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Glycaemic Index of Eight Types of Commercial Rice in Malaysia

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ABSTRACT

This experimental study was carried out to investigate the effect of eight types of commercial rice in Malaysia on blood glucose response and to determine their glycaemic index (GI) values. Ten healthy Malay volunteers (7 males, 3 females, BMI=23.6kgm^{-2}, age=25.1years) participated in this study. The eight types of rice tested were three high fibre rice (HFR A, HFR B & HFR C), three white rice (WR D, WR E and WR F) and two fragrant rice (FR G and FR H). The subjects were required to go through the study protocol on eleven separate occasions (eight tests for the test rice samples and three repeated tests for the reference food) after an overnight fasting. Capillary blood samples were taken immediately before (0min) and 15, 30, 45, 60, 90 and 120min after consumption of the test foods. The blood glucose response was obtained by calculating the incremental area under the curve (iAUC). The GI was determined according to the standardised methodology. This study showed that out of eight types of rice tested, three (HFR B, WR E and WR F) could be categorised as having intermediate GI while the remaining five were considered high GI foods (HFR A, HFR C, WR D, FR G and FR H). The GI of HFR B (60 ± 5.8) and WR E (61 ± 5.8) were significantly lower than the reference food (glucose; GI=100) ($p<0.05$). No significant difference of GI value was seen between the reference food and the rest of the test rice ($p>0.05$). The GI value of the rice tested in descending order were HFR C, 87 ± 9.0 followed by HFR A (81 ± 6.7), FR G (80 ± 5.5), FR H (79 ± 7.6), WR D (72 ± 8.5), WR F (69 ± 8.3), WR E (61 ± 5.8) and HFR B (60 ± 5.8). There was no relationship between the dietary fibre content of the rice with the iAUC ($r= -0.05$, $p=0.63$) and GI values ($r= -0.08$, $p=0.46$). This shows that the GI values of the test rice were independent of the dietary fibre content of the rice. Other factors that may influence the GI value of rice include amylose content, gelatinisation process and botanical sources. The results of this study will provide useful information for dietitians and nutritionists in selecting the appropriate type of rice for the daily diet of diabetics.

INTRODUCTION

Rice is the most important cereal crop and the staple food of over half of the world's population. It provides 20% of the world's dietary energy supply. As the primary dietary source of carbohydrate, rice plays an important role in supplying energy and nutrients (FAO, 2004).

Rice is reported to give a relatively high blood glucose response compared with other starchy foods like wheat, millet (*ragi*) and noodles (Chan *et al.*, 2001; Kumari & Sumathi, 2002). Rice has given a

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wide range of glycaemic index (GI) values from studies around the world (Foster-Powell, Holt & Brand-Miller, 2002). The GI of white rice ranges from as low as 54 to as high as 121 (Brand-Miller, Pang & Bramall, 1992). This is likely due to the inherent botanical differences of rice from different countries (Foster-Powell, Holt & Brand-Miller, 2002). Brand-Miller, Pang & Bramall (1992) emphasised the need for individual countries to carry out their own GI testing, particularly with raw agricultural products like rice, which are more likely to vary from one geographical location to another. This variation makes it difficult to classify rice as a high or low GI food, and advice to patients, notably diabetics, may be incorrect.

The GI has been recommended to help guide food choices (FAO/WHO, 1998) because low GI foods have been shown to improve blood glucose control in diabetics (Brand-Miller *et al*., 2003b), reduce serum lipids (Opperman *et al*., 2004), increase insulin sensitivity (Frost *et al*., 1998) and improve B-cell functions (Wolever & Mehling, 2002). In addition, a low-GI diet has been associated with reduced risk of developing diabetes and cardiovascular diseases in some epidemiological studies (Salmeron *et al*., 1997a,b; Liu *et al*., 2000).

Aside from the GI properties, a high fibre diet has been shown to be beneficial in controlling blood glucose and lipid profile (Jenkins *et al*., 2002). In breads, however, the significance of the quantity and quality of dietary fibre in the regulation of postprandial blood glucose is controversial (Juntunen *et al*., 2003). Despite their different dietary fibre contents, white and whole meal breads showed similar blood glucose responses both in healthy volunteers (Juntunen *et al*., 2002) and in diabetics (Jarvi *et al*., 1999).

The objectives of this study are to determine the blood glucose response after consuming eight types of commercial rice in Malaysia and the GI value of each type of rice in healthy Malay respondents. This study also tests the hypothesis that high dietary fibre content of rice reduces the blood glucose response and demonstrates a low GI value.

