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## META ANALYSIS STUDY OF GLYCEMIC INDEX OF VARIOUS FOOD GROUPS

Nazni.P<sup>1\*</sup> and Ravinder Singh<sup>2</sup>

<sup>1</sup>Department of Food Science and Nutrition, Periyar University, Salem, Tamilnadu, India, <sup>2</sup>Indian Council of Medical Research (ICMR), New Delhi.

\*Corresponding Author: [naznip@gmail.com](mailto:naznip@gmail.com)

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### ABSTRACT

This study represents the reliable and compiled data for GI values of Indian foods. These GI values help to identify the ability of foods that raise the blood glucose levels. In this study, 120 food items were tabulated. White bread and glucose were used as a reference food to determine the GI values of foods. Also, this table reveals the available carbohydrates of the specific foods. According to the GI values, foods were also classified as High, Medium, Low glycemic index foods. It is hoped that, this table will help to reduce the repetition in determining the GI values of foods.

**Keywords:** Blood, Glucose, Glycemic Index, Foods.

### INTRODUCTION

The glycemic index or Glycaemic Index (GI) is a number associated with a particular type of food that indicates the food's effect on a person's blood glucose level (Glycemic Research institute, 2012).

A food with a high GI raises blood glucose more than a food with a medium or low GI. The GI represents the total rise in a person's blood sugar level following consumption of the food; it may or may not represent the rapidity of the rise in blood sugar. The steepness of the rise can be influenced by a number of other factors, such as the quantity of fat eaten with the food (David Mendosa *et.al.*, 2003).

The glycemic index, or GI, measures how a carbohydrate-containing food raises blood glucose. Foods are ranked based on how they compare to a reference food — either glucose or white bread. The GI is useful for understanding how the body breaks down carbohydrates and only takes into account the available carbohydrate (total carbohydrate minus fiber) in a food. Although the food may contain fats and other components that contribute to the total rise in blood sugar, these effects are not reflected in the GI ([www.diabetes.org](http://www.diabetes.org)).

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), factors this in by multiplying the glycemic index of the food in question by

the carbohydrate content of the actual serving. (Scheiner *et.al.*, 2013)

Glycemic index charts often give only one value per food, but variations are possible due to variety, 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 (Uchiki T.*et.al.*, 2012).

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. Most of the values on the glycemic index do not show the impact on glucose levels after two hours. Some people with diabetes may have elevated levels after four hours.

### DETERMINING THE GI OF FOODS

Carbohydrates rich foods which break down quickly and releases glucose rapidly into the blood stream have High GI values. Whereas, carbohydrates rich foods which break down slowly and releases glucose gradually in to the blood stream will have low GI values. According to Dr. David J. Jenkins and colleagues 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 may 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 may 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 (Temelkova-Kurktschiev TS, 2008).

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.

### GLYCEMIC INDEX OF FOODS

Relevant GI values are essential for all clinical and research applications. Therefore, the purpose of this revised table is to bring together all the relevant data published between 1990 and 2013 (Table 1). In total, the table consists of 64 familiar food items. It is hoped that the table will help to reduce the unnecessary repetition in the testing of individual foods.

