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Sri Lankan Rice Mixed Meals: Effect on Glycaemic Index and Contribution to Daily Dietary Fibre Requirement

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ABSTRACT

Introduction: The glycaemic index (GI) concept ranks starchy foods according to the blood glucose responses following ingestion. When considering commonly consumed Sri Lankan meals, only a few can be categorised as low GI. However, a significant negative correlation between the GI of Sri Lankan meals and fibre content has been observed indicating the potential to reduce the GI of meals by incorporating naturally occurring sources of fibre. Thus, the objective of this study was to study the effect of increased edible quantities of fibre on the GI of rice meals consumed in Sri Lanka. **Methods:** Meal 1 consisted of rice with several meal accompaniments (lentil curry, boiled egg, coconut gravy and *Centella asiatica* (*gotukola*) leaves salad). Meal 2 contained similar constituents as meal 1 and a *Lasia spinosa* (*kohila*) rhizome salad. The composition of meal 3 was similar to meal 2 but contained *Trichosanthes cucumerina* (snake gourd) salad instead of *Lasia spinosa* salad. Meal 3 contained similar fibre contents as meal 1 and similar meal size as meal 2. The glycaemic indices of the three meals were determined with healthy individuals (n=10, age =20-30 yrs, BMI=24±3 kg/m^2) using bread as the standard. **Results:** Meals 1 and 3 contained total dietary fibre (TDF) contents of 15.2g. Meal 2 contained 16.3g TDF. The GI values of the three meals were 63±5, 57±5, 61±5 respectively and were not significantly different from one another (p>0.05). The GI of the rice mixed meal 2 was reduced by 9% when total edible dietary fibre content of the actual meal was increased by 7.2%. **Conclusion:** The study results show that the GI of rice mixed meals may be reduced by including naturally occurring sources of fibre with starchy staples while fulfilling daily dietary fibre requirement of an adult at low cost.

Keywords: *Centella asiatica,* dietary fibre, glycaemic index, *Lasia spinosa,* rice meals

INTRODUCTION

According to the glycaemic index (GI) values, foods are categorised as low, medium and high GI foods (Beals, 2005). Low GI foods with a slow and prolonged glycaemic response have shown beneficial effects with regard to reducing the post-prandial glycaemic responses of diabetic individuals (Arvidsson-Lenner *et al*., 2004) as well as

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avoiding excessive insulin response and hyperglycaemia between meals in healthy individuals (Arvidsson-Lenner *et al.*, 2004).

Most of the foods with a low or medium GI are reported to contain considerable amounts of dietary fibre (Bjorck *et al.*, 1994; Liljeberg & Bjorck, 1994). Dietary fibre is categorised into two types, i.e., soluble dietary fibre (SDF) and insoluble dietary fibre (IDF). Among the two types of dietary fibre the SDF fraction has shown a more promising effect on lowering post-prandial blood glucose response (Braaten *et al*., 1991). The cellulose and uronic acid (IDF) of the insoluble component have also shown a significant negative relationship ($p<0.01$) with GI (Wolever, 1990) indicating the impact of IDF on GI. Low GI foods containing high fibre have also shown beneficial effects with regard to managing obesity (Bornet, Billaux & Messing, 1997). This has been attributed to the increased satiety associated with high fibre foods and reduction of appetite due to decreased rate of digestion and absorption of the said foods (Havel, 2001)**.**

When considering Sri Lankan meals, only a few basic foods and meals can be categorised as low GI (Hettiaratchi, Ekanayake & Welihinda, 2009(a); Widanagamage Ekanayake & Welihinda, 2009). However, a significant negative correlation between GI of Sri Lankan meals and fibre contents (IDF, SDF, TDF (Total Dietary Fibre)) had been observed (Hettiaratchi, Ekanayake & Welihinda, 2009 (b)) indicating the potential to reduce the GI of meals by the inherent fibre in the foods.

Among the meals analysed previously by the authors with non-diabetic individuals (Hettiaratchi *et al*., 2009 (b)), two rice meals, i.e., meal A (red rice meal) and meal B (red rice mixed meal), elicited significantly different ($p<0.05$) GI values (meal A; GI = 99 ± 10 and meal B; GI = 60 ± 5). Meal B contained an increase of TDF by 5 g, protein / fat by 10 g compared with meal A (Hettiaratchi *et al*., 2009 (b)). Thus, the present study focused on the effect of a further increase in dietary fibre content while maintaining the normal edible portion size and palatability on the subsequent GI. This study was carried out by serving meals containing rice as the starchy staple. Rice was selected as the staple food as it enables inclusion of a variety of accompaniments that will provide good quality nutrients giving rise to a balanced diet.

METHODS

The enzymes were purchased from Sigma Chemical Company (St. Louis, MO, USA) and Roche Diagnostics (Mannheim, Germany). All the chemicals used were of analytical grade and purchased from BDH (Poole, England).