MATERIALS AND METHODS

Subjects

Twelve healthy Malay volunteers were recruited to participate in this study. Two subjects were excluded from the study, as they were unable to comply with the study protocol. The ten subjects comprised of seven men and three women and their mean age and body mass index (BMI) were 25.1 ± 3.8 years and 23.6 ± 2.3kgm^{-2} respectively (Table 1). The subjects were non-smokers and not on any medication. The subjects were requested to maintain their usual daily food intake and activity throughout the study period. The purpose and protocol of the study were explained to the subjects and their written consent was obtained. This study was approved by

Table 1. Age and anthropometry of the study subjects (n=10)

Subjects Characteristic	*Mean ± SD*	*Range*
Age (years)	25.1 ± 3.8	20-31
Body Weight (kg)	62.8 ± 6.2	55.2-71.0
Height (cm)	163.0 ± 0.1	156-174
BMI (kgm^{-2})	23.6 ± 2.3	20.0-27.5

the Medical Ethical Review Committee of the Hospital University Kebangsaan Malaysia (HUKM).

Test rice and reference food

This study was supported by a research grant from a local rice manufacturer. Therefore, the selection of the eight types of rice tested in this study was based on the samples provided by this rice company. These rice products were high fibre rice (HFR A, HFR B and HFR C), white rice (WR D, WR E and WR F) and fragrant rice (FR G and FR H). HFR A, HFR C and WR D are organic rice imported from Cambodia (Abdul Rahman *et al.*, 2004). These Cambodian varieties especially HFR A have higher dietary fibre content than several varieties of Malaysian rice (Xinhuanet News, 2002), while the HFR B is a brown rice variety that has the outer hull removed but retains its bran layer. Since the bran is not milled, brown rice contains four times the amount of dietary fibre compared to white rice. WR E and WR F are known as polished white rice as the hull and bran layers have been removed. Meanwhile FR G and FR H are categorised as fragrant rice, as these types of rice have flavour and aroma. The different characteristics of the cooked rice were also noted and distinguished by the cohesiveness or dryness of rice, tenderness or hardness, whiteness or other colours, and aroma.

The nutrient analyses of the test rice were carried out by the approved independent laboratory consultant. The protein (N x 6.25), fat and total dietary fibre content were determined using the Kjeldahl method, Soxhlet method and Fiber-tec System, respectively. All the above determinations were based on the method of AOAC (1995) while the total carbohydrate content was calculated by difference.

The rice was prepared according to the manufacturers' instructions and was cooked using a rice cooker six hours before serving. One gram of salt per serving size of rice tested was added to the rice to enhance flavour. Glucose (Glucolin™, The Boots Company, England), which was given as the reference food, was dissolved in 500ml of water. Both test rice and reference food consisted of 50g available carbohydrate. The available carbohydrate was measured as the total carbohydrate content minus total dietary fibre (FAO/WHO, 1998). Table 2 shows the nutrient composition of the rice, their preparation and the weight of uncooked rice to be consumed by the subjects.

Experimental procedures

Subjects were required to go through the study protocol on eleven separate occasions (one test of each rice tested and three repeated tests of the reference food) in the morning after a 10-12h overnight fasting. The tests on the reference food should be repeated three times in order to reduce the variability within the subjects (Wolever, 2003). After fasting blood sample was taken, subjects were requested to consume the test rice with 250ml plain water (during the protocol of the test rice) or the glucose in 500ml water (during the protocol of the reference food) in random order at a comfortable pace within 15 min. They had further blood samples taken at 15, 30, 45, 60, 90 and 120 min after the initial intake. Whole blood samples (32*u*l) were obtained by finger-prick with a lancet (Hemocue Safety Lancet® USA) and were collected into a capillary tube (Selzer® Reflotron, Germany). Blood glucose was assayed using the glucose oxidase method (Wolever *et al.*, 1991) by an automatic glucose analyser (Reflotron-Plus, Roche, Germany).

Data analysis

The blood glucose response for every point of time over two hours was used to

Table 2. Energy, nutrients content, weight of uncooked rice for 50g of available carbohydrate portion and preparation of the test rice

Test rice	*Energy (Kcal)*	*Available carbohydrate (g)*	*Protein (g)*	*Fat (g)*	*Total Dietary Fibre (g)*	*Weight of uncooked rice of 50-g available carbohydrate portion (g)*	*Preparation*
High fibre rice A (HFR A)	271	50	5	2	8.436	74	Boiled for 40 min
High fibre rice B (HFR B)	261	50	5	2	5.400	72	Boiled for 45 min
High fibre rice C (HFR C)	245	50	4	1	4.032	72	Boiled for 35 min
White rice D (WR D)	205	50	5	0	0.868	62	Boiled for 30 min
White rice E (WR E)	225	50	5	0	0.775	62	Boiled for 20 min
White rice F (WR F)	225	50	5	0	0.775	62	Boiled for 20 min
Fragrant rice G (FR G)	225	50	4	0	0.775	62	Boiled for 20 min
Fragrant rice H (FR H)	225	50	4	0	0.775	62	Boiled for 20 min

All nutrient analyses were based on the method of AOAC (1995).

calculate the incremental area under curve (iAUC), ignoring area beneath the baseline for each test individually by encoding in Lotus software (123, CA USA). The iAUC calculation used was as described by the Food and Agriculture Organization of the United Nations (FAO/WHO, 1998).