**Table 1 – Glycemic Index Values of Various Food Groups**

| Food items        | GI value | GI Classification | Reference food | Subjects (Type and number) | Available carbohydrates (gm) | References                                    |
|-------------------|----------|-------------------|----------------|----------------------------|------------------------------|---|
| <b>CEREALS</b>    |          |                   |                |                            |                              |   |
| Basmati Rice      | <55      | Low               | White bread    | Diabetic,7                 | 35                           | Dinesh srinivasa <i>et.al.</i> , <sup>1</sup> |
| Parboiled Rice    | 64       | Medium            | White bread    | Diabetic,7                 | 38                           | B.J. Venn <i>et.al.</i> , <sup>2</sup>        |
| Brown rice        | 79       | High              | White bread    | Diabetic,8                 | 38                           | www.lowglycemicload.com                       |
| White bread       | 71       | High              | Glucose        | Healthy,10                 | 14                           | Suzanne Albrecht <sup>3</sup>                 |
| Whole wheat bread | 67       | Medium            | Glucose        | Healthy,12                 | 13                           | Mani UV <i>et.al.</i> , <sup>4</sup>          |
| Macaroni          | 47       | Low               | White bread    | Healthy,8                  | 45                           | B.J. Venn <i>et.al.</i> , <sup>2</sup>        |
| Noodles           | 70       | High              | White bread    | Healthy,10                 | 30                           | www.glycemicindex.com                         |
| Cornflakes        | 83       | High              | White bread    | Healthy,12                 | 85                           | www.glycemicindex.com                         |
| Oatmeal           | 61       | Medium            | White bread    | Healthy,8                  | 26                           | www.glycemicindex.com                         |
| All bran          | 42       | Low               | White bread    | Healthy,7                  | 25                           | www.glycemicindex.com                         |
| Barley            | 25       | Low               | White bread    | Diabetic,15                | 28                           | www.glycemicindex.com                         |
| <b>PULSES</b>     |          |                   |                |                            |                              |   |
| Rajmah            | 42       | Low               | White bread    | Diabetic,8                 | 18                           | Mani UV <i>et.al.</i> , <sup>4</sup>          |
| Lentils           | 22       | Low               | White bread    | Diabetic,10                | 18                           | Mani UV <i>et.al.</i> , <sup>4</sup>          |
| Bengal gram       | 47       | Low               | White bread    | Diabetic,9                 | 13                           | Mani UV <i>et.al.</i> , <sup>4</sup>          |
| Green gram        | 48       | Low               | White bread    | Diabetic,10                | 20                           | www.glycemicindex.com                         |
| Black gram        | 48       | Low               | White bread    | Diabetic,10                | 23                           | www.glycemicindex.com                         |
| Soyabean          | 16       | Low               | White bread    | Diabetic,10                | 39                           | www.glycemicindex.com                         |
| <b>VEGETABLES</b> |          |                   |                |                            |                              |   |
| Mashed potato     | 74       | High              | Glucose        | Diabetic,12                | 30                           | B.J. Venn <i>et.al.</i> , <sup>2</sup>        |
| Baked potato      | 121      | High              | Glucose        | Diabetic,8                 | 28                           | www.lowglycemicload.com                       |
| Carrots (cooked)  | 41       | Low               | Glucose        | Diabetic,8                 | 6                            | Suzanne Albrecht <sup>3</sup>                 |
| Cucumber          | 0        | Low               | Glucose        | Healthy,12                 | 2                            | Suzanne Albrecht <sup>3</sup>                 |
| Green beans       | 0        | Low               | Glucose        | Healthy,10                 | 15                           | Suzanne Albrecht <sup>3</sup>                 |
| Peas              | 48       | Low               | Glucose        | Healthy,8                  | 7                            | Suzanne Albrecht <sup>3</sup>                 |
| Yam               | 51       | Low               | White bread    | Healthy,12                 | 30                           | www.glycemicindex.com                         |
| Beetroot          | 64       | Medium            | White bread    | Healthy,7                  | 10                           | www.glycemicindex.com                         |
| Cabbage           | 10       | Low               | Glucose        | Diabetic,10                | 3                            | Mani UV <i>et.al.</i> , <sup>4</sup>          |
| Onion             | 10       | Low               | Glucose        | Diabetic,8                 | 5                            | www.glycemicindex.com                         |

