The Effect of Rice Variety and Parboiling on *in vivo* Glycemic Response

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ABSTRACT.   *Improved and traditional rice varieties grown in Sri Lanka namely, Bg 300, Bg 352, Bg 358, Bg 406, LD 356, Rathkaral, Wedaheenati and Heendikwel were studied for their in vivo glycemic response. Proximate compositions and amylose content of rice were determined according to standard methods and available carbohydrate content was calculated using the difference method. The in vivo glycemic response of selected improved and traditional rice varieties was assessed by determining the glycemic index (GI) using ten healthy subjects. Further, the effect of parboiling of rice on glycemic response was also assessed. The crude protein content was higher in parboiled rice as compared to nonparboiled rice. According to the amylose content, rice varieties studied were classified as intermediate and high amylose rice. The amylose content of Bg 406 was the lowest (20.18% ±0.17) while Rathkaral showed the highest (29%±0.07). The Glycemic index of rice varieties studied ranged from 57±1 to 73± 2. The Wedaheenati variety exhibited the lowest GI while Bg 406 exhibited the highest GI value. Unparboiled Bg 406, LD 356 and parboiled Bg 406 were classified as high GI foods while the rest of the rice varieties studied were categorized as intermediate GI foods. Parboiled rice brought about a reduction in glycemic response in healthy subjects. The maximum reduction of 10% in glycemic index upon parboiling was observed with Bg 352. The traditional rice produced significantly lower (p<0.05) postprandial glycemic effect than did the improved rice. By their low post-prandial glycemic response they could be potentially useful in low GI diets.*

Key words: Aamylose, Glycemic index (GI), Parboiling, Rice.

INTRODUCTION

Rice is the dietary staple of the people of Sri Lanka. It comprises of 75-80% carbohydrates as starch. The fact that higher proportion of rice starch is included in the Sri Lankan diet signifies the need for investigating the bioavailability and metabolic responses of rice. There is a considerable variation in bioavailability of carbohydrates among different foods though a higher percentage of carbohydrates in most human diet is digested and absorbed in the small intestine. It has been suggested that diets containing large amounts of rapidly digestible carbohydrates may be detrimental to health as they elevate glucose concentration in blood, which is crucial for diabetics (Jenkins *et al.* 1988). Glycemic index (GI) has been developed for the systematic classification of foods containing carbohydrates, which provides a means of quantitatively comparing the blood glucose responses following ingestion of equivalent

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amounts of digestible carbohydrates from different foods. It has been suggested that low GI foods have beneficial effects in the management of diabetes and hyperlipidemia and high GI foods are crucial as they rapidly elevate glucose concentration in blood (Brand-Miller *et al.,* 2002; Mosdol *et al.,* 2007).

Studies have shown that the digestibility of starch is partly attributed to the inherent properties of starch including crystallinity, granular structure and amylose: amylopectin ratio. Therefore, the type of crop and variety play an important role in determining the rate of digestion of their starch, hence the GI. It has become difficult to classify rice cultivated in the world as high or low GI food based on the results around the world. Glycemic Index of rice has been established as low as 59 to as high as 109 (Miller *et al*., 1992; Frei *et al*., 2003). Some of the commercial rice varieties available in Sri Lanka have shown GI values ranging from 55 to 73 (Hettiarachchi *et al*., 2000) with majority has been classified as medium GI rice.

Sri Lanka produces a range of rice varieties which have been classified according to their grain characteristics. Based on the colour of pericarp, rice is classified as white and red rice whereas it is classified as long (*nadu*) and short (*samba*) rice based on the grain size. Although there is no scientific evidence, people believe that red rice is better in reducing blood glucose levels in diabetics. In this context, the present study was conducted to study the glycemic properties of different types of rice available in Sri Lanka.

MATERIALS AND METHODS

Rough rice samples of improved (Bg 300, Bg 352, Bg 358, Bg 406 and LD 356) and traditional rice varieties (*Wedaheenati*, *Rathkaral* and *Heendikwel*) were obtained from Rice Research and Development Institute, Bathalagoda and Department of Crop Science, Faculty of Agriculture, University of Peradeniya, respectively. Samples of rice were cleaned of extraneous material and dehulled followed by double pass whitening in a laboratory mill (model PM 500). The samples of parboiled rice were prepared by, steeping rice in excess water at room temperature for 8 h followed by steaming until the grains in the top began to split. Steamed rice was then sun dried until the grain moisture content reached 12-14%.

