Glycemic and Insulinemic Responses to Isis Cookies and Danish Traditional Cookies in Healthy Subjects

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Abstract
Glycemic indices (GIs) and insulin responses are useful for measuring biological effects and consequences of available carbohydrates when designing healthy diets, particularly for people with or at risk of developing diabetes and others disorders such as metabolic syndrome. In this study, we investigated GIs and insulin (indirectly measured by C-peptide) responses of healthy participants to ISIS cookies (produced in Chekia, with no added sugar by ISIS Food Products, Denmark) and Danish traditional cookies (Cookie and Co). Using a cross-over design, 13 subjects (male 7, female 6) consumed equivalent carbohydrate amounts (50 g of available carbohydrate) of the test foods and glucose (as reference food). Serum glucose levels were determined at 0, 30, 45, 60, 90 and 120 minutes (min) and C-peptide levels were determined at 0, 30, 60, 90 and 120 min after the test meals. Serum glucose was measured by glucose-oxidase method and serum C-peptide (a marker for insulin) by chemiluminescent ELISA method. Glycemic Indices and Glycemic Loads (GLs) were calculated by using standard formulas. Both the cookies showed significantly lower serum glucose response compared to that of glucose. Danish traditional cookies had significantly lower GI (p<0.001) than that of ISIS cookies [ISIS cookies 70.0 ± 25.4 vs Danish traditional cookies 37.6 ± 15.9]. The GL of ISIS cookies and Danish traditional cookies are 8 and 6 respectively. Danish traditional cookies showed significantly lower C-peptide responses compared to ISIS cookies and also to reference food at 120 min (p<0.01) but higher than ISIS cookies at 30 minutes. As judged against the mean values of the international table, ISIS cookies is a high GI and Danish traditional cookies is a low GI food. However, from the dietary practices in Bangladeshi society, ISIS cookies and Danish traditional cookies may be used as a low GI food.

Keywords
Glycemic index; Glycemic load; Cookies; Diet; Mixed meal

Introduction
Current epidemiological and clinical research [1,2] and subsequent dietary recommendations [3] highlight the importance of improving the overall quality of carbohydrate in diet. Blood glucose response to the ingestion of carbohydrate-containing foods has been shown to vary dramatically, depending on factors, including the molecular structure of the carbohydrate, fiber content, and degree of processing. The blood glucose response to a carbohydrate-containing food is indicated by its glycemic index (GI) which is a ranking of foods on a scale from 0 to 100 according to the extent to which they raise blood sugar levels after eating [4].

GI reflects the effect of available carbohydrates in individual foods on the postprandial glycemic response whereas glycemic load (GL) includes both GI and carbohydrate content of a portion; thus, when calculated on total daily food consumption, it approximates the total glycemic effect of diet which gives an overall idea of carbohydrate-based choices of the total diet [5]. Dietary GI and GL can affect carbohydrate metabolism in vivo: high GI and GL have been associated with hyperinsulinemia, impaired glucose tolerance, and higher circulating insulin-like growth factor (IGF) concentrations [6]. Low-GI food has been shown to have reduced postprandial blood glucose and insulin responses and improved the overall blood glucose and lipid concentrations in normal subjects and patients with diabetes mellitus [7].

GI has been recommended to help guide food choices because it has been reported that a high GI diet may have adverse health consequences by increasing the risk for chronic diseases [8]. Recent evidence suggests that high GI/GL diets may increase the risk for cardiovascular diseases [9,10], type 2 diabetes [11,12] and the metabolic syndrome [13]. A high GI diet may increase the risk for chronic diseases through the stimulation of hyperglycemia and hyperinsulinemia. In contrast, a low GI diet has been reported to have health benefits [8].

Since insulin resistance is known to be atherogenic, low GI foods (due to fats with high in saturated) seems to be good but at the expense of hyperinsulinemia may not be useful as it cause other health related underlying problems [8]. Thus, a ranking of food based on their insulin- secretory capacity, along with the glycemic response, is necessary. Endogenous insulin secretion is assessed best by measurement of C-peptide, which is cosecreted with insulin in a one-to-one molar ratio but unlike insulin experiences little first pass clearance by the liver. Measurement of C-peptide under standardized conditions provides a sensitive, well accepted, and clinically validated assessment of β-cell function [14].

