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BRIEF ARTICLE

Glycemic index and glycemic load of selected Chinese traditional foods

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Abstract

AIM: To determine the glycemic index (GI) and glycemic load (GL) values of Chinese traditional foods in Hong Kong.

METHODS: Fifteen healthy subjects (8 males and 7 females) volunteered to consume either glucose or one of 23 test foods after 10-14 h overnight fast. The blood glucose concentrations were analyzed immediately before, 15, 30, 45, 60, 90 and 120 min after food consumption using capillary blood samples. The GI value of each test food was calculated by expressing the incremental area under the blood glucose response curve (IAUC) value for the test food as a percentage of each subject's average IAUC value for the glucose. The GL value of each test food was calculated as the GI value of the food multiplied by the amount of the available carbohydrate in a usual portion size, divided by 100.

RESULTS: Among all the 23 Chinese traditional foods tested, 6 of them belonged to low GI foods (Tuna Fish Bun, Egg Tart, Green Bean Dessert, Chinese Herbal Jelly, Fried Rice Vermicelli in Singapore-style, and Spring Roll), 10 of them belonged to moderate GI foods (Baked Barbecued Pork Puff, Fried Fritter, "Mai-Lai" Cake, "Pineapple" Bun, Fried Rice Noodles with Sliced Beef, Barbecue Pork Bun, Moon Cakes, Glutinous Rice Ball, Instant Sweet Milky Bun, and Salted Meat Rice Dumpling), the others belonged to high GI foods (Fried Rice in Yangzhou-Style, Sticky Rice Wrapped in Lotus Leaf, Steamed Glutinous Rice Roll, Jam and Peanut Butter Toast, Plain Steamed Vermicelli Roll, Red Bean Dessert, and Frozen Sweet Milky Bun).

CONCLUSION: The GI and GL values for these Chinese traditional foods will provide some valuable information to both researchers and public on their food preference.

Key words: Glycemic index; Glycemic load; Chinese traditional foods

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INTRODUCTION

The glycemic index (GI) was firstly introduced by Jenkins *et al*[1]. It was defined as the incremental area under the blood glucose response curve (IAUC) after a portion of food containing 50 g available carbohydrate expressed as a percentage of that after the same amount of carbohydrate from a reference food, usually glucose or white bread, taken by the same subject. The glycemic load (GL) was more recently introduced to reflect overall glucose response[2,3], and it was calculated as the GI value of the food multiplied by the amount of the available carbohydrate in a usual portion size, divided by 100. GI and GL of foods have been shown to related to some chronic diseases, such as diabetes[2,3], metabolic syndrome[4], cardiovascular disease[5] and even some types of cancers[6]. Low GI and GL diets could contribute to a reduction in body mass in overweight, obese adolescents[7], or coronary heart disease (CHD)[8] and have a small but clinically useful effect on medium-term glycemic control in patients with diabetes[9].

The relevance of dietary GI and GL is still debated[10] and the availability of a reliable table of GI is critical for continuing research and resolution of the controversy. The GI and GL values of over 2480 individual food items were listed in the more recent edition of the international GI and GL tables[10], among which there were only about 50 Chinese foods. Chinese traditional foods, although some styles are very popular and well-known worldwide, are very different from western foods with recipes followed strictly as laboratory instructions.

In some studies investigating the effect of food intake on local people[11,12], there were no precise GI and GL values for many local Chinese foods. They had to use international GI tables to find similar foods or seek for a "best estimate" from experts in this field. These studies indicated that there might be some differences between the estimated GI values and the real values. Furthermore, during recent years the GI and GL values of different local foods have been reported[13-15]. Therefore, it was worthwhile to determine the GI and GL values of Chinese traditional foods so as to advise local individuals on their daily diets and provide tools to undertake related studies in this area. The purpose of this study was to determine GI and GL values of some Chinese traditional foods in Hong Kong, which would be preliminary information which may act as the basis for the development of a GI and GL database for Chinese traditional foods.