The GI is the ratio between the iAUC of 50g available carbohydrate of the test rice and the mean iAUC of 50g available carbohydrate of the reference food obtained from the same subjects multiplied by 100. Subjects who had GI exceeding 2s.d were also excluded from the group (known as outliers) and a final GI was recalculated to give each test rice a GI (Sugiyama *et al.*, 2003). The formula of GI calculation follows (Wolever *et al.*, 1991):

$$GI = \frac{\text{iAUC of test rice}}{\text{Mean iAUC of reference food}} \times 100$$

Results were expressed as mean ± SEM. Blood glucose values at each time, the iAUC and the GI values were subjected to repeated measure of ANOVA followed by Tukey's multiple range test. Differences were considered significant if $p \leq 0.05$. The statistical computations were performed using SPSS software (version 11.5).

RESULTS

Characteristics of the cooked rice

The different characteristics of the cooked rice were described based on cohesiveness, or dryness, tenderness or hardness, colour and aroma. The characteristics of the cooked rice are tabulated in Table 3.

Blood glucose response and GI value

Table 4 shows the mean blood glucose at different time points observed after consuming the rice and reference food. No significant difference at time 0 (fasting) among the subjects for each test rice and the reference food ($p>0.05$). There was a significant increase in fasting blood glucose ($p<0.01$) after ingestion of each test rice and the reference food. The test rice,

Table 3. Cooking characteristic of the test rice samples

Test rice	*Cooking Characteristic*
High Fibre rice	
HFR A	Cohesive, slightly hard, brownish, no aroma
HFR C	Cohesive, slightly hard, light brownish, no aroma
Brown rice	
HFR B	Cook dry, fluffy kernel, become hard upon cooling, brownish, no aroma
Polished white rice	
WR D	Cohesive, tender, light brownish, no aroma
WR E	Cohesive, moist, tender, whitish, no aroma
WR F	Cohesive, moist, tender, whitish, no aroma
Fragrant rice	
FR G	Sticky, moist, tender, whitish, aromatic
FR H	Sticky, moist, tender, whitish, aromatic

Table 4. Mean blood glucose responses of subjects at different time point after consuming the test rice and the reference food

Foods	*0 (min)*	*15 (min)*	*30 (min)*	*45 (min)*	*60 (min)*	*90 (min)*	*120 (min)*
High fibre rice A	4.54 ± 0.09	*6.47 ± 0.26	**7.96 ± 0.22**	7.00 ± 0.46	6.23 ± 0.38	5.22 ± 0.21	5.00 ± 0.18
High fibre rice B	4.68 ± 0.13	*5.90 ± 0.20	**7.55 ± 0.31**	6.98 ± 0.27	5.95 ± 0.31	5.06 ± 0.28	4.82 ± 0.26
High fibre rice C	4.71 ± 0.12	*5.75 ± 0.28	**7.82 ± 0.20**	7.54 ± 0.31	6.60 ± 0.36	5.50 ± 0.17	5.60 ± 0.23
White rice D	4.61 ± 0.12	*5.88 ± 0.27	**7.39 ± 0.25**	6.58 ± 0.33	6.13 ± 0.58	5.42 ± 0.24	5.29 ± 0.19
White rice E	4.71 ± 0.09	*6.04 ± 0.25	**7.55 ± 0.15**	6.84 ± 0.31	5.50 ± 0.20	5.27 ± 0.18	5.01 ± 0.10
White rice F	4.78 ± 0.13	*6.23 ± 0.25	**7.96 ± 0.36**	6.96 ± 0.41	6.27 ± 0.41	5.54 ± 0.32	5.10 ± 0.16
Fragrant rice G	4.97 ± 0.14	*6.20 ± 0.23	**8.17 ± 0.18**	7.40 ± 0.29	6.61 ± 0.41	6.01 ± 0.30	5.12 ± 0.21
Fragrant rice H	4.60 ± 0.87	*6.05 ± 0.20	**7.80 ± 0.22**	7.23 ± 0.32	6.10 ± 0.36	5.60 ± 0.26	5.04 ± 0.20
Reference food (Glucose)	4.60 ± 0.09	*7.14 ± 0.20	**8.85 ± 0.15**	7.62 ± 0.29	6.53 ± 0.29	5.61 ± 0.14	4.62 ± 0.24