In view of the fact that biological response to nutritional components vary from population to population, it is essential that the food items must be tested in each population for their effects on relevant parameters in health. In the above context, it is important to remark, that GI and GL are by nature a relative test that is not influenced very much by which population it is tested. The objectives of the study are to determine the glycemic response expressed as GI and GL of two types of cookies (ISIS and Danish traditional cookies) of a popular and well-known Danish company.

Materials and Methods
Subjects
Fifteen healthy volunteers took part in the study. Two of the
participants could not complete the whole study. The male-female ratio was 1:1. The participants were requested to maintain their usual daily food intake and activity throughout the study period. The purpose and protocol of the study were explained to them, and written consent was obtained from each participant.

Foods

The study included two test meals: ISIS (produced in Chekia - with no added sugar) and Danish traditional cookies (produced by Cookie & Co), with glucose serving as the reference food. Both the test foods and the reference food consisted of 50 g of available carbohydrates. The portion sizes of food necessary to reach 50 g of available carbohydrate were 104 and 80 g for ISIS and Danish traditional cookies respectively. The nutrient composition of the test foods is shown in Table 2. The values have been taken from the labels and verified by standard nutritional analyses. The relation between soluble and insoluble fibre was calculated from compositional data of the raw materials used.

Study design

Participants were requested to go through the study protocol on four separate occasions (one trial for test food and two repeated trials for the reference food) in the morning after a 10-12-hour overnight fasting. The test and reference meals were given to the participants under a cross-over design with a wash-out period of seven days to avoid the 'second meal effect' [15]. The participants were advised to rely on recommended standard carbohydrate diet and also instructed not to eat legumes in the meal preceding the test. An intravenous cannula was inserted into a superficial vein in the forearm on the day of experiment, drawing the fasting (0 hour) blood sample of the participant, and then the subjects were requested to consume the test foods with 250-mL plain water (for the protocol of the test food) or the glucose in 250-mL water (for the protocol of the reference food) in random order at a comfortable place within 10 min. Further blood samples were taken at 30, 60, 90 and 120 min after the initial intake of sample. Blood sample was allowed to stage centrifugal at 3,000 rpm (1,350 g) for 15 min. Separated serum was allocated in the labeled eppendorf tubes and preserved at -70°C until biochemical analysis.

Laboratory method

Serum glucose was estimated by glucose-oxidase (GOD-PAD) method using reagents from SERA PAK, USA [16], and C-peptide was determined by ELISA method using kits from DRG Diagnostics (Germany).

Ethical consideration

The Ethical Review Committee of the Diabetic Association of Bangladesh approved the protocol.

Statistical analysis

All analyses were done using the SPSS software for Windows (version 11.5). The incremental areas under the curve (iAUC) were calculated by the standardized criteria [15], ignoring any area below the baseline. The average iAUC for the two glucose tests was used as the reference value, and each subject’s individual GI for each food was calculated. GI of each food was calculated by multiplying the amount of available carbohydrate in a typical serving of the food and the GI of that food divided by 100. The serving size used follows the recommendations from the organization Food Drink Europa regarding serving size for biscuits and cakes. As the ISIS cookies are packed in a 2 cookie unit of 24 g, this is the serving size used for both cookies in the calculation. Significant differences between the mean values of GI were calculated using paired t-test. All parametric variables were expressed as mean ± SD, and non-proportional data were expressed in percentages. p<0.05 and p<0.001 were considered statistically significant.

Results

Characteristics of subjects

The participants (n=13) were healthy subjects (7 males and 6 females); age 25 ± 6 years, (mean ± SD). Their mean body mass index (BMI) was 21 ± 3 (mean ± SD) while their mean waist-hip ratio was 0.85 ± 0.6 (Table 1).

