**The following article contains information about two different measurements of the Glycemic Index. Glycemic Diet Software's product, the Glycemic Index Menu Planner, uses glucose = 100.**

# Good Carbs, Bad Carbs

BY RITA SCHEFRIN, MA, RD

The nutrition armies continue to battle, wielding words and theories, each camp claiming it possesses the weapon to win the weight war and promote health. The purported great debate is this: Should we be eating a diet high in protein (often accompanied by high saturated fat) and low in carbohydrate, high in unrefined carbohydrate and low in fat, or should mundane moderation be the maxim? Further, could it be conceivable that there is a reconciling bridge, a common thread, between these three seemingly opposing theories? Such a bridge—increasingly gaining acceptance, though still controversial—exists: the glycemic index and glycemic load.

Glycemic index and glycemic load are two measurements that have been developed to rate the effect of carbohydrate-containing foods on blood sugar, also called blood glucose. Foods containing carbohydrates cause blood glucose to rise. The pancreas responds by releasing insulin into the blood to restore a normal blood glucose level—the higher the rise in blood glucose, the more insulin the pancreas releases into the blood. So, by measuring the effect that a carbohydrate-containing food has on blood glucose, scientists can indirectly gauge the body's insulin response to that food.

One reason that the high-protein camp advises a severe restriction of carbohydrate consumption is to prevent this blood glucose and insulin rise. Now, some scientists who advocate a diet of moderation and those who advocate a diet high in unrefined carbohydrates and low in fat are also advising minimizing this glucose and insulin response, believing that the degree and speed with which a carbohydrate-containing food increases the level of blood glucose and subsequent insulin response may dramatically impact health and weight.

These researchers are recommending restriction or elimination of the carbohydrates that quickly increase blood glucose with a subsequent insulin rush and advocating consumption of the carbohydrates that affect blood glucose more moderately. The carbohydrate-containing foods that produce a small blood glucose rise and subsequent small insulin reaction are those from which glucose is absorbed slowly into our bodies: most fruits, vegetables (nonstarchy), and legumes and many whole, intact grains. The carbohydrate-containing foods

that produce a large blood glucose rise and subsequent large insulin reaction are those from which glucose is absorbed quickly into our bodies: refined foods high in starch, including many baked flour products.

## What Is a Carbohydrate?

Carbohydrate is an essential nutrient that provides our bodies and brains with the energy needed to function. The National Academies' Institute of Medicine recommends that carbohydrates contribute 45% to 65% of an adult's daily calories.

Carbohydrates are divided into two groups: simple carbohydrates (simple sugars) and complex carbohydrates (starches). Simple carbohydrates are composed of one (monosaccharides) or two (disaccharides) molecules and include glucose (a monosaccharide) also called dextrose, which is found in most plant foods; fructose, or fruit sugar (a monosaccharide), which is found in fruit, some vegetables, honey, and saps; sucrose, or table sugar (a disaccharide), which is also found in honey, maple syrup, fruits, vegetables, and grains; and lactose, or milk sugar (a disaccharide), which is found in dairy products. Fruits, nonstarchy vegetables, and dairy products are simple carbohydrates.

Complex carbohydrates consist of long chains of glucose and are found in grains, such as rice and wheat; legumes (dried beans), such as chick peas and lentils; and tubers, such as potatoes and yams. Glucose is the form of sugar that our bodies use for energy and is the form of sugar found in our blood. After a carbohydrate-containing food is digested and absorbed, the body (liver) converts all of the other forms of carbohydrate in that food to glucose.

Scientists measure carbohydrates in grams. Meats and fats such as oils and butter contain almost no carbohydrates. To learn the carbohydrate content of fruits, vegetables, grains, legumes, and dairy, a table of food values is needed. The following are some examples to keep in mind: one small apple contains approximately 15 grams; one slice of bread contains approximately 15 grams; ½ cup of cooked beans contains approximately 15 grams; 1 cup of milk contains approximately 12 grams; and ½ cup of cooked carrots contains approximately 5 grams.[1] Different fruits and vegetables contain different amounts of carbohydrates. In general, fruits contain more carbohydrates than vegetables, with dried fruits containing the most.

