Influence of Carbohydrate and Fat Diet upon the Carbohydrate Metabolism in Rabbits Poisoned with Alloxan

By

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INTRODUCTION

To replace a large amount of carbohydrate by fat and protein in the diet in the treatment of diabetes, will confront with serious problems in the countries as Japan, where carbohydrate food is predominant, not only for patients themselves but for the nation on the whole, particularly at the time-being. Both food and economic conditions are still grave.

From the view-point the diabetic food, proposed by Yamakawa et al.1-4) years ago, which is high in carbohydrate and low in fat, must now more widely circulated than before, we believe. In this country physicians in general are however mostly still unacquinted with the method of Yamakawa, notwithstanding that irrefutable testimonies have been offered by them at that time clinically and experimentally as well.

With this request of the present time in mind, I have compared the influence upon the alimentary glycemia of two kinds of food, one qualified with a richness in carbohydrate and a poorness in fat and another vice versa, in rabbits poisoned with alloxan. The drug acts thereupon to bring about a hyperglycemia lasting for several days.

EXPERIMENTAL

Method

Exclusively matured male rabbits were experimented on.

Alloxan was intravenously given in a dose of 200 mg. per kg. body weight as a 5% watery solution. It may be superfluous to say here that the drug effects at first a conspicuous increase in the blood sugar, with disturbances in the liver and kidneys, anemia and injuries in all the body
tissues except the islets of Langerhans. The animal looks seriously. The acute symptoms will then be followed by a long lasting hyperglycemia.

The feeding test was started at the time when the general appearance was well recovered, the good appetite and the height of hyperglycemia showed large fluctuations no more, a matter of two months later.

The routine diet consists for rabbits of 1.8 to 2.5 kg. of 300 g. tofukara (bean-curd husk) and 100 g. carrot, with about 240 Cal. and for those of 2.5 to 3 kg. of 350 g., 100 g. and 270 Cal. respectively. The body weight remains then almost unchanged.

The test diet is composed from tofukara, carrot, potato and cow's fat. The fuel value being taken as quite the same as the routine diet, the ratio of the food-stuffs was so adjusted as to involve much carbohydrate and less fat and vice versa, in the manner shown in the accompanying table. The animal was on the test diet for a certain number of days, say 5–7.

**Table I**

Composition of Various Diets Tested

(For rabbits of 1.8–2.5 kg. The numerals in parentheses: for rabbits of 2.5–3.0 kg.)

1. **Normal Diet** (per diem)

<table>
<thead>
<tr>
<th></th>
<th>Tofukara 300 (350) g.</th>
<th>Carrot 100 g.</th>
<th>Total g.</th>
<th>Cal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate</td>
<td>24 (28)</td>
<td>7.5</td>
<td>31.5 (35.5)</td>
<td>126 (142)</td>
</tr>
<tr>
<td>Fat</td>
<td>4.8 (5.6)</td>
<td>0.5</td>
<td>5.3 (6.1)</td>
<td>46 (53)</td>
</tr>
<tr>
<td>Protein</td>
<td>15.6 (18.2)</td>
<td>1.5</td>
<td>17.1 (19.7)</td>
<td>69 (80)</td>
</tr>
</tbody>
</table>

Total: 241 (275)

2. **High carbohydrate, low fat diet** (per diem)

<table>
<thead>
<tr>
<th></th>
<th>Tofukara 200 (250) g.</th>
<th>Carrot 100 g.</th>
<th>Potato 80 g.</th>
<th>Total g.</th>
<th>Cal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate</td>
<td>16 (20)</td>
<td>7.5</td>
<td>15.4</td>
<td>38.9 (42.9)</td>
<td>156 (172)</td>
</tr>
<tr>
<td>Fat</td>
<td>3.2 (4)</td>
<td>0.5</td>
<td>0.1</td>
<td>3.8 (4.6)</td>
<td>34 (41)</td>
</tr>
<tr>
<td>Protein</td>
<td>10.4 (13)</td>
<td>1.5</td>
<td>0.8</td>
<td>12.7 (15.3)</td>
<td>51 (61)</td>
</tr>
</tbody>
</table>

Total: 241 (274)

3. **Low carbohydrate, high fat diet** (per diem)

<table>
<thead>
<tr>
<th></th>
<th>Tofukara 150 (200) g.</th>
<th>Carrot 100 g.</th>
<th>Cow's fat 11 g.</th>
<th>Total g.</th>
<th>Cal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate</td>
<td>12 (16)</td>
<td>7.5</td>
<td></td>
<td>19.5 (23.5)</td>
<td>78 (94)</td>
</tr>
<tr>
<td>Fat</td>
<td>2.4 (3.2)</td>
<td>0.5</td>
<td>11</td>
<td>13.9 (14.7)</td>
<td>125 (132)</td>
</tr>
<tr>
<td>Protein</td>
<td>7.8 (10.4)</td>
<td>1.5</td>
<td></td>
<td>9.3 (11.9)</td>
<td>37 (48)</td>
</tr>
</tbody>
</table>

