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Glycaemic Index of Commercially Available Brown Rice in East Coast of Peninsular Malaysia

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Abstract: Rice is a staple routine food of huge world population including Malaysian. Two brown rice varieties commercially available in East Coast of Peninsular Malaysia were investigated for its Glycemix Index values (GI). The total dietary fiber contents of Long grain specialty 1 (LGS1) and Long grain specialty 2 (LGS2) were 4.19g and 4.79g/100g and significantly higher than white rice which had low dietary fiber (0.15g/100g). Both LS1 and LS2 brown rice samples had 21 % amylose content. The LS1 brown rice had GI value of 64±6.3 while LS2 had GI value of 72±6.6. The difference between mean iAUC of LS1 and LS2 was statistically significant (p=0.6). The iAUC value of LS1 was 110 mmol.min/L while iAUC value of LS2 was 127 mmol.min/L. LS1 could be categorized as having Medium GI while the LS2 was found to have High GI values. The main factors which influence the GI value of rice are specifically the chemical properties such as amylose content and gelatinization process.LS1 could be categorized as having Medium GI while the LS2 was found to have high GI values.

Key words: Brown Rice · Glycemic Index · Amylose Content

INTRODUCTION

Rice serves as staple food for half of the world's population which contributes for more than 21% of total calorie requirement of them and about 76% of South East Asians [1]. People who consumes white rice instead of brown rice and are more likely to get chronic diseases such as diabetes as revealed by meta-analysis [2]. Worldwide prevalence of diabetes was 382 million in 2013 and expected to reach 592 million by 2035 [3] and escalating numbers rapidly in major rice consuming countries in Asia. Pre-diabetes population fed with brown rice instead of white had improved metabolic indicators and lowered risk of type II diabetes [4].

The variations in blood glucose response after consumption of carbohydrate from different sources was first investigated as glycaemic index (GI) and utilized to classify carbohydrate foods [5]. GI is determined as percentage of proportion of incremental area under curve (iAUC) due to blood glucose level of 50 g available carbohydrate from test food and standard food [6]. The International Organization for Standardization (ISO) has classified carbohydrate foods into low (≤55), medium (56-69) and high (≥70) GI foods [7]. Several systematic reviews have highlighted the protective effects of low GI carbohydrate foods on type II diabetes [8], endometrial cancer risks [9], estrogen receptor negative breast cancer [10] and cardiovascular disease [11]. One recent review on intervention studies revealed that health benefits due to low GI foods were found consistent compared to high dietary fibre foods or whole grains. Meanwhile, GI of brown rice has been seen widely varying from low (<55) to high GI (>70) [12]. In this context, the importance of brown rice will be more if it is of low GI value.

Many studies on polished rice have reported that rice differs in starch digestibility and glycaemic response due to variations in amylose: amylopectin ratio, starch lipid complex formation during cooking [13], particle size

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of the food and presence of α-amylase inhibitor (lectin, phytates) [14]. However, the presence of higher content of polyphenols, fibre and lipid as well as degree of gelatinization were considered contributing factors for lower glycaemic response of brown rice compared to polished rice [15]. In addition, intact bran layer which prominently occurred in unpolished rice may limit swelling and leaching of molecules after cooking as well as portion of bran that adheres to starch may prevent digestible enzymes rendering lower glycaemic response.

Aim of the Study: The aim of the present study was to investigate the effects of GI values of commercially available brown rice in East Coast of Peninsular Malaysia.

MATERIALS AND METHODS

Sample Preparation: Two samples of long grain rice specialty variety (*Oryza sativa* L) (5kg each) were purchased from local Hypermarket in Kota Bharu, Kelantan state (East Coast) of Peninsular Malaysia. The identity of Specialty variety was confirmed by the supplier companies. Rice sample was categorized based on dietary fiber content and texture. Both LGS1 and LGS2 were long grain specialty varieties commonly favoured by local rice consumers. Both brown rice samples were cooked by using National brand rice cooker of 4 liter capacity (Made in Japan) for 30 min.