## So Simple, Yet So Complex

Today, some experts claim that complex carbohydrates are healthier than simple carbohydrates because complex carbohydrates contain fiber. However, a complex carbohydrate can be refined, such as white breads, white rice, and white flours. These refined complex carbohydrates have had vitamins, minerals, and most of their fiber removed. Fiber is healthy because it lowers blood cholesterol, aids elimination, is filling, and slows the absorption of glucose into our bodies. Alternatively, simple carbohydrates can be unrefined and contain fiber, such as the simple carbohydrates in whole fruits and vegetables. Instead of "complex," the term to describe the healthier carbohydrates should be "unrefined"—the carbohydrates as they are found in nature, such as fruits, vegetables, legumes, and whole, intact grains.

## The Origin of the Theory

Until the early 1980s, scientists assumed that all simple carbohydrates and all complex carbohydrates had the same effect on blood glucose levels. Then, a group of scientists, led by Dr. David Jenkins at the University of Toronto, began questioning this belief and, in order to help people with diabetes, started testing many common carbohydrate-containing foods. The results confirmed their hunches, and the glycemic index was born.

## Slow and Steady Should Be the Pace

Why should you care how quickly your body converts carbohydrates to glucose? After eating carbohydrates, which raises blood glucose, the pancreas pours insulin into the blood to restore a normal blood glucose level. Insulin lowers blood glucose by "escorting" glucose from the blood into the cells, where the glucose is used. A rapid rise of blood glucose causes the pancreas to pour out an excessive amount of insulin.

So, what's the problem with high blood glucose and insulin levels? First, they may play a role in the development of heart disease and hypertension (high blood pressure). Another problem may be type 2 diabetes, which has reached epidemic proportions. One theory of the cause of type 2 diabetes is that the pancreas, after years of spewing out insulin, wears out and stops producing insulin. In other words, one of the causes of type 2 diabetes may be an exhausted pancreas, possibly caused by years of overwork due to a diet of high-glycemic-index carbohydrates. In the past, type 2 diabetes occurred mostly in adults, but the number of children with type 2 diabetes is on the rise. Obesity, which has also reached epidemic proportions, may be yet another problem. An abundance of insulin significantly lowers blood glucose (hypoglycemia), causing hunger. Insulin, a fat-favoring hormone, also helps our bodies produce and store fat.

## Insulin Resistance and Syndrome X (Metabolic Syndrome)

When the body's cells need more insulin to accept glucose from the blood, that is insulin resistance. This condition overworks the pancreas, forcing it to produce more insulin. The factors that contribute to insulin resistance are obesity, physical inactivity, a diet that promotes insulin production, a diet low in monounsaturated and polyunsaturated fatty acids and high in trans fatty acids, and genetics. In addition to possibly leading to diabetes, insulin resistance may also cause Syndrome X or metabolic syndrome, a cluster of risk factors associated with heart disease: insulin resistance, abdominal obesity, high blood pressure, high blood triglyceride levels, low high-density lipoprotein levels, high blood insulin levels, and elevated fasting blood glucose levels. In *Syndrome X*, author Dr. Gerald Reaven states that approximately 25% to 30% of Americans are insulin resistant and that the high-carbohydrate, low-fat diets are perilous for this population.[2]

## Our Paleolithic Past

While most of our stone-age relatives did not live long enough to suffer from any of the chronic diseases that plague us today and that we now believe are at least in part diet- and lifestyle-related, a look at our ancestral "table" is interesting and perhaps instructive.

In *The Paleolithic Prescription*, Dr. S. Boyd Eaton writes that before the inception of agriculture (8,000 B.C. to 10,000 B.C.), we were hunter/gatherers eating a diet consisting of approximately one-third wild game (according to Eaton, this meat was closer in quality to poultry, fish, and shellfish, having much less total and saturated fat than domesticated meat), with the remaining two-thirds of the diet comprised mostly of a wide variety of fruits and vegetables, with occasional honey. Absent from this diet were grains, dairy (skeletal remains indicate denser bones than we have today, probably due to calcium-rich vegetables and plenty of exercise), legumes, and sugars, such as sucrose and molasses. Even when grains were introduced, they were unrefined—whole and intact.[3]

So, the foods of our ancestors, lacking in refined carbohydrates, did not produce an intense increase of blood glucose with a consequent insulin rush. The diet was "pancreas-friendly." However, as the agricultural age progressed, grains were ground into flours, which became more and more refined until, as is the case of today's white bread and white flour, the fiber almost totally disappeared. Eventually, refined sugars were also introduced.