Chemical analysis

The cooked and dried rice were ground to a fine powder in an electric blender and analyzed for proximate composition as per AOAC methods (2000). The available carbohydrate content of each rice variety was calculated using the difference method. Amylose content was determined according to the method outlined by ISO, 6647 (1987) with minor modifications.

In vivo glycemic response

A group of 10 volunteers from both sexes aged between 25 and 45 years with a normal BMI and apparently healthy with no family history of diabetes, impaired glucose tolerance or obesity were selected for the study. The subjects were not on medication for any disease and all were non-smokers. Before being admitted to the study, subjects were given a detailed written and oral explanation of the different procedures involved in the study and written informed consent was obtained from all subjects. Cooking of rice was carried out according to preset conditions adding similar quantity of water and rice and similar duration of cooking for a particular variety of rice. After 10 to 12 h overnight fast, subjects were given cooked

rice portions containing 50 g of available carbohydrates, which were consumed over 10 to 15 min. Test food was given with 5 g of chilli paste and 250 mL of water. Finger prick blood samples were obtained at 0 (fasting), 15, 30, 45, 60, 90, 120 min after the ingestion of the test food. The concentration of glucose in blood was measured using a glucometer. Glycemic response to the test foods was compared with the response to the reference food. Reference food was glucose that was prepared by dissolving 50 g of glucose in 250 mL of water. For each rice type, the incremental area under the curve (AUC) was calculated and compared with the average AUC for the glucose in that particular subject. Any area under the base line was ignored. GI was calculated using the following equation and presented as the mean ± SEM.

$$GI = \frac{Incremental\ AUC\ for\ rice}{Incremental\ AUC\ for\ glucose} \times 100$$

Statistical analysis

Data obtained from each subject were fitted into a completely randomized design (CRD) and subjected to analysis of variance and multiple comparisons to determine statistical differences among varieties at a significance level of 0.05.

RESULTS AND DISCUSSION

Weight of cooked rice portions containing 50 g of available carbohydrate was lowest in unparboiled B*g* 406 (143 g) and highest in B*g* 300 (195 g) (Table 1). All rice types contained approximately the same quantity of crude protein, crude fiber, crude fat and ash. The rice varieties with red pericarp contained significantly (p<0.05) higher crude fiber content than did the rice with white pericarp. The results further showed that the crude protein content in parboiled rice was relatively higher as compared to their unparboiled counterparts.

The postprandial blood glucose level (Fig. 1) reached a peak 30 min after the ingestion of unparboiled rice. Among the rice varieties, the maximum peak was observed with *Rathkaral* whereas B*g* 406 exhibited the lowest peak in blood glucose response curve. The area under the curve for blood glucose response to all rice varieties were significantly (p<0.05) lower than that observed for pure glucose.

**Table 1. Proximate composition and weight of cooked rice portions equivalent to 50 g available carbohydrate**

Variety	Weight of portion (g)	Moisture (g)	Crude protein (g)	Crude fibre (g)	Ash (g)	Crude fat (g)
Bg 300 UPB	195	141.74	2.50	0.38	0.33	0.20
Bg 352 UPB	162	108.74	2.14	0.38	0.26	0.23
Bg 358 UPB	150	96.26	2.21	0.43	0.38	0.31
Bg 406 UPB	143	90.03	2.23	0.55	0.34	0.26
Bg 356 UPB	149	94.79	2.67	0.52	0.29	0.28
Rathkaral UPB	181	127.22	2.76	0.52	0.26	0.31
Wedaheenati UPB	191	136.92	3.16	0.59	0.28	0.34
Heendikwel UPB	173	119.58	2.69	0.52	0.34	0.32
Bg 352 PB	159	104.46	3.50	0.39	0.26	0.32
Bg 358 PB	147	92.86	3.24	0.42	0.29	0.38
Bg 406 PB	146	92.11	3.59	0.57	0.29	0.32
Bg 356 PB	143	89.86	2.59	0.50	0.26	0.33

PB –parboiled, UPB- unparboiled

The peak blood glucose response was observed 45 min after the ingestion of parboiled rice. This reveals that the parboiled rice takes longer time to be digested in healthy subjects compared to the unparboiled rice (Fig. 1. b through e).

