Glycemic Index and Glycemic Load of Foods and Food Products in Malaysia : A Review

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Review

Glycaemic index and glycaemic load of foods and food products in Malaysia: a review

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Abstract

Glycaemic index (GI) is a method used to classify the type of carbohydrate-rich foods according to their effect on postprandial glycaemic responses. While the GI concept provides a measure of carbohydrate quality, glycaemic load (GL) quantifies the overall glycaemic effects by considering both the quality and quantity of carbohydrate-rich foods. The higher the GI and GL of the foods, the greater the elevation of blood glucose and insulin demand. Reduction in dietary GI and GL are associated with the prevention and control of chronic diseases, including type 2 diabetes. Although the GI concept has been applied in various nutrition-related interventions in Malaysia, a reliable database on Malaysian foods and food products are scarce. This review attempts to determine and compile reliable data of GI and GL values of Malaysian foods and food products. A literature search was performed using predefined terms and criteria not only limited to web-based databases (n = 20), but included abstracts (n = 6) and manufacturer (n = 1). The GL value for each food was calculated. A total of 83 foods was identified with the most common being rice (25.3%) and bread (16.9%), either eaten alone or in mixed meals. Food with the highest GI value was sago (GI = 156; GL = 59), while food with the lowest GI value was spaghetti with chicken soup (GI = 35; GL = 4). This review shows that the number of foods and food products with the assigned GI and GL values in Malaysia is still limited, which warrants for more studies in this area.

Introduction

Glycaemic index (GI) classifies different types of dietary carbohydrate-rich foods according to their effects on postprandial or postmeal blood glucose effects. The GI is defined as an incremental area under the curve (iAUC), for the blood glucose responses after consumption of 50 g available carbohydrate, relative to that produced by the same amount of reference food taken by the same subject (Wolever, 2006). Carbohydrate-rich foods can be classified into three categories which are high GI (GI value more than 70), moderate GI (GI value ranges from 55 to 70), and low GI (GI value less than 55) (Australian Standard, 2007). The higher the GI of the food, the greater the postprandial blood glucose level. In contrast, foods with a lower GI value is slowly digested and absorbed, resulting in a reduced level in blood glucose levels (Wolever, 2013) (Figure 1).

Besides the types of carbohydrate, the amount of carbohydrate consumed also impacts on blood glucose levels. The higher the amount of carbohydrate, the more significant impact on the blood glucose levels, and these changes are referred to as glycaemic response. To better predict the glycaemic response, it is best to combine both the amount and the type of carbohydrate, which is known as the glycaemic load (GL) concept. The GL is methodologically determined by multiplying the grams of available carbohydrate in the food by the food's GI and dividing by 100. The higher the GL of the carbohydrate-rich foods, the

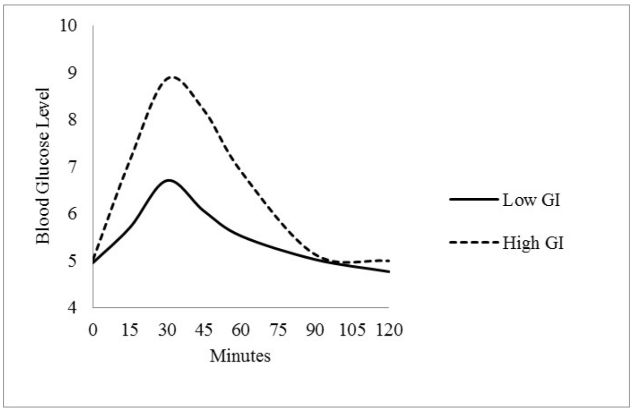

Figure 1. Glycaemic response.

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higher the impact on glycaemic response. The GL values for a standardised portion of carbohydrate-rich foods or food products includes ≤ 10 as low GL, 11 to 19 as medium GL, and ≥ 20 as high GI categories (ADA, 2007).

Studies have shown that diets with high GI or GL may lead to higher glycaemic responses and insulin concentrations (Barazzoni *et al.,* 2017). The increase in glycaemic response and insulin demand overtime could impair the pancreatic beta-cell function, thus causing insulin resistance and glucose intolerance, which eventually lead to type 2 diabetes development (T2D) (Cersosimo and Oliveira, 2012). The GI concept helps to improve postprandial glycaemic responses following carbohydrate-rich meals (Nisak *et al.,* 2010; Shyam *et al.,* 2012).