The blood glucose response at fasting (0min) was not significantly different between each test rice and reference food ($p>0.05$)
*Significant increase in blood glucose response from fasting for all test foods ($p<0.01$)
Values in bold showed the peak blood glucose response that was achieved at 30 min after consumption of all test rice and the reference food

including the reference food, reached peak blood glucose values at 30 min (Figure 1). The iAUC, which reflects the changes occurring in blood glucose level after consuming test rice, was calculated for the blood glucose response over 2 hours (SUGiRS, 1995). In this study, the iAUC of the test foods ranged between 135.11 ± 16.6mmol.min/L and 224.75 ± 19.99mmol.min/L with the reference food yielding the highest response, while WR E showed the lowest response in blood glucose. However, the differences in iAUC value were not significant among the test rice and the reference food (Figure 2).

Brand-Miller *et al*. (2003a) have documented that the GI value can be classified into three categories; low GI food (less than 55), intermediate GI food (56 to 69) and high GI food (more than 70). Table 5 shows the mean value and GI classification of the rice tested. HFR B (60 ± 5.8) and WR E (61 ± 5.8) had significantly lower GI than the reference food (glucose; GI=100) ($p<0.05$) but were not significantly different from the rest of the test rice ($p>0.05$). The GI values of the remaining rice tested were HFR C, 87 ± 9.0 followed by HFR A (81 ± 6.7), FR H (80 ± 5.5), FR G (79 ± 7.6), WR D (72 ± 8.5) and WR F (69 ± 8.3). There was no relationship between the dietary fibre content of the rice with the iAUC (r= -0.05, p=0.63) or GI values (r= -0.08, p=0.46).

DISCUSSION

White and brown rice are considered high GI foods (Brand-Miller, Pang & Bramall, 1992, Chan *et al*., 2001), and GI values of rice over 70 are typical (Brand-Miller *et al*., 2003a). Sugiyama *et al*. (2003) found that the blood glucose response of white rice correlated positively with glucose (r=0.853, $p<0.01$), thus suggesting the feasibility of using white rice as a reference food in the GI study as a replacement of glucose or white bread. In this study, three types of rice tested (HFR B, WR E and WR F) were found as having intermediate GI while the remaining five had high GI values.

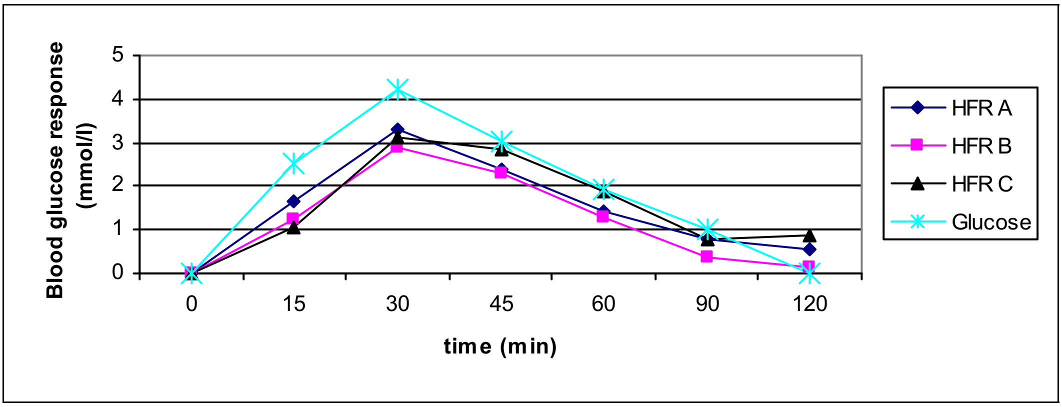
Wide differences in digestibility and GI value of rice products have been ascribed to various factors. These include the fibre content (Augustin *et al*., 2002), the botanical sources (Brand-Miller, Pang & Bramall, 1992), food processing (Sagum & Arcot, 2000), physiochemical properties particularly gelatinisation characteristics (Panlasigui *et al*., 1991), particle size (Holt & Miller, 1994), amylose to amylopectin