As shown in Table 2, the GI of rice varieties investigated in the present study ranged from 57±1 to 73±2. Result showed that there were significant differences in the glycemic responses of healthy individuals to different varieties of rice. Traditional rice variety *Wedaheenati* exhibited the lowest, whereas B*g* 406 exhibited the highest GI. According to the categorization of carbohydrate rich foods based on GI, the rice varieties studied can be classified as high and medium GI (Table 2). Parboiled and unparboiled BG 406 and unparboiled LD 356 fell into high GI foods whereas all other rice varieties studied fell into medium GI rice. Both parboiled and unparboiled B*g* 406 samples yielded low GI values. Unparboiled B*g* 356, 352, and 358, and both parboiled and unparboiled B*g* 406 exhibited significantly (p<0.05) higher GI values among the rice varieties studied.
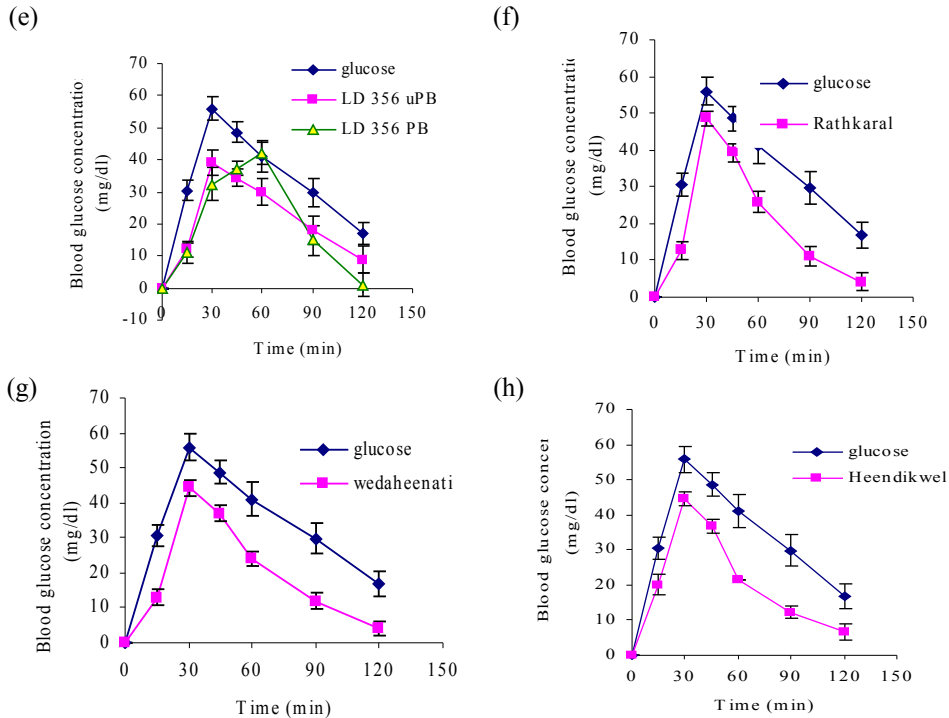
(a)

(b)

(c)

(d)
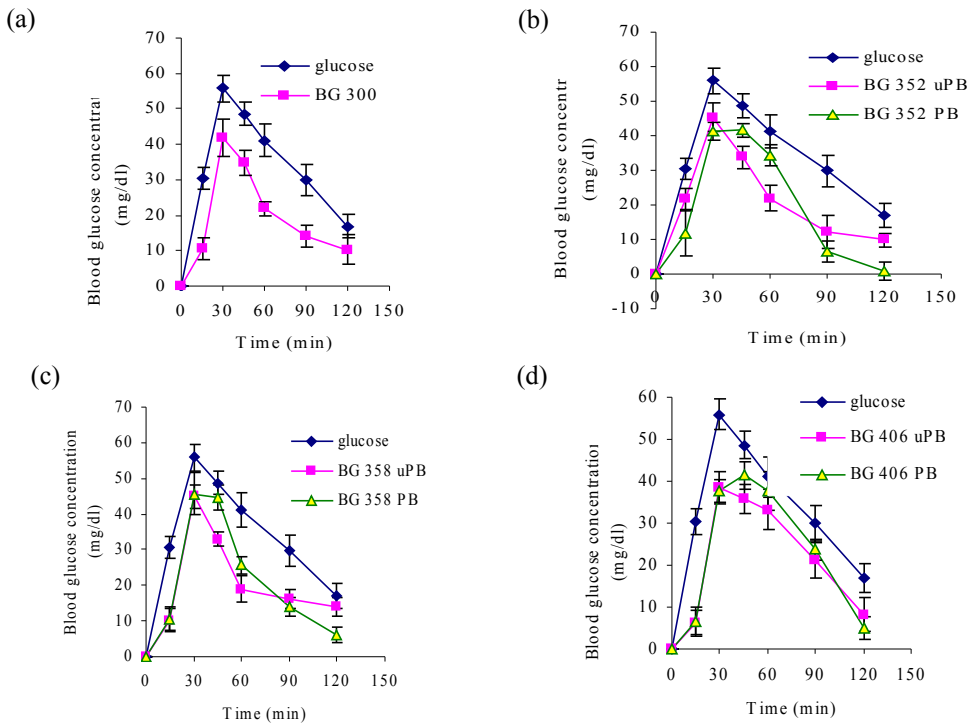
Fig. 1. **Postprandial glucose responses to different improved and traditional rice varieties in healthy subjects (a) B*g* 300, (b) B*g* 352, (c) B*g* 358 (d) B*g* 406 (e) LD 356 (f) *Rathkaral* (g) *Wedaheenati* and (h) *Heendikwel.* PB – parboiled and uPB – unparboiled.**