In Malaysia, various studies have shown the benefits of using the low GI concept in the management of T2D and gestational diabetes mellitus (GDM), as well as to prevent T2D in women with a history of GDM (Nisak *et al.,* 2010; Shyam *et al.,* 2013; Farhanah *et al.,* 2017). The GI concepts have been integrated into professional diabetes guidelines in several countries including United Kingdom (Connor, 2003), Australia (NHRMC, 2001), Canada (Diabetes Canada, 1999), and America (Bantle *et al.,* 2008). In Malaysia, Clinical Practice Guidelines for T2D (MOH, 2009) and Medical Nutrition Therapy T2D (MDA, 2013) support the utilisation of GI in the management of diabetes.

Although the concept has been widely used, a database on Malaysian foods and food products remains scarce. Therefore, this review aims to determine and compile reliable data of GI and GL values of Malaysian foods and food products. The database is essential to support and extend the applications of GI and GL concept in Malaysia. A healthcare professional can use the database to choose the appropriate type and amount of carbohydrate in minimising the postprandial glycaemic responses for the prevention and treatment of T2D.

Literature search strategy

A literature search was performed using the ProQuest and Medline databases until November 2018, using the term "glycaemic index," "glycaemic responses," OR "glycaemic load" AND "Malaysia." The search was restricted to human studies conducted using a standardised methodology. The standardised method for GI testing is published by FAO/WHO, and recently updated (Australian Standard, 2007; ISO, 2010). A manual search of relevant citations was also performed, and respective researchers were also contacted for unpublished studies or conference abstracts/proceedings.

Data organisation

The GI values are expressed with the GI of glucose (GI = 100) as the reference because the scale of glucose is widely used (Atkinson *et al.,* 2008). The original GI value expressed in mean ± SEM. The table is divided into several columns, which include serving size, available carbohydrates, and GL values. Serving size in the tables for each food group are standardised based on the Food Composition Table (Tee, 1997). The amount of carbohydrates were obtained from the reference paper, and if the data was not available, the serving size was derived from the Malaysian Food Composition Table (Tee, 1997). Foods were classified based on the following GI and GL categories; high GI (GI > 70), moderate GI (55 to 70), and low GI (GI < 55); as well as high GL (GL ≥ 20), medium GL (11 to 19), and low GL (GL ≤ 10) (Australian Standard, 2007).

The foods were grouped into 12 groups, according to the Malaysian Food Composition Table (Tee, 1997). The food groups include (1) rice, (2) rice in mixed-meal, (3) bread and bread product, (4) bread with spread, (5) noodle and pasta, (6) cereal-based food, (7) biscuit, (8) starchy root, tuber, and product, (9) traditional *kuih*, (10) beverage, (11) fruit, and (12) sugar and syrup. Within each section, foods were arranged in alphabetical order by their common name.

Results

A total of 83 foods were identified with their GI being extracted from the published data (*n* = 20), conference abstract (*n* = 6), and manufacturer (*n* = 1). Based on the food groups, the foods tested included (1) rice (*n* = 13), (2) rice in mixed-meal (*n* = 8), (3) bread and bread product (*n* = 10), (4) bread with spread (*n* = 4), (5) noodle and pasta (*n* = 10), (6) cereal-based food (*n* = 6), (7) biscuit (*n* = 1), (8) starchy root, tuber and product (*n* = 4), (9) traditional *kuih* (*n* = 14), (10) beverage (*n* = 5), (11) fruit (*n* = 5), and (12) sugar and syrup (*n* = 2). A total of 72 GI values were tested in healthy subjects, six GI values were obtained from patients with T2D, and the other five data did not report the study population, which was performed by the industries. The GL values for five foods were not able to be determined as the data were not available in the Food Composition Table or reference paper. These foods include two types of brown rice long grain, fried rice (not specified), peanut butter and jam sandwich and guava, and *kuih bakar* (Table 1).

Most of the data were the staple foods consumed by Malaysians. From the database, the most

Table 1. Glycaemic index[1] of Malaysian foods.