## The Glycemic Index

The glycemic index measures a person's blood glucose response to a carbohydrate-containing food, independent of the number of carbohydrate grams in a portion of that food. The glycemic index is lowest for foods that raise blood glucose levels slowly and moderately; foods with a low glycemic index are converted to glucose slowly because they are slowly digested and absorbed. The glycemic index is highest for foods that raise blood glucose levels quickly and high; foods with a high glycemic index are converted to glucose quickly because they are quickly digested and absorbed. In other words, the harder that your body has to work to convert

the starch and sugar in a food to glucose, the lower that food's glycemic index will be. So, anything that slows the digestion and absorption of a carbohydrate-containing food will lower its glycemic index.

The glycemic index of a food is affected by: 1) particle size—larger particle sizes found in stone-ground flour as opposed to finely processed flours slow digestion and lower the glycemic index; 2) soluble, or viscous, fiber—this type of fiber, found in some fruits and vegetables, legumes, oat bran, and oatmeal, slows digestion and lowers the glycemic index; 3) fibrous covering—foods with a fibrous cover, such as beans and seeds, are digested more slowly and have a lower glycemic index; 4) acidity—the acid found in more acidic foods, such as some fruits, pickled foods, and vinegar, slows digestion and lowers the glycemic index; 5) the ratio of different sugars—fructose, for example, has a lower glycemic index than glucose because it is absorbed more slowly since the liver must convert it to glucose; 6) the ease of digestibility of the starch in a food—gelatinized starches and starches with a high amylopectin content are more easily digested and raise the glycemic index; and 7) fat content—fat slows digestion and lowers the glycemic index.

Scientists are now compiling tables of the glycemic index of carbohydrate-containing foods with Dr. Jennie Brand-Miller at the University of Sydney, Australia, who is doing much of the research. (This article cites figures from the book, *The New Glucose Revolution*, by Brand-Miller, Wolever, Foster-Powell, and Colagiuri.)[4] Because the glycemic index is an approximate value, values may differ somewhat from one table to another.

Here is how the scientists unlock the secret: They test foods on volunteers to determine each food's effect on blood glucose. They take a test food that contains carbohydrate, such as a carrot, and compare its effect on blood glucose with the effect of a reference food on blood glucose. They measure the reference and test food's effect on the rise and subsequent fall of a person's blood glucose. The portion size of the reference food and the food being tested must contain identical amounts of available carbohydrates ("available" carbohydrates do not include fiber, a carbohydrate, because the body cannot digest fiber). Usually, the amount of food needed to provide 50 grams of available carbohydrates is used.

To complicate matters, two measurements of glycemic index exist. Some researchers are comparing foods with pure glucose (one reference food), while other researchers are comparing foods with white bread (the other reference food). Pure glucose is 100% carbohydrates, while white bread is not. (White bread also contains water, protein, fat, fiber, vitamins, and minerals, which add to its weight.) Three tablespoons of pure glucose provides 50 grams of available carbohydrates, and approximately 3½ slices of white bread provides 50 grams of available carbohydrates.

How is this done? A healthy volunteer fasts overnight. The next morning, the volunteer ingests the chosen reference food. He or she drinks either 50 grams of pure glucose dissolved in water or eats enough white bread to provide 50 grams of available carbohydrates. Blood samples measuring the rise and fall of the volunteer's blood glucose are taken several times over the next two or three hours (in people with diabetes). Another day, also after an overnight fast, the volunteer eats a test food—enough to provide 50 grams of available carbohydrates. Again, blood samples are taken over the next two or three hours. The volunteer's response to the reference and test foods are repeated several times, and an average for each is calculated.

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The reference food receives a value of 100. The glycemic index of the test food is calculated by dividing the volunteer's blood glucose response to the test food by the volunteer's blood glucose response to the reference food (glucose or white bread).

Because we all respond to a glucose "challenge" a little differently and may respond to individual foods a little differently, these tests are performed on eight to 10 people. An average is calculated to establish the glycemic index of each food.