Diets that result in gradual and slow increase in postprandial blood glucose concentration are gaining increased attention as they can potentially reduce the risk of diseases related to impaired glucose metabolism (Brigheuti *et al*., 2006). Therefore, majority of the rice varieties studied which fall into medium GI foods would be beneficial to balance blood glucose level in diabetics when they are incorporated in their diets.

Results of GI studies around the world reveal that GI of rice varies widely among different cultivars or varieties. Miller *et al*., (1992) noticed GI values ranging from 64±9 to 93±11 for rice. GI values ranging from 68 to 109 were observed by Frei *et al*. (2003). These results revealed that some rice varieties produce larger glycemic response as high as the glycemic response produced by glucose or white bread. However, as compared to the above results, the varieties considered in the present study showed comparatively low GI values.

Starches with high amylose content are less susceptible to hydrolysis by α- amylase mainly because amylose has a larger molecule size than amylopectin and does not have a branched, but a linear structure (Fitzgerald, 2004). The amylose content of the rice varieties investigated in the present study varied from 21.50%±0.30 to 29.5%±0.36 (Table 2). There was a significant ($p < 0.05$) negative correlation between GI and amylose content. This is in accordance with the findings of Miller *et al*. (1992). They have also reported that the rice with higher amylose content gives a significantly lower GI than did the rice with low

amylose content. However, others have reported a non significant correlation between amylose content and digestibility of starch (Frei *et al.*, 2003).

Rice varieties cultivated in Sri Lanka are generally classified as white and red rice based on the colour of the pericarp. The unparboiled red rice is popular among patients with diabetes in Sri Lanka. However, the results of the present study do not support this belief. ANOVA showed that rice with red pericarp does not give significantly low GI, and poor correlation between grain colour and GI was exhibited in the correlation analysis. In this study, red rice varieties *Heendikwel*, *Rathkaral* and *Wedaheenati* gave comparatively lower GI of 62, 60 and 57, respectively.

Table 2. Glycemic index and amylose content (% dry wt basis) of different rice varieties

Variety	Amylose content (%)	GI $\pm$ SEM (n = 10)	GI category
Bg 300 UPB	27.1±0.16[c]	61 $\pm$ 3[a]	Medium
Bg 352 UPB	27.0±0.17[c]	67 $\pm$ 3[b]	Medium
Bg 358 UPB	29.0±0.52[d]	67 $\pm$ 6[b]	Medium
Bg 406 UPB	24.5±0.70[b]	73 $\pm$ 2[b]	High
LD 356 UPB	21.5±0.30[a]	70 $\pm$ 2[b]	High
Rathkaral UPB	29.5±0.06[d]	60 $\pm$ 2[a]	Medium
Wedaheenati UPB	29.0±0.36[d]	57± 1[a]	Medium
Heendikwel UPB	27.7±0.19[c]	62 $\pm$ 2[a]	Medium
Bg 352 PB	n.d.	60 $\pm$ 2[a]	Medium
Bg 358 PB	n.d.	62 $\pm$ 2 [a]	Medium
LD 356 PB	n.d.	64 $\pm$ 5[a]	Medium
Bg 406 PB	n.d.	71 $\pm$ 2[b]	High

Means within the same column bearing different superscripts are significantly (p<0.05) different. PB –parboiled, UPB- unparboiled, n.d. – not determined.