MATERIALS AND METHODS

Participants

Fifteen healthy adults (8 males and 7 females, mean ± SE: age, 25.4 ± 1.2 years; BMI, 21.2 ± 0.6 kg/m^2) volunteered to participate in the study. All subjects reported no history of diabetes and all female subjects were non-pregnant and non-lactating. The present study was approved by the University Clinical Research Ethical Committee and all subjects gave written informed consent.

Procedures

The GI values of 23 Chinese traditional foods were determined by using the Food and Agriculture Organization (FAO) recommended methods[16]. All subjects were required to refrain from alcohol consumption and vigorous physical activities 24 h before test. They were required not to consume unusually large meals and have balanced diets on the previous day. After 10-14 h overnight fast, the subjects were required to report to the lab between 8 am and 10 am. On arrival, the subjects rested for around 15 min and the baseline finger-prick capillary samples were collected. Then the subjects consumed either reference (50 g anhydrous glucose) or test foods containing 50 g of available carbohydrate, based on the information from the label of food or from the food nutrition content table provided by the Center of Food Safety, the Government of the Hong Kong Special Administrative Region[17]. Each subject was given 50 g anhydrous glucose 3 times and 25 g anhydrous glucose twice as a reference. Among all the selected foods, 2 foods, which contained both 50 g and 25 g available carbohydrate, were tested twice to compare whether the different portion sizes gave the same result. Only one food contained 25 g available carbohydrate for size limitation.

The intervals between two tests were at least two days. Foods for testing were randomized in blocks of 4 foods[18]. A drink of 250 mL water was served with test food in each test and all foods were required to be consumed within 10 min. Further blood samples were collected at 15, 30, 45, 60, 90, and 120 min after starting to eat. All the blood samples were analyzed with YSI glucose analyzer (YSI 1500, USA; YSI).

The food items included Baked Barbecued Pork Puff (BBPP), Fried Rice in Yangzhou-style (FRYS), Fried Fritter (FF), "Mai-Lai" Cake (MLC), Tuna Fish Bun (TFB), Sticky Rice Wrapped in Lotus Leaf (SRWLL), Steamed Glutinous Rice Roll (SGRR), "Pineapple" Bun (PAB), Jam and Peanut Butter Toast (JPBT), Fried Rice Noodles with Sliced Beef (FRNSB), Egg Tart (ET), Plain Steamed Vermicelli Roll (PSVR), Green Bean Dessert (GBD), Barbecue Pork Bun (BPB), Red Bean Dessert (RBD), Moon Cakes (MC), Glutinous Rice Ball (GRB), Chinese Herbal Jelly (CHJ), Instant Sweet Milky Bun (ISMB), Frozen Sweet Milky Bun (FSMB), Fried Rice Vermicelli in Singapore-style (FRVSS), Salted Meat Rice Dumpling (SMRD) and Spring Roll (SR). All foods were prepared on the test morning or the day before the test; when necessary the foods were steamed by hot water. Because of special cooking methods and habits, some Chinese traditional foods were actually mixed meals. However, they were very popular in China and all of them were prepared by fixed methods. Therefore, the GI value of the same kind of food produced in different places was expected to be similar. The detailed information of each food was listed in Table 1.

Statistical analysis

The individual GI value was calculated by expressing the IAUC for each test food as a percentage of each subject's average IAUC for the glucose. IAUC were calculated ignoring area beneath the fasting level[16,19]. The mean of all the individual GI values for each test food calculated from all subjects was the GI value for that food. GL values were calculated by multiplying GI values of a food by the carbohydrate content of the usual portion

Table 1 Portion size, macronutrient composition and preparation of the test foods