Total Dietary Fibre and Amylose Content: Total dietary fiber content was analyzed according to the methods of AOAC [16] while amylose content was determined according to the method of [17]. One hundred mg of defatted brown rice flour, 1 mL (95% ethanol) and 9 mL of 1 M NaOH were mixed and left for 24 hrs at room temperature. Volume was made up to 100 mL and 5 mL from that was taken, mixed with 2 mL of 0.2/L iodine solution (I2: 2 g/ KI: 20 g/L) and again volume made up 100 mL by distilled water. After incubating the starch: iodine solution for 20 min at room temperature, spectrophotometric measurements conducted at 620 nm wavelength. Besides, standard curves were obtained by using standard potato amylose.

Subjects: Fourteen healthy volunteers were recruited to participate in this study. The subjects (nine Malay and five Chinese) comprised of five men and nine women and their mean age and body mass index (BMI) were 26.1±3.1 years and 23.2±3.0 kgm-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 the Human Research Ethics Committee of UniversitiSains Malaysia.

Determination of Glycemic Index (GI): Subjects were required to go through the study protocol on seven separate occasions (three repeated tests of the reference food and two test of each rice tested) in the morning after 10-12h overnight fasting. The test on the reference food should be repeated three times in order to reduce the variability within the subjects [18]. After fasting blood sample was taken, subjects were requested to consume the brown rice with 250ml plain water (during the protocol of the test rice) or the glucose in 250ml 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 were obtained by finger-prick with a lancet (Accu-Chek Safe-T-Pro Plus). Blood glucose was assayed by a glucometer (HemoCue Glucose 201 RT, Sweeden).

The blood glucose response for every point of time over two hours was used to calculate the incremental area under curve (iAUC). The iAUC calculation used was as described by the Food and Agriculture Organization of the United Nations [6]. The GI is the ratio between the iAUC of 25g available carbohydrate of the test rice and the mean iAUCog 25g available carbohydrate of the reference food obtained from the same subjects multiplied by 100. The formula of GI calculation is as follows [19]:

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

Data Analyses: 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 test. Differences were considered significant if $p \leq 0.05$. The statictical computations were performed using MS Excel 2007 and GraphPad Prism Software (Version 6.01, USA).

RESULTS AND DISCUSSION

Total Dietary Fibre and Amylose Content: Brown rice certainly contained higher total dietary fiber than white rice. Both LGS1 and LGS2 samples were considered as high fiber rice. The total dietary fiber contents of LGS1 and LGS2 were 4.19g and 4.79g/100g (Table 2) and significantly higher than white rice (control) which had low dietary fiber (0.15g/100g). [20] found dietary fibre content of brown rice samples in the range of 4.96 to 8.08 g/100 g in some Indian brown rice. Total dietary fibre of long grain and medium grain (raw) brown rice reported to be 3.88 and 3.99g/100g (USDA National Nutrient Database for Standard Reference 2014). Therefore, the total dietary fibre content of two varieties of commercially available brown rice of Malaysia showed higher values as compared to previous reports.

Amylose content of both LS1 and LS2 was 21.0% (Table 3). This value is considered in the medium classification. A few previous reports showed that brown rice long grain variety (SungyodPhatthalung) cultivated in Thailand had low amylose rice [21, 22] while Chiang Phatthalung variety was found to has medium amylose [21] which was similar to our investigation.

Glycemic Index (GI) Value: The mean and SEM of individual subject mean incremental area under curve (iAUC) of three times repeated reference glucose tests are 169±13 mmol.min/L with coefficient of variation (CV) of 26%. Individual subject mean iAUC was found between 92.1 and 251.6 mmol x min/l. CV produced by individual ranged from 9.6 to 48.4%. [12] has 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). Result obtained from the present study revealed that Long grain specialty 1 (LS1) brown rice had medium GI value (64±6.3) while Long grain specialty 2 (LS2) had a high GI value (72±6.6). Glucose which used as reference food recorded GI value of 100 (Table 4).

