyperlipidaemic effect between dietary sucrose and saturated fat in man.
In the rat, lipoprotein lipase activity in adipose tissue is lower when saturated rather than
polyunsaturated fat is fed (Pawar & Tidwell, 1968). It will be of interest to study plasma tri-
glyceride turnover under the above described dietary conditions to seek an explanation of the
phenomenon.

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REFERENCES