Table 5. The glycaemic index (GI) of the rice samples tested

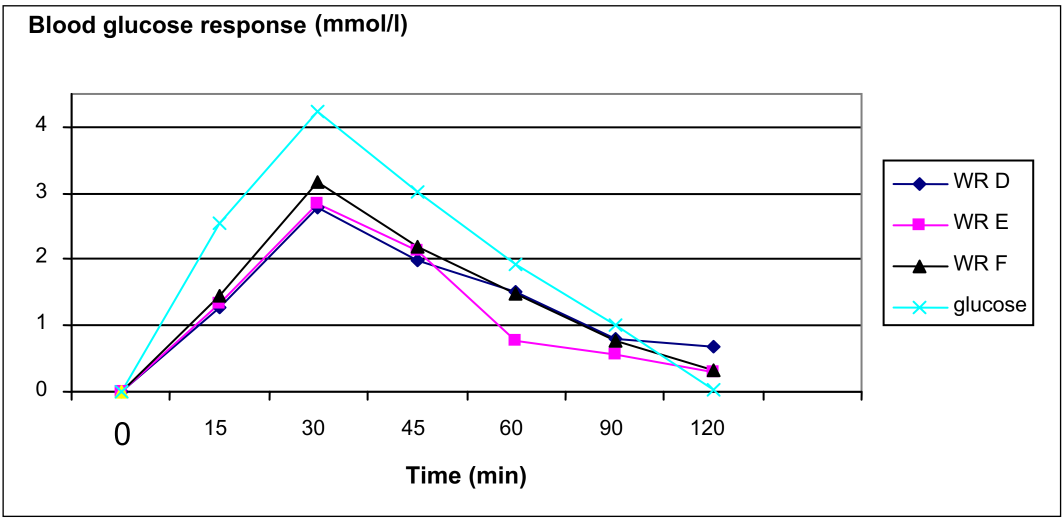
Test rice	*N*	*GI ± SEM*	*GI classification (Brand-Miller et al., 2003a)*
HFR A	10	81 ± 7.4	High
HFR B	9[a]	*60 ± 5.8	Intermediate
HFR C	10	87 ± 9.0	High
WR D	10	72 ± 8.5	High
WR E	10	*61 ± 5.8	Intermediate
WR F	9[a]	69 ± 8.3	Intermediate
FR G	10	79 ± 7.6	High
FR H	10	80 ± 5.5	High

[a]Subject exceeding 2s.d. were excluded from the group
*Significantly lower than the reference food (GI glucose= 100) ($p<0.05$)

(a)



(b)



(c)

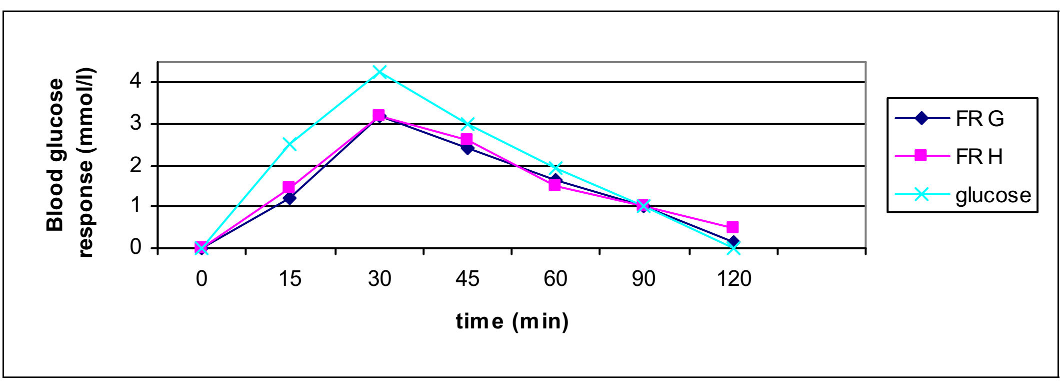


Figure 1. Blood glucose concentration after consuming (a) 3 types of high fibre rice (b) 3 types of white rice, (c) two types of fragrant rice compared with the reference food (glucose). Significant increase in blood glucose at 15 min ($p<0.01$) and peaked at 30 min after consumption of all test rice including reference food. High fibre rice A (HBR A), High fibre rice B (HBR B), High fibre rice C (HBR C), White rice D (WR D), White rice E (WR E), White rice F (WR F), Fragrant rice G (FR G) and fragrant rice H (FR H).