Food Items	Serving (g)	Energy (kcal)	Protein (g)	Available CHO (g)	Fat (g)	Fiber (g)	Sugar (g)	Method of preparation
BBPP	161	708	14.3	50.0	50.0	2.1	9.2	Hoixe Cake Shop, H.K.; Instant
FRYS	217	412	15.2	50.0	17.1	4.8	1.3	Instant
FF	139	653	12.0	50.0	44.5	1.8	1.3	Ocean Empire International Ltd., H.K.; Instant
MLC	114	319	7.8	50.0	9.2	3.0	19.4	Instant
TFB	139	417	15.3	50.0	16.7	1.9	19.5	Maxim's MX, H.K.; Instant
SRWLL	167	351	12.7	50.0	11.2	2.0	3.0	Maxim's MX, H.K.; Instant
SGRR	109	283	5.6	50.0	7.1	1.9	6.4	Instant
PAB	91	319	7.8	50.0	10.0	1.5	9.1	Hoixe Cake Shop, H.K.; Instant
JPBT	106	350	11.7	50.0	11.7	5.5	12.7	Instant
FRNSB	250	350	10.0	50.0	12.8	5.5	1.8	Instant
ET	143	458	7.4	50.0	25.7	1.4	27.2	Maxim's MX, H.K.; Instant
PSVR	238	262	3.1	50.0	5.2	Trace	1.5	Instant
GBD	333	243	8.3	50.0	1.1	5.3	30.6	NISSIN brand, Nissin Foods Co., LTD.; Instant
BPB	119	309	8.7	50.0	8. 7	1.9	16.7	Maxim's MX, H.K.; Instant
RBD	263	247	9.5	50.0	1.0	7.6	26.3	NISSIN Brand, Nissin Foods Co., LTD.; Instant
MC	80	324	6.6	50.0	10.9	2.5	NA	Kee Wah Bakery Shop, H.K.; Instant
GRB	115	424	5.8	50.0	23.1	Trace	30.6	Lee Chun Brand, Lee Chun Food Ltd., H.K.; Boiled
CHJ	333	212	0.0	50.0	0.0	0.0	36.4	Guang Jian Tang Brand, Kwong Tai Agency Co., Ltd.; Instant
ISMB	114	285	4.9	50.0	7.3	2.2	31.9	Instant
FSMB	114	285	4.9	50.0	7.3	2.2	31.9	AMOY Brand, Amoy Food Ltd., H.K.; Frozen, Steamed
FRVS (50 g)	333	533	21.0	50.0	28.0	12.0	3.2	Instant
FRVS (25 g)	167	267	10.5	25.0	14.0	6.0	1.6	Instant
SMRD (50 g)	200	360	11.4	50.0	13.4	3.4	0.7	Ocean Empire International Ltd., H.K.; Instant
SMRD (25 g)	100	180	5.7	25.0	6.7	1.7	0.3	Ocean Empire International Ltd., H.K.; Instant
SR (25 g)	114	388	10.4	25.0	27.4	2.2	2.5	Instant

BBPP: Baked barbecued pork puff; FRYS: Fried rice in Yangzhou-Style; FF: Fried fritter; MLC: "Mai-Lai" Cake; TFB: Tuna fish bun; SRWLL: Sticky rice wrapped in lotus leaf; SGRR: Steamed glutinous rice roll; PAB: "Pineapple" Bun; JPBT: Jam and peanut butter toast; FRNSB: Fried rice noodles with sliced beef; ET: Egg tart; PSVR: Plain steamed vermicelli roll; GBD: Green bean dessert; BPB: Barbecue pork bun; RBD: Red bean dessert; MC: Moon cakes; GRB: Glutinous rice ball; CHJ: Chinese herbal jelly; ISMB: Instant sweet milky bun; FSMB: Frozen sweet milky bun; FRVS: Fried rice vermicelli in singapore-style; SMRD: Salted meat rice dumpling; SR: Spring roll.

sizes of this food, divided by 100. The usual portion sizes of different foods were taken from manufacturers' information or from mean values of testing foods.