No.	Food	Glycaemic index (Mean +SE) [2]	GI category	Subject (number and type)	Serving size[5]	Carbs (g)[4]	Glycaemic load	GL category	Reference
	Rice								
1	Basmati Rice (Herbal Ponni)	65 ± 3.0	medium	8, healthy	70 g (1.5 cup)	24.28	16	medium	Lee and Nik (2005b)
2	Brown Rice	60 ± 5.8	medium	10, healthy	100 g (1.5 cup)	77	46	high	Yusof *et al.* (2005)
3	Brown Rice Long Grain (East Coast Malaysia)	64 ± 6.3	medium	10, healthy	NA	NA	NA		Wan Rosli *et al.* (2016)
4	Brown Rice Long Grain (East Coast Malaysia)	72 ± 6.6	high	9, healthy	NA	NA	NA		Wan Rosli *et al.* (2016)
5	High Fibre Rice (Organic Rice Cambodia)	81 ± 7.4	high	10, healthy	100 g (1.5 cup)	69.4	65	high	Yusof *et al.* (2005)
6	Parboiled Rice	57 ± 7.3	medium	10, healthy	100 g (1.5 cup)	22.7	13	medium	Osman (2016)
7	Red Rice (Thailand)	62 ± 6.9	medium	10, healthy	100 g (1.5 cup)	30	19	medium	Osman (2016)
8	White Fragrant Rice (Thailand AAA)	65 ± 7.0	medium	10, healthy	100 g (1.5 cup)	32.47	21	high	Osman (2016)
9	White Rice (Arnab Emas®)	90 ± 12.0	high	12, healthy	100 g (1.5 cup)	30	27↑		Sathyasurya *et al.* (2006)
10	White Rice (Fragrance)	79 ± 7.6	high	10, healthy	70 g (1.5 cup)	55.02	43	high	Yusof *et al.* (2005)
11	White Rice (Polished)	61 ± 5.8	medium	10, healthy	100 g (1.5 cup)	76.8	47	high	Yusof *et al.* (2005)
12	White Rice (Organic Rice Cambodia)	72 ± 8.5	high	10, healthy	80 g (1.5 cup)	63.1	45	high	Yusof *et al.* (2005)
13	White Rice (5% Broken)	87 ± 14.4	high	11, healthy	168 g (1.5 cup)	38.5	33	high	Ngan *et al.* (2012)
	Rice in Mixed -Meal								
1	Coconut Milk Rice (Nasi Lemak)	50 ± 5.0	low	10, diabetes	230 g (1 plate)	45.8	22.9	high	Robert and Ismail (2011)
2	Coconut Milk Rice (Nasi Lemak)	66 ± 5.0	medium	8, obese	230 g (1 plate)	45.8	30	high	Nik Shanita (2005)
3	Fried Rice (Nasi Goreng Kampung)	59 ± 3.9	medium	8, obese	230 g (1 plate)	86.5	51	high	Nik Shanita (2005)
4	Fried Rice (Not Specified)	71 ± 6.0	high	10, healthy	NA	NA	NA		Tan (2010)
5	Fried Parboiled Rice (Nasi Goreng Cina)	38 ± 3.6	low	10, healthy	230 g (1 plate)	52.3	20	high	Osman (2016)