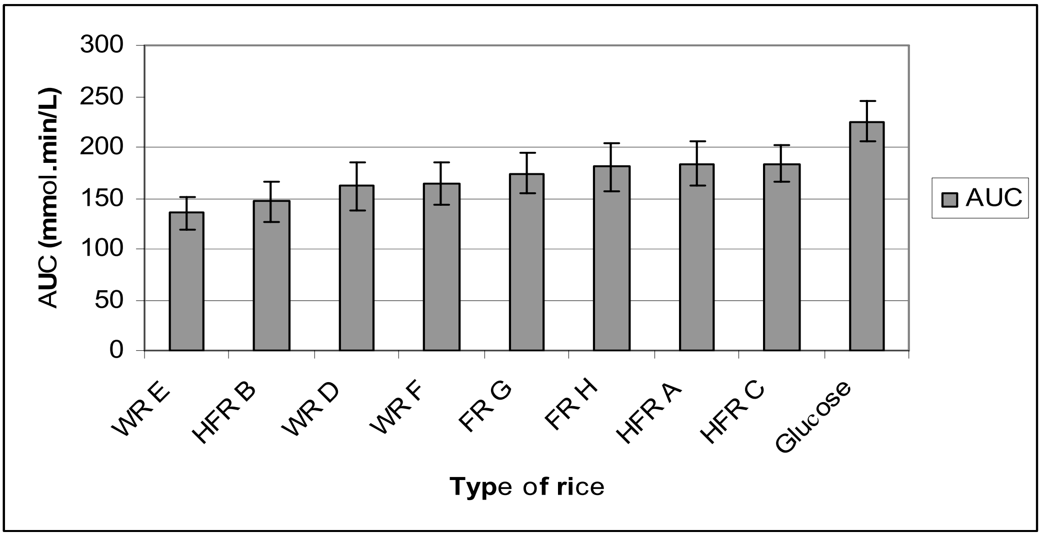


Figure 2. The mean (± SE) blood glucose changes over 2 hours of study after consuming test rice and glucose. The iAUC of each test rice and the reference food were not significantly different (p>0.05). High fibre rice A (HBR A), High fibre rice B (HBR B), High fibre rice C (HBR C), White rice D (WR D), White rice E (WR E), White rice F (WR F), Fragrant rice G (FR G) and Fragrant rice H (FR H).

ratio and the presence of lipid-amylose complexes (Hu *et al.*, 2004).

High fibre rice was believed to be able to reduce the blood glucose response and hence lower the GI of the rice. However, this study found the GI value to be independent of the dietary fibre content of the rice. The relationship between dietary fibre with the postprandial blood glucose and GI value of rice tested was not significant. For example, the GI of HFR A with 11.4g of dietary fibre per 100g of rice is already high (81) whereas WR E and WR F with dietary fibre content of only 1.25g per 100g of rice are classified as intermediate GI. Our finding is in agreement with the study by Juntunen *et al.* (2002), who found that pasta, which gave the lowest glucose and insulin response, contained less dietary fibre than rye breads. Björck & Elmstahl (2003) noted that most wholegrain products such as whole-meal bread, brown rice and whole-wheat spaghetti have GI that are similar to those of their white counterparts. This might be due to their particle size rather than the dietary fibre content itself (Lia & Andersson, 1994). Besides that, only highly viscous soluble fibre was reported to be more effective on postprandial glucose concentration than insoluble fibre (Ricardi & Rivellese, 1991). In this study, the high dietary fibre content of HFR A is predominantly from insoluble fibre (Nutrient Analysis- Unpublished report, September 2004). Therefore, lower postprandial blood glucose might be explained by the differences in the structural properties of the rice and the type of dietary fibre rather than the quantity of dietary fibre consumed per se (Juntunen *et al.*, 2003).

It is clear that the structure of the rice can have a profound effect on the rate of digestibility and the response of blood glucose to the rice (Hallfrich & Behall, 2000). Rice is a polysaccharide consisting of long chains of glucose molecules that are linked together either in the form of amylose or amylopectin. Amylose consists of a linear molecule while amylopectin is highly branched (Brand-Miller *et al.*, 2003a). In general, most rice contains about 20% of amylose and 80% of amylopectin (Brand-Miller, Pang & Bramall, 1992). Rice with high amylose fraction of about 28% such as Basmati and Doongara brown rice have been shown to produce a lower blood glucose and insulin response (Brand-Miller, Pang & Bramall, 1992). Slower rate of digestion after ingesting high amylose rice might be due to the formation of complexes between amylose and lipids upon heating, thus entailing reduced enzyme susceptibility, resulting in a slower rate of digestion whereas amylopectin molecules did not form complexes with most emulsifiers (Guraya, Kadan & Champagne, 1997). Besides that, the glucose units of amylose participate more in hydrogen bonding than do glucose units of amylopectin, making them less accessible to enzymatic digestion. Moreover, amylopectin is a larger molecule than amylose, so that has a larger area for enzymatic attack (Behall & Hallfrisch, 2002). Thus, the classification of rice as low or high GI food may depend on the amylose content of commercial varieties.

