The following is taken from these sources and provides a general overview. The most authoritative source of information on this topic is the following website: http://www.glycemicindex.com/.

- https://en.wikipedia.org/wiki/Glycemic_index
- https://www.gisymbol.com/about-glycemic-index/
- http://www.glycemicindex.com/

The glycemic index or glycaemic index (/ɡlærˈsiːmək/;[1] GI) is a number associated with the carbohydrates in a particular type of food that indicates the effect of these carbohydrates on a person's blood glucose (also called blood sugar) level. A value of 100 represents the standard, and is the response associated with an equivalent amount of pure glucose.[2]

The GI represents the rise in a person's blood sugar level two hours after consumption of the food. The glycemic effects of foods depends on a number of factors, such as the type of carbohydrate, physical entrapment of the carbohydrate molecules within the food (food matrix), fat and protein content of the food and organic acids or their salts in the meal. The GI is useful for understanding how the body breaks down carbohydrates[3] and takes into account only the available carbohydrate (total carbohydrate minus fiber) in a food. Glycemic index does not predict an individual's glycemic response to a food, but can be used as a tool to assess the insulin response burden of a food, averaged across a studied population. Individual responses vary greatly.[4]

The glycemic index is usually applied in the context of the quantity of the food and the amount of carbohydrate in the food that is actually consumed. A related measure, the glycemic load (GL),[5] factors this in by multiplying the glycemic index of the food in question by the carbohydrate content of the actual serving. Watermelon has a high glycemic index, but a low glycemic load for the quantity typically consumed.[6] Fructose, by contrast, has a low glycemic index, but can
have a high glycemic load if a large quantity is consumed.

GI tables are available that list many types of foods and their GIs (see http://www.glycemicindex.com/). Some tables also include the serving size and the glycemic load of the food per serving. [3]

Graph describing blood sugar change after a meal.

A practical limitation of the glycemic index is that it does not measure insulin production due to rises in blood sugar. As a result, two foods could have the same glycemic index, but produce different amounts of insulin. Likewise, two foods could have the same glycemic load, but cause different insulin responses. Furthermore, both the glycemic index and glycemic load measurements are defined by the carbohydrate content of food. For example, when eating steak, which has no carbohydrate content but provides a high protein intake, up to 50% of that protein can be converted to glucose when there is little to no carbohydrate consumed with it. [7] But because it contains no carbohydrate itself, steak cannot have a glycemic index. For some food comparisons, the "insulin index" may be more useful.

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Accuracy

Glycemic index charts often give only one value per food, but variations are possible due to
• ripeness (riper fruits contain more sugars increasing GI)
• cooking methods (the more cooked, or over cooked, a food, the more its cellular structure is broken, with a tendency for it to digest quickly and raise GI more)
• processing (e.g., flour has a higher GI than the whole grain from which it is ground as grinding breaks the grain's protective layers) and the length of storage. Potatoes are a notable example, ranging from moderate to very high GI even within the same variety. [8][9]

More importantly, the glycemic response is different from one person to another, and also in the same person from day to day, depending on blood glucose levels, insulin resistance, and other factors. [9] [4]

The glycemic index only indicates the impact on glucose level two hours after eating the food. People with diabetes have elevated levels for four hours or longer after eating certain foods. [9]

### Determining the GI of a Food

Foods with carbohydrates that break down quickly during digestion and release glucose rapidly into the bloodstream tend to have a high GI; foods with carbohydrates that break down more slowly, releasing glucose more gradually into the bloodstream, tend to have a low GI. The concept was developed by Dr. David J. Jenkins and colleagues in 1980–1981 at the University of Toronto in their research to find out which foods were best for people with diabetes. A lower glycemic index suggests slower rates of digestion and absorption of the foods' carbohydrates and can also indicate greater extraction from the liver and periphery of the products of carbohydrate digestion. A lower glycemic response usually equates to a lower insulin demand but not always, and can improve long-term blood glucose control and blood lipids. The insulin index is also useful for providing a direct measure of the insulin response to a food.

The glycemic index of a food is defined as the incremental area under the two-hour blood glucose response curve (AUC) following a 12-hour fast and ingestion of a food with a certain quantity of available carbohydrate (usually 50 g). The AUC of the test food is divided by the AUC of the standard (either glucose or white bread, giving two different definitions) and multiplied by 100. The average GI value is calculated from data collected in 10 human subjects. Both the standard and test food must contain an equal amount of available carbohydrate. The result gives a relative ranking for each tested food. [2][12]

The current validated methods use glucose as the reference food, giving it a glycemic index value of 100 by definition. This has the advantages of being universal and producing maximum GI values of approximately 100. White bread can also be used as a reference food, giving a different set of GI values (if white bread = 100, then glucose ≈ 140). For people whose staple carbohydrate source is white bread, this has the advantage of conveying directly whether replacement of the dietary staple with a different food would result in faster or slower blood glucose response. A disadvantage with this system is that the reference food is not well-defined, because there is no universal standard for the carbohydrate content of white bread.