6	Fried Red Rice (*Nasi Goreng Cina*)	43 ± 5.5	low	10, healthy	230 g (1 plate)	68.5	22	high	Osman (2016)
7	Fried White Fragrant Rice (*Nasi Goreng Cina*)	47 ± 6.8	low	10, healthy	230 g (1 plate)	74.7	35	high	Osman (2016)
8	White Rice served with Chicken Curry	41	low	11, healthy	1 cup	69.7	28	high	Ramlah and Edwards (2013)
	Bread and Bread Product								
1	Whole Grain (100%; Gardenia®)	55	medium	NA	2 slc (61.5 g)	16.9	9	low	
2	Whole Grain (Canadian Purple Wheat Gardenia®)[6]	46	low	NA	2 slc (61.5 g)	15.4	7	low	
3	Bran and Wheatgerm Light Fibremeal (Gardenia®)[6]	66	medium	NA	2 slc (61.5 g)	25.2	17	medium	
4	Brown Bread Breakthru (Gardenia®)[3]	36	low	NA	2 slc (50.4 g)	10.4	4	low	
5	Honey Wholemeal High Fibremeal (Gardenia®)[6]	64	medium	NA	2 slc (61.5 g)	19.8	13	medium	
6	Multi-Grains Bread	56 ± 6.2	medium	12, healthy	2 slc (72 g)	22	12	medium	Mohd Yusof *et al.* (2008)
7	Sandwich Sardine	73 ± 2.9	high	8, healthy	2 pc	30.1	22	high	Nik Shanita (2005)
8	White Bread (Gardenia®)	82 ± 6.5	high	12, healthy	2 pc (63 g)	30.1	25	high	Mohd Yusof *et al.* (2008)
9	Wholemeal Bread	85 ± 5.9	high	12, healthy	2 slc	25.2	21	high	Mohd Yusof *et al.* (2008)
10	Wholemeal Bread with Oatmeal	67 ± 6.9	medium	12, healthy	2 slc	25	16	medium	Mohd Yusof *et al.* (2008)
	Bread and Spread								
1	Peanut Butter and Jam Sandwich and Guava	86 ± 30.0	high	10, healthy	NA	NA	NA		Fong (2013)
2	White Bread with Margarine and Sugar	64 ± 10.1	medium	8, healthy	2 slc+ 1 tbsp sugar	44.9	29	high	Nor Muaiza (2005)
3	White Bread with Peanut Butter	54 ± 3.1	low	8, healthy	2 pc	30.1	16	medium	Nor Muaiza (2005)
4	White Bread with Pineapple Jam	55 ± 6.3	medium	8, healthy	2 slc + 1 tbsp jam	32.7	18	medium	Nor Muaiza (2005)
	Noodle and Pasta								
1	Fried Noodles	62 ± 9.0	medium	10, healthy	1 cup	40.2	25	high	Tan (2010)
2	Fried Noodles	61 ± 6.0	medium	10, diabetes	1 cup	40.2	25	high	Robert and Ismail (2011)

3	Fried Noodles	59 ± 9.9	medium	11, healthy	1 cup	40.2	23	high	Osman (2016)
4	Fried, Macaroni	74 ± 3.5	high	8, overweight	1 cup	37.85	28	high	Nik Shanita (2005)
5	Fried, Rice Vermicelli (Product of *Oryza sativa*)	99 ± 8.9	high	8, overweight	1 plate (170g)	40.3	40	high	Nik Shanita (2005)
6	*Kway teow* (Product of *Oryza sativa*)	85 ± 15.0	high	12, healthy	1 cup	34.3	29	high	Sathyasurya *et al.* (2006)
7	Noodles (Plain)	60 ± 6.0	medium	10, diabetes	1 cup	40.2	24	high	Robert and Ismail (2011)
8	Noodles (Plain)	55 ± 6.3	medium	11, healthy	1cup	40.2	22	high	Osman (2016)
9	Noodles with Chicken Soup	44 ± 6.9	low	11, healthy	1 cup	40.2	18	medium	Osman (2016)
10	Spaghetti with Chicken Soup	35 ± 3.6	low	11, healthy	1 cup	37.85	13	medium	Osman (2016)
	Cereal								
1	Flatbread	63 ± 4.0	medium	10, healthy	1 pc (71 g)	50	31.5	high	Robert *et al.* (2016)
2	Flatbread With 10% Fenugreek Powder	43 ± 5.0	low	10, healthy	1pc (74 g)	50	21.5	high	Robert *et al.* (2016)
3	Paratha (Lazat) (Paratha)	71 ± 2.0	high	10, diabetes	1 pc	46	33	high	Robert and Ismail (2011)
4	Paratha with Dhal	64 ± 2.0	medium	10, diabetes	1 pc + ½ cup	52.9	34	high	Robert and Ismail (2011)
5	*Roti Canai*	62 ± 9.21.0	medium	10, healthy	1 pc (99 g)	40	25	high	Tan (2010)
6	*Roti Canai* with Dhal	71 ± 4.6.0	high	8, healthy	1 pc + ½ cup	53.1	38	high	Nik Shanita (2005)
	Biscuit								
1	High Calcium Cracker (Danone™)	52 ± 8.0	low	11, healthy	25	17	9	low	Atkinson *et al.* (2008)
	Starchy Root, Tuber and Product								
1	Sago Porridge	116	high	12, healthy	¼ cup	37.6	44	high	Hishamuddin (2005)
2	Sago Paste	125	high	12, healthy	¼ cup	37.6	47	high	Hishamuddin (2005)
3	Sago Gel	156	high	12, healthy	¼ cup	37.6	59	high	Hishamuddin (2005)
4	Sweet Potato (*Ubi Keledek*: *Ipomoea batatas*)	77 ± 12.0	high	12, healthy	½ cup	21.3	16	medium	Sathyasurya *et al.* (2006)