Nonetheless, this study did not examine the proportion of amylose and amylopectin in the rice. However, this ratio could be observed from the physicochemical properties of cooked rice (Lu, Chen & Lii, 1997). It is because the amylose content is considered as the main parameter of cooking characteristic and eating quality. The higher content of amylose results in non-sticky or hard cooked rice upon cooling, whereas lowest amylose rice produces soft and sticky cooked rice (Dipti *et al.*, 2004). This study found that HFR B might be high in amylose because it tends to make the cooked rice dry and hard, produces fluffy kernel and requires longer cooking time resulting in the lowest GI value. High-amylose starches require temperatures up to 150^{O}C in the presence of water in order to become fully gelatinised (Van-Amelsvoort & Weststrate, 1992). In contrast, the FR G and FR H, which were moist and sticky after cooking, could be low in amylose, thus have a higher GI value.

Aside from high amylose content, the GI value of rice is also reported to be influenced by the process of gelatinisation. The higher the degree of gelatinisation, the higher the GI value (Brand-Miller *et al.*, 2003a). Gelatinisation occurs when rice granules are heated in liquid until they swell. The swelling of the granules increases their size and directly changes the texture of the rice (Hu *et al.*, 2004). Gelatinisation is dependent on a number of factors such as the amount of water, the temperature, timing, stirring and the presence of acid, sugar, fat and protein (Hu *et al.*, 2004). However, controlling the gelatinisation process in this study is not apparent and requires different investigations focusing on physicochemical properties of rice measured in the laboratory setting.

CONCLUSION

In this study, three type of rice tested (HFR B, WR E and WR F) could be categorised as having intermediate GI while the remaining five were found to have high GI values (HFR A, HFR C, WR D, FR G and FR H). This study also indicates that GI of rice cannot be predicted solely by the content of dietary fibre. Other factors influence the GI value of rice, specifically the chemical properties such as amylose content and gelatinisation process. Studies that determine the amylose content and gelatinisation effects of rice should be undertaken.

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REFERENCES

Abdul Rahman AB, Rohani Y, Saad A, Aini Z, Othman O, Zulkifli M, Sariam O & Azmiman (2004). 4th International Crop Science Congress. <http: //www.regional.org.au/au/cs/2004/poster/2/5/2/553_bakarar.htm> (February 2005).

AOAC (1995). Official Methods of Analysis, 16th ed. AOAC International, Gaithersburg, MD.

Augustin LS, Franceschi S, Jenkins DJA, Kendall CWC & Vecchia L (2002). Glycemic index in chronic disease: a review. *Eur J Clin Nutr* 56:1049-1071.

Behall KM & Hallfrisch J (2002). Plasma glucose and insulin reduction after consumption of breads varying in amylose. *Eur J Clin Nutr* 56:913-920.

Björck I & Elmstahl HL (2003). The glycemic index: importance of dietary fibre and other food properties. *Proc Nutr Soc* 62:201-206.

Brand-Miller J, Foster-Powell K, Wolever TMS & Calagiuri S (2003a). The new glucose revolution: The authoritative guide to the glycemic index. Marlowe & Company. New York.

Brand-Miller J, Pang E & Bramall L (1992). Rice: a high or low glycemic index food? *Am J Clin Nutr* 56:1034-1036.

Brand-Miller J, Petocz P, Hayne S & Colagiuri S (2003b). Low glycemic index diets in the management of diabetes; a meta-analysis of randomized control trials. *Diabetes Care* 26:2261-2267.

Chan HM, Brand-Miller JC, Holt SH, Wilson D, Rozman M & Petocz P (2001). The glycaemic index values of Vietnamese foods. *Eur J Clin Nutr* 55:1076-1083.

Dipti SS, Hossain ST, Bari MN & Kabir KA (2004). Physiocochemical and cooking properties of some fine rice varieties. *Pakistan J Nutr* 1:188-190.

FAO (2004). Rice is life. http://www.fao.org/newsroom/en/focus/200436887/ (February 2005).

FAO/WHO Expert Consultation (1998). Carbohydrate in human nutrition. Report of joint FAO/WHO Expert Consultation paper 66. Rome: FAO Food and Nutrition.

Foster-Powell K, Holt SHA & Brand-Miller JC (2002). International table of glycemic index and glycemic load values. *Am J Clin Nutr* 76:5-56.

Frost G, Leeds A, Trew G, Margara R & Dornhorst A (1998). Insulin sensitivity in women at risk of coronary heart disease and the effect of a low glycemic index diet. *Metabolism* 47:1245-1251.

Guraya HS, Kadan RS, Champagne ET (1997). Effect of rice starch-lipid complexes on in vitro digestibility, complexing index, viscosity. *Cereal Chemistry* 74:561-565.

Hallfrisch J & Behall KM (2000). Mechanisms of the effect of grains on insulin and glucose responses. *J Amer Coll Nutr* 3:320S-325S.

Holt SH & Miller JB (1994). Particle size, satiety and glycemic response. *Eur J Clin Nutr* 48:496-502.