### Classification

GI values can be interpreted intuitively as percentages on an absolute scale and are commonly interpreted as follows:

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https://med.libretexts.org/Courses/American_Public_University/APU%3A_Basic_Foundation_of_Nutrition_for_Sports_Perform…

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<table>
<thead>
<tr>
<th>Classification</th>
<th>GI range(^{[13]})</th>
<th>Examples(^{[13]})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low GI</td>
<td>55 or less</td>
<td>fructose; beans (black, pinto, kidney, lentil, peanut, chickpea); small seeds (sunflower, flax, pumpkin, poppy, sesame, hemp); walnuts, cashews, most whole intact grains (durum/spelt/kamut wheat, millet, oat, rye, barley); most vegetables, most sweet fruits (peaches, strawberries, mangos); tagatose; mushrooms; chilis</td>
</tr>
<tr>
<td>Medium GI</td>
<td>56–69</td>
<td>white sugar or sucrose, not intact whole wheat or enriched wheat, pita bread, basmati rice, unpeeled boiled potato, grape juice, raisins, prunes, pumpernickel bread, cranberry juice,(^{[14]}) regular ice cream, banana, sweet potato(^{[15]})</td>
</tr>
<tr>
<td>High GI</td>
<td>70 and above</td>
<td>glucose (dextrose, grape sugar), high fructose corn syrup, white bread (only wheat endosperm), most white rice (only rice endosperm), corn flakes, extruded breakfast cereals, maltose, maltodextrins, white potato (83).</td>
</tr>
</tbody>
</table>

A low-GI food will cause blood glucose levels to increase more slowly and steadily, which leads to more suitable postprandial (after meal) blood glucose readings. A high-GI food causes a more rapid rise in blood glucose level and is suitable for energy recovery after exercise or for a person experiencing hypoglycemia.

The glycemic effect of foods depends on a number of factors, such as the type of starch (amylose versus amylopectin), physical entrapment of the starch molecules within the food, fat and protein content of the food and organic acids or their salts in the meal – adding vinegar, for example, will lower the GI.\(^{[16]}\) The presence of fat or soluble dietary fiber can slow the gastric emptying rate, thus lowering the GI. In general, coarse, grainy breads with higher amounts of fiber have a lower GI value than white breads.\(^{[17]}\) However, most breads made with 100% whole wheat or wholemeal flour have a GI not very different from endosperm only (white) bread.\(^{[18]}\) Many brown breads are treated with enzymes to soften the crust, which makes the starch more accessible (high GI).

While adding fat or protein will lower the glycemic response to a meal, the relative differences remain. That is, with or without additions, there is still a higher blood glucose curve after a high-GI bread than after a low-GI bread such as pumpernickel.

Fruits and vegetables tend to have a low glycemic index. The glycemic index can be applied only to foods where the test relies on subjects consuming an amount of food containing 50 g of available carbohydrate.\(^{[citation needed]}\) But many fruits and vegetables (not potatoes, sweet potatoes, corn) contain less than 50 g of available carbohydrate per typical serving. Carrots were originally and incorrectly reported as having a high GI.\(^{[19]}\) Alcoholic beverages have been reported to have low GI values; however, beer was initially reported to have a moderate GI due to the presence of maltose. This has been refuted by brewing industry professionals, who say that all maltose sugar is consumed in the brewing process and that packaged beer has little to no maltose present. Recent studies have shown that the consumption of an alcoholic drink prior to a meal reduces the GI of the meal by approximately 15%.\(^{[20]}\) Moderate alcohol consumption more than 12 hours prior to a test does not affect the GI.\(^{[21]}\)

Many modern diets rely on the glycemic index, including the South Beach Diet, Transitions by Market America and NutriSystem Nourish Diet.\(^{[22]}\) However, others have pointed out that foods generally considered to be unhealthy can...
have a low glycemic index, for instance, chocolate cake (GI 38), ice cream (37), or pure fructose (19), whereas foods like potatoes and rice have GIs around 100 but are commonly eaten in some countries with low rates of diabetes.[15]

Weight Control

Dietary replacement of saturated fats by carbohydrates with a low glycemic index may be beneficial for weight control, whereas substitution with refined, high glycemic index carbohydrates is not.[23] A Cochrane review found that adoption of low glycemic index (or load) diets by people who are overweight or obese leads to more weight loss (and better fat control) than use of diets involving higher glycemic index/load or other strategies.[24] Benefits were apparent even with low glycemic index/load diets that allow people to eat as much as they like.[24] The authors of the review concluded that "Lowering the glycaemic load of the diet appears to be an effective method of promoting weight loss and improving lipid profiles and can be simply incorporated into a person's lifestyle."[24]

In clinical management of obesity, diets based on a low glycemic index/load appear to provide better glycemic and inflammatory control than ones based on a high glycemic index/load (and therefore could potentially be more effective in preventing obesity-related diseases).[25] In overweight and obese children, adoption of low glycemic index/load diets may not lead to weight loss but might potentially provide other benefits.[26]

Disease Prevention

Several lines of recent [1999] scientific evidence have shown that individuals who followed a low-GI diet over many years were at a significantly lower risk for developing both type 2 diabetes, coronary heart disease, and age-related macular degeneration than others.[27] High blood glucose levels or repeated glycemic "spikes" following a meal can promote these diseases by increasing systemic glycative stress, other oxidative stress to the vasculature, and also by the direct increase in insulin level.[28] The glycative stress sets up a vicious cycle of systemic protein glycation, compromised protein editing capacity involving the ubiquitin proteolytic pathway and autophagic pathways, leading to enhanced accumulation of glycated and other obsolete proteins.[29]

Postprandial hyperglycemia is a risk factor associated with diabetes. A 1998 study shows that it also presents an increased risk for atherosclerosis in the non-diabetic population.[30] and that high GI diets, high blood-sugar levels more generally,[31] and diabetes[32] are related to kidney disease as well.