You can convert a glycemic index value compared with white bread to a glycemic index value compared with glucose and vice versa. Here is how: With glucose as the reference food, white bread has a glycemic index of 70, or 70%. This means that glucose causes a 30% higher increase of blood glucose than white bread does. Because the reference food gets a value of 100, or 100%, the conversion factor between white bread and glucose is approximately 1.4: 100/70 = 1.43.

For example, spaghetti has an average glycemic index of 38, or 38%, when compared with glucose. Multiply this glycemic index by 1.4, and you get a glycemic index of 53 when spaghetti is compared with white bread. So, to convert a glycemic index compared with glucose to a glycemic index compared with white bread, multiply the value by 1.4. To convert a glycemic index compared with white bread to a glycemic index compared with glucose, divide the value by 1.4. Because white bread has a glycemic index 1.4 times lower than that of glucose, a test food will have a glycemic index 1.4 times higher when compared with white bread than when compared with glucose.[5] Because the glycemic index numbers differ depending upon the reference food employed, you should always know if glucose or white bread was used as the reference food when looking at the figures.

While the glycemic index is a relative scale, when measured against glucose, a glycemic index less than 55 is considered low, a glycemic index between 55 and 70 is considered intermediate, and a glycemic index more than 70 is considered high.[6]

When measured against white bread, a glycemic index less than 77 is considered low, a glycemic index between 77 and 98 is considered intermediate, and a glycemic index more than 98 is considered high.

## The Glycemic Load

The problem with the glycemic index is that the portion size of the test food is the portion size that contains 50 grams of available carbohydrates from that food. With some foods, however, a portion providing 50 grams of available carbohydrates does not represent an average portion. For example, to analyze the glycemic index of the amount of carrots providing 50 grams of available carbohydrate, 1½ pounds of carrots had to be consumed—not exactly the amount that most people eat at one sitting. The problem then becomes how to measure the effect of a specific portion size on blood glucose.

Enter the glycemic load. Glycemic load is a measure conceived by researchers at Harvard University that takes into account the portion size of food being consumed. To calculate the glycemic load of a portion of food, multiply that food's glycemic index by the number of grams of carbohydrate contained in that portion.

For example, to calculate the glycemic load of ½ cup of boiled carrots, multiply the glycemic index of carrots (49, or 49%, when compared with glucose) by the number of carbohydrate grams contained in ½ cup of carrots, or five grams. The glycemic load for ½ cup of boiled carrots is 2.45 (.49 X 5). (Glycemic load numbers for the same food will differ, depending upon which reference

food was used to calculate the glycemic index used.) The glycemic load for one cup of boiled carrots is 4.9 (.49 X 10); 9.8 (.49 X 20) for two cups of boiled carrots; and 14.7 (.49 X 30) for three cups of boiled carrots.

In contrast, consider spaghetti. When measured against glucose, white spaghetti has a glycemic index of 38. One and one-half cups of spaghetti contains 48 grams of carbohydrates. The glycemic load for 1½ cups of the spaghetti is calculated by multiplying .38 X 48, which provides a glycemic load of 18.24. Think about what a 1-cup measuring cup looks like. When you eat spaghetti, do you think that you are eating only 1½ cups? Perhaps you are eating 2, 3, or maybe even 4 cups? If you eat three cups, you are eating a glycemic load of 36.48 (.38 X 96). You can see that 3 cups of boiled carrots has a lower glycemic load than 3 cups of spaghetti. So, a food with a higher glycemic index may have a lower glycemic load when portion size is considered.

What glycemic load should we aim for? In *The New Glucose Revolution*, Brand-Miller et al advise that a person eating 250 grams of carbohydrates daily (which translates into 1,000 calories of carbohydrate) averages a glycemic load between 138 and 163, depending upon whether that person's goal is to eat all or only one-half of his or her carbohydrates from low-glycemic-index carbohydrates.[7]