Bg 406 and LD 356 showed significantly (p<0.05) higher GI values than Bg 300, Bg 352 and Bg 358 although they have a red pericarp. These observations indicate that the GI of a rice variety could not be predicted based on its grain colour. However, Perera and Jansz (2000) have suggested that parboiling and red pigment together can slow down the enzymatic hydrolysis of starch.

The results revealed that parboiling tends to reduce the glycemic response in healthy subjects (Fig. 2). Results of ANOVA exhibited that a significant (P< 0.05) difference exists between the observed GI of parboiled and unparboiled rice. The maximum reduction in GI of 10% upon parboiling was observed in B*g* 352. The retrogradation of starch brought about by parboiling of rice could be attributed to the reduced GI in parboiled rice compared to their unparboiled counterparts. Moreover, the presence of higher proportions of amylose in the starch may promote the retrogradation of starch in this rice variety. In addition, protein was found to reduce the access of enzymes to starch through physical encapsulation and starch-protein interactions are reported to reduce the digestibility of starch in wheat bread (Jenkins *et al.*, 1987). However, the protein content of wheat bread is higher than that of rice. With respect to the protein content of rice varieties used in the present study, parboiled rice

contained higher protein content than unparboiled rice. According to these results, it could be further suggested that the observed low GI of parboiled rice may perhaps be due to the high protein content and increased physical hardness of the grains for digestion.
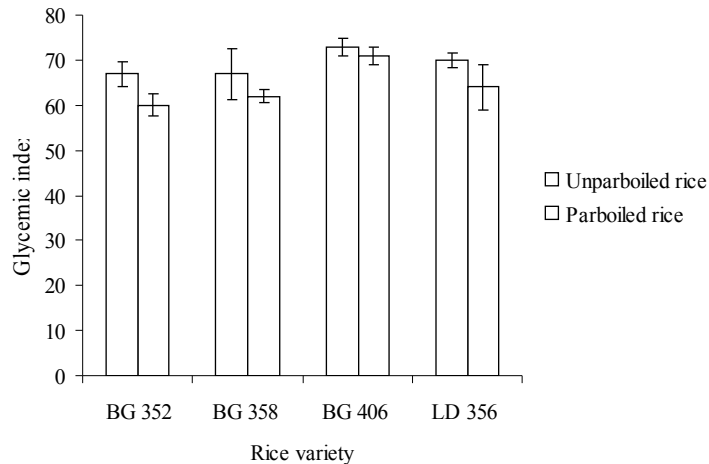

Fig. 2.   Effect of parboiling on glycemic index of selected improved rice varieties

In addition to the improved rice varieties grown in Sri Lanka, there are traditional rice varieties which fueled the diet of Sri Lankan people in the past. The extinction of traditional rice has begun with the evolution of improved varieties and the latter became more popular due to improved characteristics such as resistance to pests and diseases, higher yields and better cooking and eating characteristics. However, consumers still believe that traditional rice has better nutritional properties and they tend to keep them under satire condition for a long time. Among the traditional rice varieties, *Rathkaral*, *Wedaheenaty* and *Heendikwel* are three varieties commonly consumed by Sri Lankans. Results revealed that, traditional rice produced a significantly ($P< 0.05$) lower postprandial glycemic effect than did the improved varieties. The lowest GI among all the rice varieties studied in the present study was observed in *Wedaheenati*. Moreover, the parboiled rice of improved varieties except B*g* 352, showed higher GI compared to unparboiled rice of traditional varieties. According to these results, it could be suggested that traditional rice possibly possess beneficial effects for health since they tend to be digested slowly compared to improved rice.

CONCLUSIONS

The amylose content of rice shows a strong negative correlation with the GI value of rice. Parboiling generally reduces the GI of most of the rice varieties. The traditional rice varieties studied exhibit lower GI than improved rice vareties. The colour of the grain pericarp does not appear as a good indicator in predicting its glycemic index. Based on the results of the present study, it can be concluded the GI value varies significantly with the rice variety Moreover, the GI of the rice varieties investigated in the present study ranged in the moderate and high GI foods. These varying results emphasize the need to carry out glycemic index testing for other rice varieties available for consumption in Sri Lanka.

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