	Traditional *Kuih*								
1	*Cucur Bilis*	58 ± 8.0	medium	10, healthy	1 pc (18 g)	5	3	low	Osman (2016)
2	*Cekodok Pisang*	56 ± 4.0	medium	10, healthy	1 pc (15 g)	6.25	4	low	Osman (2016)
3	Curry puff (Potato)	54 ± 1.0	low	8, healthy	1 pc	17.6	10	low	Nik Shanita (2005)
4	Doughnut (Dunkin Doughnut™)	57 ± 3.0	medium	8, overweight	1 pc	42.4	24	high	Nik Shanita (2005)
5	Dumpling (Chicken Curry, Kart's)	80 ± 16.0	high	8, healthy	1 pc	35.4	28	high	Lee and Nik (2005a)
6	Dumpling (Lotus Seed, Kart's)	55 ± 5.0	medium	7, healthy	1 pc	44.1	24	high	Nik Shanita (2005)
7	Dumpling (Kart's Red Bean)	51 ± 3.0	low	7, healthy	1 pc	44.1	22	high	Nik Shanita (2005)
8	*Keropok Lekor*	57 ± 4.0	medium	10, healthy	1 pc (21 g)	8	5	low	Osman (2016)
9	*Kuih Bakar*	47 ± 5.0	low	12, healthy	NA	NA	NA		Aminuddin (2010)
10	Lacy Pancakes (*Roti Jala*)	49 ± 6.0	low	10, diabetes	1 pc	25	12	medium	Robert and Ismail (2011)
11	*Popia Goreng*	63 ± 9.0	medium	10, healthy	1 pc (34 g)	11.8	7	low	Osman (2016)
12	*Popia Basah*	78 ± 18.0	high	10, healthy	1 pc (51 g)	11.8	9	low	Osman (2016)
13	*Seri Muka*	51 ± 6.0	low	12, healthy	1 pc	35.9	18	medium	Aminuddin (2010)
14	*Wajik*	57 ± 4.0	medium	11, healthy	1 pc	14.1	8	low	Aminuddin (2010)
	Beverages								
1	Milo 3 In 1 Original	58 ± 3.7	medium	8, healthy	1 sachet	24	14	medium	Pakbaz (2011)
2	Nescafe 3 In 1	51 ± 6.4	low	9, healthy	1 sachet	16	8	low	Pakbaz (2011)
3	Soy Milk (Miko™)	35 ± 5.0	low	8, healthy	300 ml	36.6	13	medium	Pakbaz (2011)
4	Teh Tarik	78 ± 6.5	high	8, obese	1 cup	24.78	19	medium	Nik Shanita (2005)
5	Tropicana Twister Orange Juice	43 ± 4.1	low	7, healthy	1 bottle: 335 ml	24	23	high	Pakbaz (2011)
6	Yakult[6]	46 ± 6.0	low	10, healthy	65 ml	12	6	low	

	Fruit								
1	Banana (*Pisang Berangan: Musa paradisiaca)*	55 ± 12.0	medium	12, healthy	1 whole	15	8	low	Sathyasurya *et al.* (2006)
2	Durian (*Durio zibethinus*)	49 ± 5.0	low	8, healthy	3 piece	15	7	low	Robert *et al.* (2008)
3	Papaya (*Carica papaya*)	58 ± 6.0	medium	8, healthy	1 slc	15	9	low	Robert *et al.* (2008)
4	Pineapple (*Ananas comosa*)	82 ± 4.0	high	10, healthy	1 slc	15	12	medium	Robert *et al.* (2008)
5	Watermelon (*Citrulius vulgaris* – Red Variety)	55 ± 3.0	medium	10, healthy	1 slc	15	8	low	Robert *et al.* (2008)
	Sugars and Syrups								
1	Australian Honey (Wescobee Limited)	59 ± 5.0	medium	8, healthy	15 g	16	9	low	Robert and Ismail (2009)
2	Malaysian Wild Honey (Madu Tualang, Agromas, FAMA)	65 ± 7.0	medium	8, healthy	15 g	16	10	low	Robert and Ismail (2009)