Glycemic response to food items

Both the cookies showed a significantly lower serum glucose response compared to that of glucose (Figure 1). [Increment area under the curve (mean ± SD) of test foods were: 176.8 ± 83.0 in glucose vs. 109.0 ± 9.5 in ISIS cookies and 58.0 ± 23.1 in Danish traditional cookies; p<0.05 and 0.001 respectively] (Table 3). The GI (mean ± SD) of Danish traditional cookies was 37.6 ± 15.9, which was significantly lower (p<0.001) than that of ISIS cookies (70.0 ± 25.4). Glycemic load of ISIS cookies and Danish traditional cookies were 8 and 6 respectively (based on portion size).

C-peptide response of the food items

The basal values of serum C-peptide among the three meals did not differ with each other but at the postprandial stage Danish traditional cookies showed significantly lower C-peptide responses compared to ISIS cookies and also to the reference food (Figure 2) [120 min; (0.73 ± 0.34), (1.83 ± 1.07), and (1.82 ± 1.07) respectively; p<0.001]. This was also supported by the 120-min C-peptide: glucose ratio (Table 4).

Discussion

Calculating the diet GI may be useful in epidemiologic studies as a marker of the physiologic effect of dietary carbohydrate. The results of the present study also reflect the importance of GI as a tool for regular healthy food choice. Glycemic responses and GI showed that the blood glucose response after consuming Danish traditional cookies was significantly lower when compared with glucose (p<0.001) and also with ISIS cookies (Figure 1). This lower glycemic response was also reflected in the GI value. Danish traditional cookies showed a low GI but the ISIS cookies had just crossed the high level (Table 3). The blood glucose response may be influenced by a number of factors, such as insulin response, differences in the rates of digestion and absorption influenced by the presence some types of dietary fiber, fat, cooking, anti-nutrients, particle size, food form, and...
Table 2: Nutrient composition of test meals (g/100 g).

<table>
<thead>
<tr>
<th>Sample</th>
<th>Carbohydrate</th>
<th>Added sugar (sucrose)</th>
<th>Other sugars</th>
<th>Protein</th>
<th>Fat</th>
<th>Fiber</th>
<th>Soluble fiber (by calculation)</th>
<th>Insoluble fiber (by calculation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISIS cookies</td>
<td>48</td>
<td>0</td>
<td>5</td>
<td>8.5</td>
<td>12</td>
<td>26</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>Danish traditional cookies</td>
<td>63</td>
<td>40</td>
<td>0</td>
<td>6</td>
<td>24</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 3: Glycemic and C-peptide response of study subjects (n=13) after ingestion of test meals.

<table>
<thead>
<tr>
<th>Test food</th>
<th>Serum glucose (mmol/L)</th>
<th>Serum C-peptide (ng/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>iAUC (mmol/L)</td>
<td>GI</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------</td>
<td>------</td>
</tr>
<tr>
<td>Glucose</td>
<td>176.8 ± 63.0</td>
<td></td>
</tr>
<tr>
<td>ISIS cookies</td>
<td>109.0 ± 39.5 a*</td>
<td>70.0 ± 25.4</td>
</tr>
<tr>
<td>Danish traditional cookies</td>
<td>58.0 ± 23.1 a*** b***</td>
<td>37.6 ± 15.9 b***</td>
</tr>
</tbody>
</table>

*p<0.05 and ***p<0.001 were considered significant compared to reference food in independent sample t-test; a=Glucose; b=ISIS cookies; AICC=Absolute incremental changes of C-peptide

Table 4: C-peptide status of the study subjects (n=13) at different time intervals after ingestion of test meals.

<table>
<thead>
<tr>
<th>Test food</th>
<th>Serum C-peptide (ng/ml)</th>
<th>AICC (ng/mL)</th>
<th>C-peptide: glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 min</td>
<td>120 min</td>
<td>0 min</td>
</tr>
<tr>
<td>Glucose</td>
<td>0.46 ± 0.23</td>
<td>1.82 ± 1.07</td>
<td>1.36 ± 1.00</td>
</tr>
<tr>
<td>ISIS cookies</td>
<td>0.38 ± 0.15</td>
<td>1.83 ± 1.07</td>
<td>1.45 ± 1.04</td>
</tr>
<tr>
<td>Danish traditional cookies</td>
<td>0.41 ± 0.33</td>
<td>0.73 ± 0.34</td>
<td>0.31 ± 0.53</td>
</tr>
</tbody>
</table>

*a** and **p<0.01 were considered significant compared to reference food in Independent sample t-test; a: Glucose; b: ISIS cookies; AICC=Absolute incremental changes of C-peptide

Figure 1: Postprandial blood glucose response of test foods and reference food.
and starch structure. The rich content of fat in Danish traditional cookies may be suppressing its glycemic response because results of a study showed a notice that the addition of fat to carbohydrate-based meal can reduce the postprandial blood glucose response mechanism probably because of a delay in gastric emptying, which may be mediated through an effect of fat on the duodenum and/or ileum [17].