The differences in IAUC and GI values between male and female subjects were compared with independent samples *t*-test. The differences in IAUC and GI values between FRVS (50 g) and FRVS (25 g), SMRD (50 g) and SMRD (25 g) were compared with paired *t*-test. The differences in the mean IAUC value and within-subject coefficient of variation for repeated references (CVref) between Reference (50 g) and Reference (25 g) were also compared with paired *t*-test. The results were analyzed using the SPSS for Windows version 12.0 (SPSS, Chicago, IL) software package. The values were presented as mean ± SE and the significance level was set at $P < 0.05$.

RESULTS

All subjects completed the experiment except one subject who did not consume the foods containing 25 g available carbohydrate for individual reasons. The determined GI and GL values of test foods were shown in Table 2.

The mean IAUC value of all the test foods calculated from male subjects (IAUCmale) was lower than that from female subjects (IAUCfemale) (91.10 ± 3.09 mmol·min·L^{-1} *vs* 118.60 ± 4.05 mmol·min·L^{-1}, $P < 0.001$), however there were no differences between the mean GI value of all the test foods determined from data of male subjects (GImale) and that from female subjects (GIfemale) (64 ± 2 *vs* 67 ± 2, $P = 0.224$). When grouped by each test food, there were no differences either in the mean IAUC or GI value between male and female subjects.

The mean IAUC value calculated from the data elicited by 50 g anhydrous glucose (IAUCref50) was higher than that from the data elicited by 25 g anhydrous glucose (IAUCref25) (167.54 ± 14.54 mmol·min·L^{-1} *vs* 108.40 ± 8.86 mmol·min·L^{-1}, $P < 0.001$). However, there were no differences in the mean within-subject CVref (CVref = 100% × SD/mean) (28.00% ± 3.55% *vs* 21.56% ± 3.74%, $P = 0.163$) for the 14 subjects between 50 g and 25 g anhydrous glucose.

The mean IAUC value calculated from the food containing 50 g carbohydrate was higher than that elicited by the same food containing 25 g carbohydrate (FRVS: 89.24

Table 2 Determined GI and GL values of test foods (mean ± SE)

Food items	IAUC (mmol·min·L^{-1})	95% CI (mmol·min·L^{-1})	GI	95% CI	Available carbohydrate (g per serving)	GL (per serving)
Foods containing 50 g available carbohydrate						
BBPP	92.14 ± 10.75	69.08-115.21	55 ± 8	39-72	16.8	9
FRYS	133.70 ± 13.85	103.99-163.40	80 ± 6	67-92	133.6	107
FF	110.83 ± 16.18	76.14-145.52	69 ± 9	50-89	34.7	24
MLC	95.63 ± 12.43	68.97-122.29	61 ± 8	44-79	37.5	23
TFB	79.91 ± 9.78	58.94-100.89	46 ± 4	38-55	31.5	14
SRWLL	137.55 ± 10.81	114.36-160.73	83 ± 5	73-93	107.4	89
SGRR	143.03 ± 12.96	115.24-170.83	89 ± 8	71-107	43.3	39
PAB	106.39 ± 11.69	81.32-131.46	65 ± 8	48-83	33.9	22
JPBT	116.51 ± 11.36	92.15-140.87	72 ± 8	54-90	34.1	25
FRNSB	107.17 ± 12.36	80.66-133.69	66 ± 7	50-81	121	80
ET	74.70 ± 7.82	57.93-91.46	45 ± 3	38-53	22.1	10
PSVR	153.15 ± 18.87	112.67-193.62	90 ± 8	74-107	40.1	36
GBD	90.24 ± 11.54	65.49-114.99	54 ± 6	40-68	33.0	18
BPB	112.11 ± 9.28	92.21-132.01	69 ± 9	51-87	25.1	17
RBD	122.20 ± 11.45	97.65-146.76	75 ± 8	58-91	38.0	29
MC	90.96 ± 9.65	70.26-111.66	56 ± 7	42-70	52.2	29
GRB	98.76 ± 13.04	70.78-126.74	61 ± 10	37-82	95.2	58
CHJ	84.19 ± 7.29	68.45-99.93	47 ± 3	41-52	33.0	16
ISMB	115.44 ± 12.42	88.80-142.07	67 ± 5	57-78	20.8	14
FSMB	114.33 ± 11.52	89.61-139.04	72 ± 8	55-90	14.5	10
FRVS (50 g)	87.41 ± 9.64	66.73-108.10	54 ± 6	41-66	87.5	47
SMRD (50 g)	116.32 ± 14.96	84.23-148.41	69 ± 8	51-87	139.6	96
Foods containing 25 g carbohydrate						
FRVS (25 g)	64.26 ± 11.09	40.30-88.22	58 ± 9	39-78	87.5	51
SMRD (25 g)	85.99 ± 9.15	66.24-105.75	81 ± 7	65-97	139.6	113
SR (25 g)	53.05 ± 7.27	37.34-68.75	50 ± 5	39-60	20.5	10