Total: 240 (274)
Influence of Carbohydrate and Fat Diet upon the Carbohydrate Metabolism

As the carbohydrate assimilation test, 20% glucose solution was intravenously injected in about one minute in doses such as 0.5 g., 1.0 g. & 1.5 g. per kg. body weight. Before and for three hours after the injection the blood sugar concentration was followed in certain intervals of time. Blood samples from the ear lobe vein was estimated by means of Fujita and Iwatake.5)

Results

The whole data are epitomized in Table II.

### Table II
Average of Blood Sugar Content of Rabbits on Glucose i. v. Administration

<table>
<thead>
<tr>
<th>Doses of Glucose (g. per kg. B.W.)</th>
<th>Diet</th>
<th>Blood sugar (mg. per dl.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Before</td>
</tr>
<tr>
<td>0.5 g. (8 cases)</td>
<td>Carbohydrate diet</td>
<td>268</td>
</tr>
<tr>
<td></td>
<td>Fat diet</td>
<td>264</td>
</tr>
<tr>
<td>1.0 g. (2 cases)</td>
<td>Carbohydrate diet</td>
<td>172</td>
</tr>
<tr>
<td></td>
<td>Fat diet</td>
<td>170</td>
</tr>
<tr>
<td>1.5 g. (5 cases)</td>
<td>Carbohydrate diet</td>
<td>183</td>
</tr>
<tr>
<td></td>
<td>Fat diet</td>
<td>160</td>
</tr>
</tbody>
</table>

The blood sugar content in the alloxan rabbits, determined early in the morning was almost the same, generally speaking, in both groups rabbits, one fed on the high carbohydrate diet, and another on the high fat one. There was detectable however some tendency, though not so significantly, that the individuals fed on the carbohydrate diet have a higher glycemia value than the other, as indicated in the third series of experiments.

Turning now to the intensity of alimentary hyperglycemia, it may be pointed out that there exists a definite discrepancy between both the groups of rabbits, though also not so significant. Namely, the excess due to the intravenous administration of glucose was invariably smaller in the group of carbohydrate diet, through all the doses, while the initial blood sugar level in that group animals was similar to or a little higher than the fat diet group, and never smaller. The table shows it clearly.

Comment

The treatment of diabetics is largely dietetic. It lasts through life. Treatment must therefore be adjusted to the conditions of patients and
environment, and should be so arranged that it can be continued for years without harm, difficulties and inconveniences, physically and economically as well.

The amount of fat in the routine diet of people varies, partly from habit and partly from economic reasons.

And, usually, in those cases where the carbohydrate in the diet is high, the fat is low, and *vice versa*.

A low carbohydrate diet, high in fat, can protect the islands of Langerhans from exhaustion, but, on the other hand, excessive fat can bring about some disturbances in liver tissue, so that the carbohydrate assimilation will be interfered with in the long run, and further the highest fat diet can result in to occasion acidosis in severe diabetics.

On the contrary a moderate carbohydrate diet acts to stimulate the islands mildly, so that they will be protected from the atrophy.

In fact in the countries, overseas, where people are living luxuriously and have plenty amounts of every sorts food-stuffs, the specialists, such as Porges & Adlersberg, Brentano, Stolte, Ercklentz, Ellis, etc., have been urging therefore by and by to take a high carbohydrate diet, low in fat. Reference rē the matter under discussion are given, fully in three papers of Yamauti.

**SUMMARY**

Rabbits, poisoned with alloxan, were fed on either a high carbohydrate diet, low in fat or a high fat diet, low in carbohydrate.

Intravenous administration of glucose in certain quantity produced a hyperglycemia there, of a similar strength and duration, irrespective of different kinds of food, or rather the high carbohydrate diet acted to moderate the alimentary hyperglycemia, though only insignificantly.

**References**

1) Yamakawa and Yamauti, Shindan to Chiryo, 1936, 23, 619.
2) Yamakawa, Rinsho no Nippon, 1937, 5, 1015.
3) Yamakawa, Shinryo to Keiken, 1938, 2, 389.
4) Kurokawa, Nippon Iji Shinpo, 1941, No. 1002 Suppl., 53.
5) Fujita and Iwatake, Biochem. Zschr., 1931, 242, 43.
10) Ellis, Quart. J. Med., 1934, 27, 137.