[1]GI value = glucose; [2]Range taken from the study; [3]GI testing run at Glycaemic Research Institute (GRI) – incomplete data; [4]25 g portion of available carbohydrates used; [5]Serving size based on Malaysian Food Composition Table Book; and [6]GI testing run at Sydney University Glycaemic Index Research Service (SUGiRS). Abbreviation: tbsp = tablespoon; tsp = teaspoon; slc = slice; and NA = not available.

common foods with GI values included rice (25.3%) and bread (16.9%), either eaten alone or in mixed meals (Table 2). The least food and food products with the GI values included beverage (0.07%), fruit (0.06%), starchy root, tuber and product (0.04%), sugar and syrup (0.02%), and biscuit (0.01%). Overall, food with the highest GI value was sago (GI = 156; GL = 59), while food with the lowest GI value was spaghetti with chicken soup (GI = 35; GL = 13). The GI value varied even within the same food section. For the rice section, the GI values of 13 types of rice ranged from 57 to 90 with no low GI rice was identified. When the rice was tested in mixed meals (*n* = 8), the GI values ranged from 38 to 71, with five of the foods were categorised as low GI foods.

In the bread section (*n* = 10), the GI values ranged from 36 to 85, with the majority of the bread was classified as medium GI. When the bread was eaten with spread (*n* = 4), the GI value ranged from 54 to 86, with half being categorised as medium GI. For the pasta and noodle (n = 10), half of the foods were classified as medium GI. In this food group, the spaghetti or noodle eaten with chicken soup were categorised as low GI. For the cereal-based product, the GI ranged from 34 to 71 with flatbread added with fenugreek powder had a low GI value. Only one type of biscuit was identified, and it was categorised as low GI. All foods in the starchy root, tuber, and product section were categorised as high GI, ranging from 77 to 156. Most of the beverages (67%) were in the low GI category. The GI value of traditional *kuih* (n = 14) ranged from 47 to 80, with five types of kuih had low GI value. The GI value of fruits ranged from 49 to 82, with the majority of them were in the medium GI category. Similarly, all sugar and syrup (n = 2) were in the medium GI category, with the GI value ranged from 59 to 65.

As for the GL value, from 83 foods, 22.8% were low GL, 21.6% were medium GL, and 49.4% were high GL. Foods with low GL was Brown Bread Breakthru (Gardenia®) (GL = 3, 2 slices per serving), and high GL was High Fibre Rice (Organic Rice Cambodia) (GL = 65, 1.5 cups per serving).

Discussion

This review determines and compiles a total of 83 Malaysian foods and food products along with their GI and GL values. The foods mainly included rice and bread, either eaten alone or in mixed meals, which are the most common foods consumed by Malaysians. There was no low GI rice when eaten alone, but when tested in mixed meals, *i.e.,* a combination of rice with fat and protein, the GI value ranged from 38 to 71 with fried parboiled rice had the lowest GI value (GI = 38). However, for the bread section, the effects were minimal either when eaten alone or in mixed meals. The GI value of bread, when eaten alone, ranged from 36 to 85 as compared to when eaten with spread (GI = 54 - 86). The low GI bread identified was the wholegrain varieties, which was also common in another study (Foster-Powell *et al.,* 2002).

The variation in GI could be due to the food factors that influence the GI value. These factors include processing (Sopade, 2017), starch structure (Kaur and Singh, 2016), the ratio of amylopectin and amylose content (Dutt *et al.,* 2019), type of carbohydrates (Jenkins *et al.,* 2002), fibre content (Gaesser *et al.,* 2019), and the presence of other nutrients (Table 3). In rice varieties, cooking methods influence the extent of starch gelatinisation as they affect the physicochemical properties of the rice varieties. The cooking process typically gelatinises the rice granules, which depend on the

Table 2. Range of GI and GL values within the same group.