± 10.17 mmol·min·L^{-1} *vs* 64.26 ± 11.09 mmol·min·L^{-1}, SMRD: 117.23 ± 16.04 mmol·min·L^{-1} *vs* 85.99 ± 9.15 mmol·min·L^{-1}, $P < 0.05$), however there were no differences between the two GI values (FRVS: 55 ± 6 *vs* 58 ± 9, $P = 0.745$; SMRD: 70 ± 9 *vs* 81 ± 7, $P = 0.319$).

DISCUSSION

The availability of reliable GI values of different foods is critical for not only researchers but also common people. The University of Sydney has determined the glycemic and insulin responses to more than 1750 foods and shown that the GI is a reproducible measure of day-long postprandial glycemia[9]. In the more recent edition of international tables of GI and GL[10], over 2480 GI values of individual food items were listed. Because of the close relationship between the food GI and human health, labeling of GI on foods has been proposed or is occurring in Australia, South Africa, Sweden, United Kingdom, and Germany, with several commercial laboratories measuring the GI of foods[20].

During recent years, the GI values of some local foods have been measured in different countries prior to their utilization in research and clinical settings among the local population[13-15]. Since there was little information about GI values of Chinese traditional foods in Hong Kong in the literature, and that had limited the related research in this area[11,12], it was worthwhile to setup a GI and GL database for Chinese traditional foods. However, there are so many traditional and special Chinese foods, according to folk culture, district, religion, and festival. For the famous classes divided by district, there are styles of Guangdong, Beijing, Shanghai, Sichuan, North-West, *etc*. These all above mentioned styles are well-known worldwide. Quite different from Western cooking whose recipes are followed strictly like laboratory instructions, Chinese cooking allows for a creative and stylistic touch to it and it is also one important reason why Chinese foods are always absent in the international GI and GL tables. In this study, by using a recommended standard method, GI and GL values of 23 Chinese traditional foods were determined.

Although GI was a classification of the blood glucose raising potential of carbohydrate foods, many other factors such as food form, particle size, cooking methods, presence of other macronutrients and starch structure, might affect the GI of foods[14,21]. Fat and protein added to carbohydrate foods have been suggested to reduce the postprandial glycemic responses which occurred by different mechanisms, such as delaying gastric emptying[22]; however, most of the studies found that the amount of protein or fat in commonly consumed foods did not affect the glycemic responses[23,24]. It was also found in the present study that no relation existed between the amounts of fats or protein in foods and their GI values.

Though there was a recommended standard protocol for the determination of GI[16,25], there were still some methodological factors which will influence the accuracy in GI determination. According to an inter-laboratory study[21], the GI values of foods were more precisely determined using capillary than venous blood sampling. A recent study[26] also found that the CV of the IAUC values was significantly lower for capillary than for venous blood. So in the present study, capillary blood samples were selected for determining the GI values of foods.