Hu P, Zhao H, Duan Z, Linlin Z & Wu D (2004). Starch digestibility and the estimated glycemic score of different types of rice differing in amylose content. *J Cereal Sci* 20:1-7.

Järvi AE, Karlström BE, Granfeldt YE, Björck IME, Asp N-G, Vessby BOH (1999). Improved glycemic control and lipid profile and normalized fibrinolytic activity on a low glycemic index diet in type 2 diabetic patients. *Diabetes Care* 22:10-18.

Jenkins DJA, Kendall CWC, Augustin LSA, Vuksan V (2002). High-complex carbohydrate or lente carbohydrate foods? *Amer J Med* 113:30S-34S.

Juntunen KS, Laaksonen DE, Autio K, Niskanen LK, Holst JJ, Savolainen KE, Liukkonen KH, Poutanen KS & Mykkanen HM (2003). Structural differences between rye and wheat breads but not total fibre content may explain the lower postprandial insulin response to rye bread. *Am J Clin Nutr* 78:957-964

Juntunen KS, Niskanen LK, Liukkonen KH, Poutanen KS, Holst JJ & Mykkanen HM (2002). Posprandial glucose, insulin and incretin responses to grain products in healthy subjects. *Am J Clin Nutr* 75:254-262.

Kumari LP & Sumathi S (2002). Effect of consumption of finger millet on hyperglycemia in non-insulin dependent diabetes mellitus (NIDDM) subjects. *Plant Foods Hum Nutr* 57:205-213.

Lia Aa & Andersson H (1994). Glycemic response and gastric emptying of oat bran and semolina porridge meals in diabetic subjects. *Scand J Nutr* 38:154-158.

Liu S, Willet WC, Stampfer MJ, Hu FB, Franz M, Sampson L, Hennekens CH & Manson JE (2000). A prospective study of dietary glycemic load, carbohydrate intake and risk of coronary heart disease in US women. *Am J Clin Nutr* 71:1455-1461.

Lu S, Chen L & Lii C (1997). Correlations between the fine structure, retrogradation of amylopectin from Taiwan rice varieties. *Cereal Chem* 74:34-39.

Opperman AM, Venter CS, Oosthuizem W, Thompson RL & Vorster HH (2004). Meta-analysis of the health effect of using glycemic index in meal planning. *Br J Nutr* 92:367-381

Panlasigui LN, Thompson LU, Juliano BO, Perez CM, Yiu SH & Greenberg GR (1991). Rice varieties with similar amylose content differ in starch digestibility and glycemic response in humans. *Am J Clin Nutrition* 54:871-877.

Riccardi G & Rivellese AA (1991). Effect of dietary fibre and carbohydrate on glucose and lipoprotein metabolim in diabetic patients. *Diabetes Care* 14:1115-1125.

Sagum R & Arcot J (2000). Effect of domestic processing methods on the starch, non-starch polysaccharides and in vitro starch and protein digestibility of three varieties of rice with varying levels of amylose. *Food Chemistry* 70:107-111

Salmeron J, Ascherio A, Rimm EB, Colditz GA, Spiegelman D, Jenkins DJ, Stampfer MJ, Wing AL & Willet WC (1997a). Dietary fibre, glycemic load and risk of NIDDM in men. *Diabetes Care.* 20:545-550.

Salmeron J, Manson JE, Stampfer MJ Colditz GA, Wing AL, Willet WC (1997b). Dietary fibre, glycemic load and risk of non-insulin-dependent diabetes mellitus in women. *JAMA.* 277:472-477.

SUGiRS (1995). Sydney University Glycemic Index Research Services <http://www.glycemicindex.com> (May 2004).

Sugiyama M, Tang AC, Wakaki Y & Koyama W (2003). Glycemic index of single and mixed meal foods among common Japanese foods with white rice as a reference food. *Eur J Clin Nutr* 57:743-752.

Van-Amelsvoort JMM & Weststrate JA (1992). Amylose-amylopectine ration in a meal affects postprandial variables in male volunteers. *Am J Clin Nutr* 55:712-718.

Wolever TMS & Mehling C (2002). High carbohydrate low glycemic index dietary advice improves glucose disposition index in subjects with impaired glucose tolerance. *Br J Nutr* 87:477-487

Wolever TMS (2003). Carbohydrate and the regulation of blood glucose and metabolism. *Nutr Reviews.* 61, Suppl 40S-48S.

Wolever TMS, Jenkins DJA, Jenkins AL & Josse RG (1991). The glicemic index :methodology and clinical implications. *Am J Clin Nutr* 54:846-854.

Xinhuanet News (2002). Cambodian Variety of Rice Can Prevent Disease, Says Study. <http://news.xinhuanet.com/english/2002-01/02/content_222263.htm> (February 2005).