Invited Editorial

The glycaemic index of foods

Janette Brand Miller PhD
Human Nutrition Unit, Department of Biochemistry, University of Sydney, NSW, Australia.

The glycaemic index of foods

The glycaemic index (GI) is a ranking of foods based on their glycaemic impact\(^1\). It has proven to be a logical and useful tool for comparing foods in situations such as diabetes, sport and appetite where fluctuations in blood sugar levels are considered important. In Australia, the GI concept is already being utilized in some diabetes education centres. The International Diabetes Institute in Melbourne has produced educational material describing the differences between foods in terms of their GI. In fact, Australia may be ahead of the rest of the world in its acceptance of the GI approach. New editions of most textbooks of nutrition and dietetics now devote a section to the subject\(^2\), but most do not give their blessing, citing conflicting early studies. However, over the last few years, many studies have proven that the GI concept is not only reproducible and predictable, but clinically useful in the dietary management of insulin-dependent diabetes mellitus (IDDM), non-insulin-dependent diabetes mellitus (NIDDM) and hyperlipidaemia\(^3,4\).

When Jenkins and co-workers introduced the GI concept in 1981\(^5\), it confirmed what others had also found but had not tabulated in the same way, ie that equal carbohydrate portions of starchy foods varied widely in their glycaemic properties from the very high responses produced by potatoes to very low responses produced by legumes. Similarly, simple sugars produced a range of responses, with sucrose being intermediate. GI seemed a more logical approach to the dietary management of diabetes, but it went against the prevailing dietary dogma that starches were all slowly digested and absorbed, while the opposite was true of sugars. Indeed the publication of the first GI of foods suggested that the system of carbohydrate exchanges for diabetic diets had little scientific validity.

In the last 12 years nearly 300 separate foods have been subjected to GI testing, representing about 200 different kinds of foods from all around the world. The team here at the University of Sydney's Human Nutrition Unit has been responsible for about half of the data. The article by Mani et al. in this issue\(^6\) of the journal is a further addition to the body of knowledge of GI of foods. In particular, their results provide more evidence that 'traditional', 'unprocessed' foods have a low GI. Legumes, whole cereal grains and millets produce exceptionally low GI values contrasting with the effects of modern foods such as bread, potatoes and many breakfast cereals which elicit high plasma glucose and insulin response\(^1\). Factory processing and milling markedly increase glycaemic responses to foods\(^1,5\). Interestingly, the staple carbohydrate foods of Nauruans, Australian Aboriginals and Pima Indians were primarily low GI foods\(^5\). In the past century these populations have adopted a Western lifestyle and modern foods, and now develop non-insulin-dependent diabetes mellitus (NIDDM) in alarming numbers. It is not unreasonable to suggest that the high GI of the diet may have some role to play. A preliminary study in rats supports the hypothesis that high GI foods worsen insulin resistance and therefore the risk of NIDDM\(^6\).

In early 1980s the debate on the GI approach to diabetes management became increasingly polarized, with the open expression and publication of directly opposing views on its usefulness\(^1,5\). Its reproducibility, application to mixed meals and long-term effects were all open to question. There was a widespread belief that GI was useful only in the comparison of single foods but not where mixed meals were concerned\(^15,1\). In 1986, the NIH consensus conference on diet and exercise in NIDDM recommended against the use of GI in the dietary management of diabetes\(^4\). The main criticisms were: no differences were apparent when individual carbohydrate foods were taken as part of a mixed meal and, secondly, there were no studies showing long-term benefits.

In the intervening six years since the NIH statement, these criticisms have been shown to be without foundation. There are now at least 15 studies on mixed meals and 11 medium-to-long term studies using the GI approach in the dietary management of diabetes. Although several early studies failed to show any differences in glycaemic response when foods of different GI were incorporated into mixed meals\(^12,13,15\), there are now three times as many studies which show that GI is very predictable in mixed meals\(^16-25\). Methodological differences can explain some of the conflict, but studies addressing the long-term effects help to answer both criticisms.

Correspondence address: Dr J. Brand Miller, Dept of Biochemistry Gar, University of Sydney, NSW, Australia 2006.
The GLYCEMIC INDEX OF FOODS

References


Of the 11 medium-to-long-term studies (2–12 weeks) which used the glycemic index (GI) approach to determine the clinical gains in diabetes or lipid management, 8–10, all but one produced positive findings. Altogether 126 subjects (63 NIDDM, 45 IDDM, 42 prediabetics and overweight) have been studied, all on an outpatient basis, in a cross-over design in which patients consumed both types of diet for an equal period of time in random order.