The difference between mean iAUC of LGS1 and LGS2 was statistically significant (p=0.6). The iAUC value of LGS1 was 110 mmol.min/L while iAUC value of LGS2 was 127 mmol.min/L. These values were significantly lower as compared to reference food which recorded iAUC value at 170 mmol.min/L. The glycemic responses represented by iAUC of LGS2 test food was significantly lesser than that of reference glucose (p=0.004). However, the GI classification of LS2 test food was not significantly different as compared to the reference glucose (categorized as high GI). Since the GI values of 4 subjects were more than 2SD for LS1 and glucose, thus hence it was identified as an outlier and eliminated. In addition, there were five subject's GI values for LGS2 test food were more than 2SD from the mean. Hence it was identified as an outlier and discarded.

Table 1: Age and anthropometric profiles of the subjects (n=14)

Subjects' characteristics	Mean ± SD	Range
Age (years)	26.1 ± 3.1	21-34
Body weight (kg)	60.6 ± 9.79	48.7-77.9
Height (cm)	161.6 ± 7.6	144.9-175.0
BMI (kgm^{-2})	23.2 ± 3.0	18.5-28.2
SBP (mm Hg)	113 ± 10.0	126-97
DBP (mm Hg)	75 ± 8.0	94-60
Fasting blood glucose (mmol/l)	4.76 ± 0.56	3.77-5.55

Table 2: Total dietary fiber of brown rice commercially available in East Coast of Peninsular Malaysia

Sample	Dietary fiber (g/100g)
Control (white rice)	0.15^{c}
LGS1	4.19^{b}
LGS2	4.79^{a}

$^{a\text{-}c}$Mean in the same column with different letter differ significantly (p<0.05)

Table 3: Amylose content of brown rice commercially available in East Coast of Peninsular Malaysia.

Sample	Amylose content (%)	Amylose classification
LS1	21.0 ± 0.18^{a}	Medium
LS2	21.0 ± 0.31^{a}	Medium

^{a}Mean in the same column with different letter differ significantly (p<0.05)

Table 4: iAUC and GI values of cooked brown rice (n=10)

Variety	Method	iAUC (mmol.min/L)	GI (n=10)±SEM	GI Classification
LGS_1	RC	110 ± 20	64 ± 6.3	Medium
LGS_2	RC	127 ± 15	*72 ± 6.6	High
Glucose	RC	170 ± 13	100	High

Data are mean ± SEM, iAUC=incremental area under curve; *n = 9

White and brown rice are considered high GI foods and GI values of rice over 70 are typical [12]. [23] 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, two types of commercially available rice were tested (Long grain Specialty variety 1, LS1 and Long grain Specialty variety 2, LS2) were found as having 'Medium' and 'High' GI values, respectively (Table 4). Wide differences in digestibility and GI value of rice products have been ascribed to various factors. These include the fibre content [14], the botanical sources, food processing [24] and physiochemical properties.

At 0 min or baseline, difference of mean fasting blood glucose responses between LGS1 and LGS2 was not significant (Figure 1). Mean blood glucose response of LGS1 was 5.2 mmol/l and slightly higher than LGS2 (5.1 mmol/l). Meanwhile, there was almost overlapping of mean glucose responses between LGS1 and LGS2 at 15 min, indicating that there was no significant difference