## Glycemic Surprises

The glycemic index and glycemic load values for a food are sometimes more different than you might expect. For example, whole-wheat bread made from finely ground, whole-wheat flour has nearly the same glycemic index as refined white bread because the fiber is so finely ground. (But, whole-wheat bread is a better nutritional bet because of its superior vitamin and mineral content.) And, would you believe that the average baked potato has a higher glycemic index than ½ cup of 16%-fat vanilla ice cream? The starch in the potato is swollen, easily digested, and quickly converted to glucose, while the sucrose (a disaccharide consisting of glucose and fructose) in the ice cream is less easily converted to glucose (fructose must be converted to glucose in the liver), and the fat lowers its glycemic index. The glycemic index of the baked potato, when compared with glucose, is 85, while the ice cream has a glycemic index of 38. These numbers translate into a glycemic load of 25.5 for the potato (multiply the potato's glycemic index by the number of carbohydrate grams in one potato, or .85 X 30) and 5.32 (.38 X 14) for ½ cup of ice cream. However, if you eat 1 cup of the ice cream, the glycemic load increases to 10.64 (.38 X 28) . And, alas, because of its high-caloric, sugar, saturated fat, and cholesterol content, this lower glycemic index does not make ice cream a food to eat indiscriminately.

Because we eat foods in combination, each meal or snack has its own glycemic index and load. Adding fat or fiber to a meal lowers its glycemic load. For example, juice will probably have a higher glycemic index and glycemic load than the fruit or vegetable from which it was made because the fiber has been lost; so, adding foods high in soluble fiber such as green, leafy vegetables or broccoli to a meal will lower that meal's glycemic load. Likewise, adding foods high in monounsaturated or polyunsaturated fats such as nuts or oil to a meal is another healthy way to lower a meal's glycemic load.

## Be Your Own Detective

Short of testing your own blood glucose—which may not even be accurate because blood glucose response can vary daily—you can get a table of glycemic indexes and loads on the Web or from a book.[8] Or, you can try to be your own detective. If you consistently get hungry ½ hour to 3 hours after eating a certain carbohydrate-containing food, that food may be excessively raising your blood glucose, thus causing an exaggerated insulin response.

## What to Eat?

No one can foretell how future nutrition advice might change as knowledge advances. However, the most recent recommendations of the National Academies' Institute of Medicine's Food and Nutrition Board advise that healthy adults eat in percentages of total daily calories a diet of 45% to 65% carbohydrates (with at least 130 grams to avoid ketosis); 20% to 35% fat, limiting saturated fat, cholesterol (animal foods provide almost all dietary saturated fat and all dietary cholesterol), and trans fats (manmade fats, also known as partially hydrogenated fats, found in many commercially processed foods) to the lowest levels possible while maintaining a healthy diet; and 10% to 35% protein (the Recommended Dietary Allowance for protein is 0.8 grams of protein per kilogram of body weight). A healthy diet is rich in fruits and especially vegetables (nonstarchy are low in calories), which provide needed vitamins, minerals, fiber, and phytochemicals (plant substances manifested through the succulent colors of the foods of the plant kingdom that include some of the antioxidants and may protect against disease), and is low in saturated fat, cholesterol, and trans fat. And, studies suggest that whole, intact grains (not refined grains) are protective against diabetes, heart disease, and perhaps cancer.

In his book *Eat, Drink, and Be Healthy*, Dr. Walter Willett, chairman of the department of nutrition at the Harvard School of Public Health and a proponent of the glycemic index and load theories, recommends daily physical activity and weight management as the basis for a healthy lifestyle. For food choices, he advises intact or coarsely ground whole grains; use of monounsaturated oils (such as canola, olive, and peanut oils) and polyunsaturated oils (such as corn, soybean, and sunflower oils); plenty of vegetables; fruits; protein foods that contain less saturated fat than red meat (such as poultry) and that provide beneficial unsaturated fats (such as fish) and are also high in fiber, vitamins, minerals, and phytochemicals (such as beans and nuts); and strict limits on the consumption of foods high in saturated fat (such as butter and red meat) and on foods with a high glycemic index or that produce a high glycemic load (such as refined grains and breads, potatoes, and sweets). Dr. Willett believes that a diet with more than 30% of its calories from fat is fine if the fats are unsaturated and that calcium supplements are the best means of insuring adequate calcium intake.[9]

While some scientists do not accept the glycemic index and load theories, others would advise that most of the carbohydrate-containing foods that you choose have a low glycemic index or that your portion sizes or meals provide a low glycemic load. Brand-Miller, Wolever, Foster-Powell, and Colagiuri believe that only one-half of one's carbohydrates need to come from low-glycemic-index foods.[10] Perhaps individual sensitivity will prove more critical than currently recognized. And, remember: "portion potion"—for weight control, calories (thus, portion sizes) count, no matter what foods are eaten.

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