An overview analysis of these 11 studies showed that, on average, low GI diets reduced glycosylated haemoglobin by 9%, fructosamine by 8%, urinary C-peptide by 20% and day-long blood glucose by 16%. Cholesterol was reduced by an average of 6% and triglycerides by 9%. Improvements were found in well-controlled, poorly controlled and overweight NIDDM subjects and applied to both adults and children with IDDM. One can criticize these results as 'modest' improvements but, so too, the results of the other 9 studies. What were not exceptionally high in fibre or low in fat and the subjects did not have to lose weight. In most studies, only half the carbohydrate was exchanged from high GI to low GI which meant that foods such as bread and potatoes could still be eaten on the low GI diet. Furthermore, the findings applied to free-living subjects, not to institutionalized or metabolic ward patients whose food intake can be strictly controlled but is not necessarily realistic. In our study, 16 compliance was high on the low GI diets and patients remarked that they felt better on them.

A recent study atQueen Emma Hospital in London, UK, is also cause for concern because it was a large study in a typical clinical setting. Sixty newly diagnosed diabetic patients were randomly assigned to either standard dietary advice or standard plus low GI advice for 12 weeks 8. The low GI group not only had a significantly lower GI, but also achieved a lower fat intake and significantly lower fibre intake. There was also a significantly greater fall in fructosamine and cholesterol in the low GI group.

GI and performance sport

Diabetes is not the only area where GI of foods may be important. The sport physiologists have suddenly discovered the GI concept and have recommended high and low GI foods for different situations. Thomas et al. 44 found that low GI foods before pre-exhausted strenuous exercise may increase endurance time by as much as 20 minutes. The findings are relevant to all forms of physical activity, especially in both humans and animals, including sport and even national defence.

GI and satiety

There is another area in which GI is relevant, that of satiety and weight maintenance. Flatt 45 has hypothesized that GI may also influence the production of a high respiratory quotient (RQ) as a result in carbohydrate being burned at the expense of fat and less deposition of glucose as glycogen. The lower glycogen stores are thought to result in hunger developing sooner and feeling of greater food intake. Both situations predispose to weight gain.

Our research has shown that high GI foods produce higher ROIs than low GI foods, both before and during exercise, and therefore have the potential to promote greater weight gains. 46,47 and others have shown that glucose and insulin responses are consistently associated with lower satiety and vice versa 48–53. These findings provide support for Flatt's hypothesis and may help to explain why modifying a high GI diet is particularly associated with overweight and obesity.

What criticisms of GI still remain?

The GI approach has been criticized because some foods have been rated as 'good' or 'bad' simply on the basis of their GI. It was never intended that the GI be used in isolation. The fat, fibre and salt content of a food are particularly relevant to diabetes. Some people have argued that GI makes high-fat foods appear in a falsely favourable light because fat slows gastric emptying and reduces gut distension. They were not wrong.

High-fat foods do tend to have a low GI, including ice cream and Mars bars TM, but fat may not be the main reason. Carbohydrates such as lactose and sucrose produce moderate glycemic responses by themselves. Jenkins and colleagues have argued that the GI approach should be applied only to low-fat, starchy foods 54. There is some discussion about recommending high-carbohydrate diets for all individuals with diabetes because of their tendency toward lower HDL cholesterol. 55-57 However, this criticism of high carbohydrate diets is overcome by use of low GI, high-fibre, low-fat diet 58.

The insulin response to a food is also important and does not always correlate with the glycemic response 59. Some rice varieties, for example, have a low GI but a substantially lower 'insulin index', compared to white bread. 60 The clinical significance of this is not clear, but it may mean that we should be producing an insulin index in addition to the GI of foods as well. The insulin index may be more relevant to individuals with impaired glucose tolerance, hyperinsulinimaemia and high blood pressure ( 'Syndrome X'). Another important point is that the usual serving size is often not a 50% carbohydrate portion. Some foods may contain so little carbohydrate that even a high GI of little practical significance, such as the case with carrots (GI=92), has a high insulin index in this category. Theoretically, it is possible to show that the expected glycemic response to the usual serving size of a food is the GI of a 50% carbohydrate meal. A further factor which has hindered the practical application of the GI has been the lack of a comprehensive list of GI of a wide variety of foods in both fats and name brands and ethnic foods. We have been addressing this issue and plan to publish an extensive list comprising nearly 300 separate food items representing about 200 different types of food in the near future.