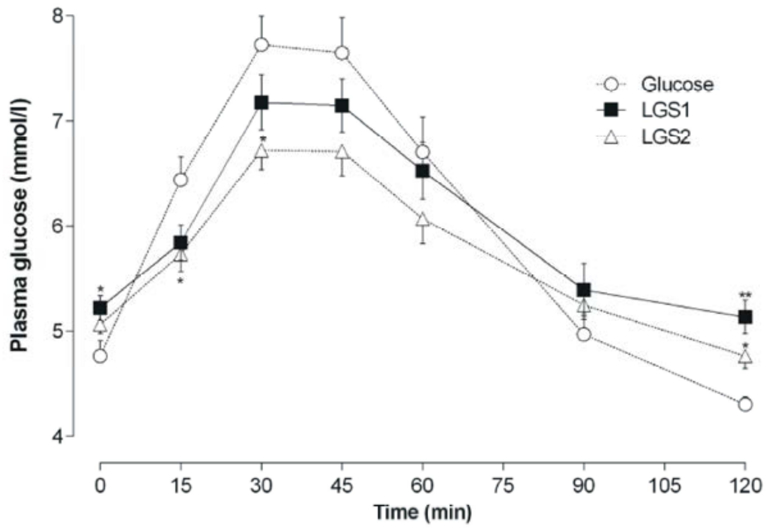

Fig. 1: Mean blood glucose responses of LS1 and LS2

between them as well. Subsequently, at min 30, mean blood glucose response of LGS1 was 7.2 mmol/l and significantly higher than mean blood glucose response of LGS2 (6.7 mmol/l). Finding from this study demonstrated that at min 45, mean blood glucose response of LGS1 was slightly reduced to 7.1 mmol/l and significantly higher than mean blood glucose response of LGS2 which maintained temporarily at 6.7 mmol/l. Next, at min 60, mean blood glucose response of LGS1 was significantly reduced to 6.5 mmol/l and significantly higher than LGS2 (6.1 mmol/l).

However the value of LGS1 was not significant with the mean blood glucose response of reference food (6.8 mmol/l). Following that, mean blood glucose response of LGS1 measured at min 90 showed no statistically significant difference with that of LGS2. The mean blood glucose response of LS1 was 5.4 mmol/l) while the mean blood glucose response of LGS2 was 5.3 mmol/l. Comparing the reference food, difference was not significant too. Finally, at min 120, mean blood glucose responses of LGS1 was significantly higher (5.1 mmol/l) than LGS2 (4.8 mmol/l) and reference food (4.4 mmol/l). Low marginal reduction of mean blood glucose response of LGS1 after 90 min (5.4 mmol/l) until 120 min (5.1 mmol/l) indicated that this sample is able to regulate the blood glucose response of the healthy subjects as compared to reference food (glucose) which reduced down to 4.4 mmol/l at 120 min. This situation is vital in prolonging satiety duration of health individuals after ingestion of brown rice.

A previous study of Malaysian commercial rice (8 varieties) with high and low TDF showed variations of GI with respect to variety irrespective of the content of dietary fibre [25]. Presence of dietary fibre can delay gastric emptying and retards digestion and absorption rate of available carbohydrates in small intestines [26]. On the contrary, other finding showed that soluble fibre had more effect on glycemia [27]. Recently, [28] reported that soluble dietary fibre can slow gastric emptying and macronutrient absorption from the gut while insoluble fibre can increase insulin sensitivity whereby both will control elevation of postprandial glycemic response.

It might be due to difference in degree of gelatinization, deformation of bran layer or leaching of amylose and amylopectin components caused by difference in duration and temperature of cooking. The duration of cooking or boiling decreases the amylose content through leaching and altering the proportion of amylose and amylopectin in the residual starch [24]. Researchers have identified several associated factors which influence GI of starchy foods. A recent study revealed that processing techniques such as steaming and baking caused marked differences on starch digestibility and hence the GI values [29]. High water absorption, swelling as well as high degree of gelatinisation due to difference in processing conditions may influence enzymatic action of digestive enzymes on starch [30]. [31] reported that rice which has high amylose results in harder texture and renders lower digestibility than low amylose varieties. Many studies have reported that features of starch are governed by amylose and amylopectin and their proportion in it [32]. The thick pericarp and aleurone layer present in brown rice may play vital role in cooking behaviour [33].

Three rice varieties namely LP, LS1 and LS2 had similar amylose content (about 21%). However, variations in GI values were observed and the results are in agreement with previous reports which showed that GI variations may occur due to variations in gelatinization properties due to size of starch granule, porosity, presence of non-starch portions as well as presence of thick pericarp layer rather than amount of amylose [15]. It is well documented that brown rice is highly beneficial due to its high dietary fiber, anti-oxidant properties of anthocyanin, flavonoid and germ oil. Long grain LS1 and LS2 were popular in Malaysian community but range of GI values of these two varieties was in medium and high GI category.

CONCLUSION

The LS1 could be categorized as having Medium GI while the LS2 was found to have high GI values. The main factors which may influence the GI value of rice, specifically the chemical properties such as amylose content and gelatinization process. Thus LS1 could be used as routine staple diet in maintaining blood glucose level of healthy individual. Studies that determine the gelatinization effects and other physicochemical and cooking properties of rice should be undertaken.

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