For a particular food, it is also important to consider how rapidly its glucose level rise or fall. The fluctuation pattern of blood glucose is significant in the case of Danish traditional cookies, where there was a sharp rise to 122% at 30 min and a sharp fall at 60 min (109%) compare to the basal states. The sharp rise of glucose response curve (GRC) of Danish traditional cookies to its peak within 30 min, therefore, might be due to rapid digestion and absorption of its glycemic carbohydrates. On the other hand, timing of glucose responses to ISIS cookies has been found different; its GRC has shown a relatively late rise (at 60 min) and after that the curve followed a steadiness response. The high fiber content of ISIS cookies (26/100 g) may slow down the sharp rise or fall response of the glucose curve. Considering this issue, it can be suggested that ISIS cookies might be a better choice than Danish traditional cookies.

Insulin is the central hormone in maintaining blood glucose homeostasis, and it has a life-saving role. Despite this activity, the level of high insulin in blood (hyperinsulinemia) has been shown to be associated with increased atherosclerosis leading to cardiovascular disorders [18]. In this context, the effect of cookies on serum insulin in this study has important implications. The results showed a notice that, although GI is a high and low for the two varieties of cookies, the C-peptide response was substantially higher. The rising trend of C-peptide was prominent in the case of ISIS cookies compare to the other two meals. There was a sharp rise of C-peptide response of Danish traditional cookies at 30 min and fall at 90 min, and after that it showed down regulation (Figure 2).

In addition the ISIS cookie has much less fat per 100 gram than the Danish traditional cookie (Table 2). Besides it has much less carbohydrate, but all of it is digestible starch, which enters quickly as glucose into the bloodstream. In the Danish traditional cookie a considerable part of the carbohydrate is sugar which has a medium GI. This together with the higher content of fat than in the ISIS cookie lowers the GI considerable more than in the ISIS cookie.

It is clearly seen, that the Danish traditional cookie gives a quicker glucose response than the ISIS cookie and is quickly back to the basic glucose level again. The ISIS cookie gives a moderate glucose peak value and a much longer slightly raised blood glucose response.

Table 5: C-peptide status of the study subjects (n=13) at different time intervals after ingestion of test meals.

<table>
<thead>
<tr>
<th>Test food</th>
<th>Serum C-peptide (ng/ml)</th>
<th>AICC (ng/mL)</th>
<th>C-peptide: glucose</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td>120 min</td>
<td>0 min</td>
</tr>
<tr>
<td>Glucose</td>
<td>0.46 ± 0.23</td>
<td>1.82 ± 1.07</td>
<td>1.36 ± 1.00</td>
</tr>
<tr>
<td>ISIS cookies</td>
<td>0.38 ± 0.15</td>
<td>1.83 ± 1.07</td>
<td>1.45 ± 1.04</td>
</tr>
<tr>
<td>Danish traditional cookies</td>
<td>0.41 ± 0.33</td>
<td>0.73 ± 0.34</td>
<td>0.31 ± 0.53</td>
</tr>
</tbody>
</table>

*p<0.05 and **p<0.01 were considered significant compared to reference food in Independent sample t-test; a: Glucose; b: ISIS cookies; AICC= Absolute incremental changes of C-peptide
than the Danish traditional cookie. This more stable glucose level without sudden excursions might from a nutritional point of view be advantageous.

Even if the traditional Danish Cookie has a lower GI than the ISIS cookie, it cannot be concluded, that it is more healthy in general. The high content of sugar and fat in the traditional Danish cookie might if ingested in bigger amounts be troublesome with regard to metabolic syndrome and coronary heart disease [19-21].

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References


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