Food category	*n*	Range of GI value	Range of GL value
Rice	13	60 - 90	13 - 65
Rice in mixed-meal	8	41 - 66	20 - 51
Bread and bread product	10	36 - 82	4 - 25
Bread and spread	4	54 - 64	16 - 29
Noodles and pasta	10	74 - 99	13 - 40
Cereals based	6	43 - 71	21.5 - 38
Biscuit	1	52	9
Starchy root, tuber, and product	4	77 - 156	16 - 56
Traditional *kuih*	14	51 - 80	3 - 28
Beverage	6	35 - 78	6 - 23
Fruit	5	49 - 82	7 - 12
Sugar and syrup	2	59 - 65	9 - 10

amylose content, granule size, molecular weight, and structure of starch granule. Besides, the amount of water used in the cooking process also influences the degree of hydration of rice and, thus, the extent of gelatinisation (Rashmi and Urooj, 2003).

Furthermore, starch from the milled particles with their cell walls removed is more easily accessible. Thus, it would be digested more quickly than the milled particles with their cell walls intact. Hence, it would increase the glycaemic response (Regand *et al.,* 2009), which influences the GI of the food, such as in white rice (GI = 72 - 90). The types of fibre can also alter GI values of rice and other food products. For example, highly viscous fibre exhibit lower postprandial glucose concentration than insoluble fibre (Riccardi and Rivellese, 1991). This explains why whole grain bread has a lower GI as compared to white and wholemeal bread, or no difference in GI value between white and brown rice. Indeed, the wholemeal bread or brown rice has a higher GI value than their refined counterparts, which could be related to the insoluble form of fibre (Riccardi and Rivellese, 1991). Insoluble fibre has minimal effects on blood glucose levels.

The presence of other nutrients such as fats and proteins in carbohydrate-rich foods influences the GI values of foods. Fat produces a lower glycaemic response by delaying gastric emptying and reduces starch gelatinisation. This can be seen when comparing white rice (GI = 87) with fried rice (GI = 59) (Sun *et al.,* 2014). However, the amount required to make a significant difference to the glycaemic response is more substantial than what would usually be consumed. It requires more than 40 g of fat to make a significant contribution to glycaemic response (Flint *et al.,* 2004; Wolever,

Table 3. Factors influencing glycaemic index.

Food factor	Effect on glycaemic response and glycaemic index
Processing	
Grinding, heat treatment	Higher GI when homogenised
Puffing or popping grain's structure	Higher GI
Milling and grinding	Starch particles within an intact grain are less accessible to digesting enzymes, thus lower GI
Cooking	Increases the digestibility of the starch and therefore GI of some foods
Toasting, freezing, defrosting, or toasting following freezing	Lower GI by promoting recrystallisation of starch chain
Cell wall and starch structure	
Degree of ripeness	Higher when increased ripeness
Heat treatment	Higher GI when gelatinised
Large granules more surface area and more amylopectin	Higher GI
Amylose and amylopectin content	
Amylopectin is branched and more rapidly digestible than amylose.	Higher GI with amylopectin content, Lower GI with amylose content
Added amylase inhibitor	Reduced GI
Monosaccharide's composition	
Type of added sugars, e.g. glucose fructose ratio	Decreased GI with increased fructose
Types of sugar	Increased GI with the ranking fructose, lactose, sucrose and glucose
Food physical structure	
Dense compact structured (e.g. nut) vs. porous foods (e.g. liquid)	Porous structured higher GI as compared to dense compact structured
Other nutrient	
Fat	Reduced GI
Protein	Reduced GI
Gel forming types of dietary fibres	Reduced GI
Organic acids e.g. acetic acid	Reduced GI

2006). Protein may also reduce the glycaemic response and thus, its GI value, by enhancing insulin secretion (Wolever, 2006). This can be seen when comparing the white bread (GI = 82) with white bread with sardine (GI = 73) (Shanita *et al.,* 2011), and white rice (GI = 87) and white rice eaten with curry chicken (GI = 41) (Osman *et al.,* 2017).