Conversely, there are areas such as Peru and Asia where people eat high-glycemic index foods such as potatoes and high-GI rice without a high level of obesity or diabetes.[citation needed] The high consumption of legumes in South America and fresh fruit and vegetables in Asia likely lowers the glycemic effect in these individuals.[citation needed] The mixing of high- and low-GI carbohydrates produces moderate GI values.[citation needed]

A study from the University of Sydney in Australia suggests that having a breakfast of white bread and sugar-rich cereals, over time, can make a person susceptible to diabetes, heart disease, and even cancer.[33]
A study published in 2007 in the American Journal of Clinical Nutrition found that age-related adult macular degeneration (AMD), which leads to blindness, is 42% higher among people with a high-GI diet, and concluded that eating a lower-GI diet would eliminate 20% of AMD cases.\(^3^4\)

The American Diabetes Association supports glycemic index but warns that the total amount of carbohydrate in the food is still the strongest and most important indicator, and that everyone should make their own custom method that works best for them.\(^3^5\)[36]

The International Life Sciences Institute concluded in 2011 that because there are many different ways of lowering glycemic response, not all of which have the same effects on health, "It is becoming evident that modifying the glycemic response of the diet should not be seen as a stand-alone strategy but rather as an element of an overall balanced diet and lifestyle."\(^3^7\)

A systematic review of few human trials examined the potential of low GI diet to improve pregnancy outcomes. Potential benefits were still seen despite no ground breaking findings in maternal glycemia or pregnancy outcomes. In this regard, more women under low GI diet achieved the target treatment goal for the postprandial glycemic level and reduced their need for insulin treatment. A low GI diet can also provide greater benefits to overweight and obese women. Interestingly, intervention at an early stage of pregnancy has shown a tendency to lower birth weight and birth centile in infants born to women with GDM.\(^3^8\)

### Other Factors

Depending on quantities, the number of grams of carbohydrate in a food can have a bigger impact on blood sugar levels than the glycemic index does. Consuming less dietary energy, losing weight, and carbohydrate counting can be better for lowering the blood sugar level.\(^9\) Carbohydrates impact glucose levels most profoundly,\(^3^9\) and two foods with the same carbohydrate content are, in general, comparable in their effects on blood sugar.\(^3^9\) A food with a low glycemic index can have a high carbohydrate content or vice versa; this can be accounted for with the glycemic load (GL) where GL= GI% x grams of carbohydrate per serving (Louie JCY, et al., 2015). Consuming carbohydrates with a low glycemic index and calculating carbohydrate intake would produce the most stable blood sugar levels.

### Criticism and Alternatives

While the glycemic index of foods is used as a guide to the rise in blood glucose that should follow meals containing those foods, actual increases in blood glucose show considerable variability from person to person, even after consumption of identical meals.\(^4^1\) This is in part because glycemic index does not take into account other factors besides glycemic response, such as insulin response, which is measured by the insulin index and can be more appropriate in representing the effects from some food contents other than carbohydrates.\(^4^0\) In particular, since it is based on the area under the curve of the glucose response over time from ingesting a subject food, the shape of the curve has no bearing on the corresponding GI value. The glucose response can rise to a high level and fall quickly, or rise less high but remain there for a longer time, and have the same area under the curve. For subjects with type 1 diabetes who do not have an insulin response, the rate of appearance of glucose after ingestion represents the absorption of the food.
itself. This glycemic response has been modeled,[41] where the model parameters for the food enable prediction of the continuous effect of the food over time on glucose values, and not merely the ultimate effect that the GI represents.

Although the glycemic index provides some insights into the relative diabetic risk within specific food groups, it contains many counter-intuitive ratings. These include suggestions that bread generally has a higher glycemic ranking than sugar and that some potatoes are more glycemic than glucose. More significantly, studies such as that by Bazzano et al.[42] demonstrate a significant beneficial diabetic effect for fruit compared to a substantial detrimental impact for fruit juice despite these having similar "low GI" ratings.

From blood glucose curves presented by Brand-Miller et al.[43] the main distinguishing feature between average fruit and fruit juice blood glucose curves is the maximum slope of the leading edge of 4.38 mmol·L\(^{-1}\)·h\(^{-1}\) for fruit and 6.71 mmol·L\(^{-1}\)·h\(^{-1}\) for fruit juice. This raises the concept that the rate of increase in blood glucose may be a significant determinant particularly when comparing liquids to solids which release carbohydrates over time and therefore have an inherently greater area under the blood glucose curve.