Australians are renowned for giving things a 'fair go' and the GI appears to be no exception. The groundwork has been well prepared and the remaining problem is how best to explain it to all the patients. Various teaching strategies are being explored at present. The GI concept is arguably one of the most logical ways to teach individuals how to manage their blood glucose levels, I think it is time that we acknowledge that the GI of foods is a clinically proven method of determining which carbohydrate foods are best.

References

Glycaemic index of some commonly consumed foods in western India

U.V. Mani MSc, PhD, FICN, B.M. Prabhu MSc, S.S. Damle MSc and I. Mani MSc, PhD*

Department of Foods and Nutrition, MS University of Baroda; *Alembic Chemical Works, Baroda, Gujarat, India.

(1) Glycaemic index (GI) was determined in 36 non-insulin-dependent diabetes mellitus (NIDDM) patients.
(2) The subjects were fed 50g carbohydrate portions of six foods consumed widely in India including Varagu (Paspalum scrobiculatum) alone and in combination with whole and dehulled greengram (Phaseolus aureus Roxb), Bajra (Pennisetum typhoidesum), Jowar (Sorghum vulgare) and Ragi (Eleusine coracana).
(3) The GI of Varagu alone, Varagu in combination with whole greengram and Bajra was significantly lower than that of Ragi which produced a glycaemic response equivalent to that of the glucose load.

Introduction
Diet is considered to be the cornerstone in the management of diabetes mellitus and more so in the case of non-insulin-dependent diabetes mellitus (NIDDM) in which the primary derangement is of carbohydrate metabolism, with secondary abnormalities of lipid and protein metabolism. Dietary management of diabetes involves the reduction of postprandial hyperglycaemia and good glycaemic control. The concept of glycaemic index (GI) emerged as a physiological basis for ranking carbohydrate foods according to the blood glucose response they produce on ingestion, and was introduced by Jenkins et al. (1981). Few foods, traditionally consumed by the Indian population, have been tested for their glycaemic response. Dilawari et al. (1981), Akhtar et al. (1987) and Mani et al. (1990) have studied the glycaemic response to cereals and a few legumes and dals (dals are dehulked and split legumes). The diet of the rural/tribal population of India is predominantly cereals and millets (coarse cereals) which provide 80% of the total energy. Further, information regarding the GI of millet-based foods is scanty. Hence, the present study was planned to determine the GI of six millet-legume/dal combinations that are important in the diet of rural areas of India.

Methods and materials
Thirty-six confirmed NIDDM patients over 40 years of age and on oral hypoglycaemic drugs were selected for testing the glycaemic responses of the recipes. The clinical data of the subjects is given in Table 1. On the first visit, the patients were subjected to an oral glucose tolerance test using 50g glucose load. Blood glucose was determined by the O-toluidine method of Hultman (1959) in fasting and postprandial 1 hour and 2 hour venous blood samples. Serum triglycerides were determined in fasting and 2 hour postprandial blood samples by the method of Foster & Dunn (1973). On a subsequent visit (within 2 weeks), the patients were given a test food containing 50g (available) carbohydrate which was consumed over an 8-10 minute interval. The composition of the foods as determined by the food tables compiled by Gopalas et al. (1979) is given in Table 2. Blood glucose response and triglyceride were again monitored for the different groups fed different foods. Blood glucose response curves for the glucose load and the test food were plotted and GI was calculated using the method described by Jenkins et al. (1981) in which the ratio of the areas under the glucose response curve for the food was compared with that of the GTT. The TG response was calculated by finding the percent increase in mean TG value over mean fasting value for each group.

The six recipes tested were Varagu (Paspalum scrobiculatum) (R₁), Varagu in combination with greengram dal (Phaseolus aureus Roxb) (R₂), Varagu in combination with whole greengram (R₃), Bajra (Pennisetum typhoidesum) (R₄), Jowar (Sorghum vulgare) (R₅) and

Table 1. Clinical data of the diabetic patients.

<table>
<thead>
<tr>
<th>Description</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Mean age ± SD (years)</td>
<td>61±12</td>
<td>50±7</td>
</tr>
<tr>
<td>Mean % ideal body weight</td>
<td>108±13</td>
<td>127±25</td>
</tr>
<tr>
<td>Mean duration of the disease ± SD (years)</td>
<td>7±6</td>
<td>4±3</td>
</tr>
</tbody>
</table>

Correspondence address: Dr Ulliyar V. Mani, Department of Foods and Nutrition, MS University of Baroda, Baroda 390002, Gujarat, India.