Fruits are generally classified as medium GI. The type of carbohydrates, *i.e.,* fructose, the fibre content, and the presence of anti-nutrients such as viscous fibre, can influence the GI of fruits. The ripening process also affects the GI values. During the ripening process, the fructose content in fruits increases while the starches decrease, which influences the GI of the fruits (Jones, 2012). Also, the different GI of fruits is due to soluble fibre such as pectin, which forms a viscous solution that binds to carbohydrates. This could limit the accessibility to α-amylase leading to a reduction in glycaemic response as well as reduce the GI value of fruits (Goñi *et al.,* 2000). The GI of durian is low (GL = 49), mainly due to the fat content in the fruits. Dietary fat influences glycaemic response indirectly by delaying gastric emptying, and thus, carbohydrate absorption would be slow (Wong and Jenkins, 2007).

In beverages, available sugar can influence the GI of the food. Glucose has more glycaemic potential than sucrose, lactose, and fructose (Wolever, 2006), for example, in orange juice (GI = 43), instant coffee (GI = 51), and white bread with pineapple jam (GI = 55). Meanwhile, the presence of the organic acids also influences the GI value by slowing down gastric emptying such in the probiotic drink (GI = 46) (Jones, 2012).

In the starchy roots, tubers and products section, sago in different physical forms had different GI; sago gel (GI = 156), sago paste (GI = 125), and sago porridge (GI = 116). The physical form of the meal can influence gastric emptying. Liquid meals leave the stomach faster as compared to semi-solid meals and solid meals (Ahmad *et al.,* 2009).

The GI of noodles and pasta can be influenced by protein content, types of flour used, and cooking process. Noodles are made of wheat flour with 11 - 13% protein content. Protein delays gastric emptying and subsequently potentiates the effect of insulin on glucose removal from the circulation, thus reducing the GI of food (Ranawana and Kaur, 2013). There are two types of rice-based noodles in Malaysia, which are known as rice vermicelli and *kway teow*. Both of the rice-based noodles are high GI; rice vermicelli (GI = 99) and *kway teow* (GI = 85). The starch granules of rice-based noodles are disrupted during the cooking process. This allows amylose or amylopectin of starch macromolecules to become available for hydrolysis. Hence, the change in particle size might disrupt the granules, which in turn can increase GI value of the food (Yeboah, 2018).

The GL of a food depends on two factors, the GI and the serving size of the food. Low GL foods can be achieved by reducing the GI of the foods or eating a smaller amount of foods. High GI diet can be changed to a low GI diet by exchanging the high GI food with low GI foods. Replacing a high GI diet with low GI diet shows a significant reduction in C-reactive protein which is a precursor for inflammation, and sustains a reduction in postprandial blood glucose (Wolever and Mehling, 2002).

Besides, eating foods in a combination of carbohydrates, proteins, fats, and fibres can also lower the postprandial glycaemic response of the food rather than eating carbohydrate-rich foods only (Meng *et al.,* 2017). The addition of 11 g of fat (Dodd *et al.,* 2011; Meng *et al.,* 2017;) and 6 g of protein (Dodd *et al.,* 2011) reduces the peak rise of postprandial blood glucose. It is thus important to have a healthy balanced meal at each mealtime to achieve a low postprandial glycaemic response.

Conclusion

This is the first compilation of the GI and GL values in Malaysia. Based on the Malaysian Food Composition Table (*n* = 783 foods), only 10.6% of foods have a known GI value, which confirms that the GI values of Malaysian foods are still minimal. From the data compiled, bread, rice, and dough-based products are in the high and medium GI group, while bread with spread falls into the medium GI group. Most Malaysian foods (49.8%) have high GL. High GI foods must be consumed in a smaller amount to reduce the glycaemic load which in turn improve the postprandial glycaemic response. The compiled data of GI and GL could benefit the research and clinical practices in Malaysia. Further GI determination of Malaysian cultural foods such as traditional *kuih* needs to be done to explore the GI classification of the foods, and this knowledge can also be beneficial. GI and GL can be used to help people in making choices regarding carbohydrate-rich foods. The best tool to facilitate food choice is via GI labelling of food items. In Malaysia, only several companies have moved toward this approach. The food labelling needs to be implemented with public awareness through education to make people choose their food product wisely.

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