One study suggested that the composition and characteristics of the evening meal might influence glucose tolerance the next morning[27]. However, no difference was found in another study on within-individual variation influenced by subject preparation between controlled trials and uncontrolled trials[28]. Furthermore, a more recent report suggested that simply advising subjects to avoid certain types of foods was almost as good and might be more cost-effective[20]. Thus, in the present study all the subjects were just advised to have a balanced dinner each night before the test. Furthermore, all subjects in the present study were also required to refrain from alcohol consumption and vigorous physical activities 24 h before test, foods for testing were randomized in blocks of 4 foods, and the intervals between two tests were at least two days[16,18].

The FAO recommended the reference food test should be repeated at least three times in each subject[16]. A recent study suggested that no evidence to justify doing 3 tests rather than 2 tests was found because the difference was small and not significant[20]. In our study, the reference of 50 g anhydrous glucose was tested three times to determine the GI and GL values for 20 of the 23 foods.

In the present study, though the mean IAUC values calculated from female subjects were higher than that calculated from male subjects, there were no differences in the mean GI values between them, which is consistent with a previous study[20].

One study showed that GI value was negatively related to the within-individual CVref, and low within-subject variation (CVref < 30%) was required for accuracy in GI determination[20]. Another study also found that most of the variation of GI values was due to within-subject variation, and in normal subjects the mean CVref was about 25.0%[22]. In the present study, both CVref of 50 g glucose and that of 25 g glucose were less than 30%, and there were no differences between the two values. This result might indicate that the determined GI values were accurate in some extent.

No differences were found between the two GI values determined for the same food containing different amounts of available carbohydrate (50 g and 25 g) in this study. It might suggest that when the portion of one food containing 50 g available carbohydrate was too large for subjects to consume, it was appropriate to select the portion of the food containing 25 g available carbohydrate to determine the GI values. The result was consistent with a previous study which showed that the relative glycemic responses to the foods containing different levels of available carbohydrate intake were the same, at least between 25 g and 100 g[29].

In conclusion, the GI and GL values for these Chinese traditional foods in the present study provide some valuable information both to researchers and to common individuals on their food preference and they are also preliminary references on the setup of a GI and GL database for Chinese traditional foods later.

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COMMENTS

Background

The glycemic index (GI) and glycemic load (GL) are closely related to some chronic diseases, however, little was known about the GI and GL values of Chinese traditional foods even in the latest international GI and GL tables.

Research frontiers

Previous studies have shown that GI is a reproducible measure of day-long postprandial glycemia and over 2480 GI values of individual food items were listed in the more recent edition of international tables of GI and GL. The relationship between food GI and human health has been largely investigated and is still one of the research hotspots in this research field. During recent years, the GI values of some local foods have been measured in different countries because most of the published GI data are based on analysis carried out in western countries, while this has limited the application of GI tables to local researchers or common people.

Innovations and breakthroughs

The present study determined the GI and GL values of some selected Chinese traditional foods which are very popular in Hong Kong. The results will provide some preliminary information which may act as the basis for the development of a GI and GL database for Chinese traditional foods.

Applications

The availability of reliable GI values of different foods is critical for not only researchers but also common people. Therefore, the results of this study will provide some valuable information both to researchers and to common individuals on their food preference.

Terminology

GI: GI was defined as the incremental area under the blood glucose response curve after a portion of food containing 50 g available carbohydrate expressed as a percentage of that after the same amount of carbohydrate from a reference food, usually glucose or white bread, taken by the same subject. The differences in the food GI values are mainly related to differences in the rate at which the carbohydrates are digested and absorbed. GL: GL was calculated as the GI value of the food multiplied by the amount of the available carbohydrate in a usual portion size, divided by 100.

Peer review

Blood glucose response to intake of traditional Chinese foods was investigated in this study. The aim of the study is interesting and the study design is good.

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