|                               |     |        |             |             |            |  |
|-------------------------------|-----|--------|-------------|-------------|------------|--|
| Lettuce                       | <15 | Low    | Glucose     | Diabetic,15 | 1          | www.lowglycemicload.com                |
| Spinach                       | <15 | Low    | Glucose     | Diabetic,12 | 1          | www.lowglycemicload.com                |
| Mushroom                      | <15 | Low    | Glucose     | Diabetic,6  | 0          | www.lowglycemicload.com                |
| Asparagus                     | <15 | Low    | Glucose     | Diabetic,6  | 1          | www.lowglycemicload.com                |
| Broccoli                      | <15 | Low    | Glucose     | Diabetic,8  | 2          | www.lowglycemicload.com                |
| Peppers                       | <15 | Low    | Glucose     | Diabetic,8  | 2          | www.lowglycemicload.com                |
| <b>FRUITS</b>                 |     |        |             |             |            |  |
| Dates                         | 103 | High   | Glucose     | Diabetic,10 | 15         | www.glycemicindex.com                  |
| Kiwi                          | 54  | Low    | Glucose     | Diabetic,8  | 15         | Mani UV <i>et.al.</i> , <sup>4</sup>   |
| Raisins                       | 64  | Medium | Glucose     | Diabetic,10 | 15         | Mani UV <i>et.al.</i> , <sup>4</sup>   |
| Strawberries                  | 40  | Low    | Glucose     | Diabetic,8  | 12         | www.glycemicindex.com                  |
| Mango                         | 65  | Medium | Glucose     | Diabetic,9  | 28         | Mani UV <i>et.al.</i> , <sup>4</sup>   |
| Orange                        | 44  | Low    | Glucose     | Diabetic,7  | 11         | www.glycemicindex.com                  |
| Papaya                        | 58  | Medium | Glucose     | Diabetic,12 | 20         | www.glycemicindex.com                  |
| Pear                          | 38  | Low    | Glucose     | Diabetic,15 | 20         | www.glycemicindex.com                  |
| Apple                         | 38  | Low    | Glucose     | Diabetic,12 | 16         | Suzanne Albrecht <sup>3</sup>          |
| Banana                        | 52  | Low    | Glucose     | Diabetic,8  | 24         | Suzanne Albrecht <sup>3</sup>          |
| Grape fruit                   | 25  | Low    | Glucose     | Diabetic,7  | 18         | Suzanne Albrecht <sup>3</sup>          |
| Pineapple                     | 59  | Medium | Glucose     | Diabetic,6  | 20         | Suzanne Albrecht <sup>3</sup>          |
| Water melon                   | 72  | High   | Glucose     | Diabetic,10 | 12         | B.J. Venn <i>et.al.</i> , <sup>2</sup> |
| <b>MILK AND MILK PRODUCTS</b> |     |        |             |             |            |  |
| Skim milk                     | 32  | Low    | White bread | Healthy,10  | 13         | Suzanne Albrecht <sup>3</sup>          |
| Milk                          | 32  | Low    | White bread | Healthy,10  | 12         | Mani UV <i>et.al.</i> , <sup>4</sup>   |
| Curd                          | 36  | Low    | White bread | Healthy,10  | 12         | Mani UV <i>et.al.</i> , <sup>4</sup>   |
| Cheese                        | <15 | Low    | White bread | Diabetic,6  | Negligible | www.lowglycemicload.com                |
| Margarine                     | <15 | Low    | White bread | Diabetic,7  | Negligible | www.lowglycemicload.com                |
| Sour cream                    | <15 | Low    | White bread | Diabetic,6  | Negligible | www.lowglycemicload.com                |
| Ice cream (high fat)          | 37  | Low    | White bread | Diabetic,10 | 13         | B.J. Venn <i>et.al.</i> , <sup>2</sup> |
| <b>MEAT AND POULTRY</b>       |     |        |             |             |            |  |
| Beef                          | <15 | Low    | White bread | Diabetic,8  | Negligible | www.lowglycemicload.com                |
| Pork                          | <15 | Low    | White bread | Diabetic,6  | Negligible | www.lowglycemicload.com                |
| Chicken                       | <15 | Low    | White bread | Diabetic,8  | Negligible | www.lowglycemicload.com                |
| Fish                          | <15 | Low    | White bread | Diabetic,7  | Negligible | www.lowglycemicload.com                |
| Lamb                          | <15 | Low    | White bread | Diabetic,6  | Negligible | www.lowglycemicload.com                |
| Egg                           | <15 | Low    | White bread | Diabetic,8  | Negligible | www.lowglycemicload.com                |
| <b>FATS AND SUGARS</b>        |     |        |             |             |            |  |
| Glucose                       | 100 | High   | White bread | Diabetic,10 | 100        | Mani UV <i>et.al.</i> , <sup>4</sup>   |
| Honey                         | 58  | Medium | White bread | Diabetic,12 | 80         | Mani UV <i>et.al.</i> , <sup>4</sup>   |
| Sucrose                       | 65  | Medium | White bread | Diabetic,10 | 68         | Mani UV <i>et.al.</i> , <sup>4</sup>   |
| Fructose                      | 43  | Low    | White bread | Diabetic,10 | 52         | Mani UV <i>et.al.</i> , <sup>4</sup>   |
| Butter                        | <15 | Low    | White bread | Diabetic,6  | Negligible | www.lowglycemicload.com                |

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. 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. However, most bread made with 100% whole wheat or wholemeal flour has a GI not very different from endosperm only (white) bread. Many brown breads are treated with enzymes to soften the crust, which makes the starch more accessible (high GI). Addition of 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 (Sheard NF *et.al.*, 2004).

Fruits and vegetables have low glycemic index. The glycemic index is applied only to foods where the test relies on subjects consuming an amount of food containing 50 g of available carbohydrate. 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. Alcoholic beverages 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. Moderate alcohol consumption more than 12 hours prior to a test does not affect the GI (Angelika Christie, 2009).

The GI symbol program is a GI certification program that helps the customers to identify the low GI foods and drinks. The GI symbol will be seen only on foods or beverages for which GI values were tested according to the standard and should meet the GI foundation's certification criteria as a healthy choice within their food group; hence they are lower in kilojoules, fat and salt.

### PREVENTION OF DISEASES

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. High blood glucose levels or repeated glycemic "spikes" following a meal may promote these diseases by increasing systemic glycative stress, other oxidative stress to the vasculature, and also by the direct increase in insulin levels. 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 (Joslin Diabetes Center, 2012).

A study from the University of Sydney in Australia suggests that having a breakfast of white bread and sugar-rich cereals, over time, may make a person susceptible to diabetes, heart disease, and even cancer.

A study published 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.

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.

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."

### CRITICISM AND ALTERNATIVES

The 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. 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, 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 (Bazzano *et al*, 2008)

According to Brand-Miller *et.al.*, 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)/hr for fruit and 6.71 (mmol/L)/hr 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.

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