Rice meals

Meal B from the previous study (Hettiaratchi *et al*., 2009 (b)) was taken as meal 1 in the present study. Compositions and preparations of the test meals are presented in Table 1 and meals were prepared according to standard methods. The quantities of accompaniments in meals 1-3 were adjusted to resemble edible portions. The same red rice variety (AT 353, Rice Research Institute, Batalagoda, Sri Lanka) used in the previous study was used in the present study.

Estimation of chemical compositions of meals

Chemical compositions of rice and meal accompaniments were determined using processed dried flour. Digestible starch content was determined according to the method of Holm *et al.*(1986) and dietary fibre contents by Asp, Hallmer & Silijestrom (1983).

Subjects

Healthy, non-diabetic individuals aged 20-30 years (n=12) and not taking any

Table 1. The compositions of meals and portion sizes of rice and meal accompaniments

Meal	*Preparation method*	*Portion sizes*
Meal 1:		
Red rice	Rice was boiled with water (1:2; w:v) in a rice cooker.	185 g
Lentil curry	Lentils (200 g) were boiled with water (400 mL) and spices for 10 min. Lentil curry was prepared by adding coconut milk (60 mL), salt (20 mL), green chilli (10 g) and curry leaves (5 g). Curry was tempered with chopped onions (10 g) and garlic (5 g).	75 g
Boiled egg	Eggs were boiled for 10 min.	25 g
Centella asiatica (*Gotukola*) salad	Chopped leaves (100 g) were mixed with coconut scrapings (50 g), onions (20 g), garlic (10 g), green chilli (10 g), salt powder (10 g) and lime.	
Coconut gravy (*Kiri hodi)*	Coconut milk extracts (175 mL) were boiled with onions (10 g), garlic (5 g), green chilli (10 g), curry leaves (5 g) and turmeric powder (1 g) for ~ 15 min.	30 mL
Meal 2:		
Constituents of meal 1 & *Lasia spinosa* (*kohila*) salad	*Lasia spinosa* rhizome was cut into small pieces (100 g), was mixed with chopped onions (25 g), garlic (10 g), green chilli (10 g), salt powder (10 g) and lime.	25 g
Meal 3:		
Constituents of meal 1 & *Trichosanthes cucumerina* (snake gourd) salad	*Trichosanthes cucumerina* flesh was cut into small pieces (100 g), and mixed with the same ingredients as in the previous salad.	25 g

medication with a BMI range of 24 ± 3 kg / m^2 participated in determining the GI.

Determination of glycaemic indices of test meals

Blood glucose responses to the three meals were determined by serving 50 g available carbohydrate portions of the meals. White sliced bread was used as the standard and given on two separate occasions. The study design was a random cross-over.

Capillary blood samples were taken after an overnight fast of 10-12 hours. A 50 g available carbohydrate portion of test meal / standard was given with water (250 mL) to be consumed within 15 minutes. Further blood samples (50 –100 μL) were obtained at 30-, 45-, 60-, 90- and 120-minute intervals after the first bite. On separate mornings, 50g available carbohydrate portions of test meals mentioned in Table 1 and standard were given and blood samples drawn as described above. Blood glucose concentrations were estimated with the enzymatic kit (GOD-PAP, Biolabo, France). Incremental areas under curves (IAUC) of the standard and test foods were calculated for each individual. GI was calculated as a ratio between the IAUC of the test food and the standard (FAO / WHO, 1998; Brouns *et al.*, 2005).

Table 2. Fibre contents, GI, IAUC and peak blood glucose concentrations of meals

Parameter	*Meal 1*	*Meal 2*	*Meal 3*
IDF (g)	10.1	11.0	10.1
SDF (g)	5.1	5.3	5.1
TDF (g)	15.2	16.3	15.2
GI ± SEM	63 ± 6	57 ± 5	61 ± 5
IAUC ± SEM	129 ±17	119 ±17	128 ± 19
*Incremental peak blood glucose concentration (mmol/L)	2.34	2.27	2.27

Meals 1, 2, 3 – details are given in Table 1; IDF – Insoluble dietary fibre; SDF – Soluble dietary fibre; TDF – Total dietary fibre; IDF, SDF, TDF values given as g/50 g available carbohydrate portion; * Incremental peak glucose values were calculated by using fasting value as zero; SEM- Standard error of mean. N=12.

Ethical clearance

Ethical clearance for the study was obtained from the Ethics Committee, Faculty of Medical Sciences, University of Sri Jayewardenepura. Informed and written consents were obtained from each individual after explaining the procedure (Approval no: A 224 on 25th January 2005).

Statistical analysis

Chemical compositions are presented as mean ± SD (standard deviation) and the GI values as mean ± SEM (standard error of mean). The results were analysed using students' *t*-test by Microsoft Excel and Minitab (version 14) with 95% taken as confidence interval.

RESULTS

Fibre contents, GI, IAUC, incremental peak blood glucose concentrations of meals (1-3) analysed are presented in Table 2. Total dietary fibre (TDF) contents of meal 1 and meal 3 were 15.2 g. Meal 2 contained 16.3 g of TDF content. Meal 2 not only had increased fibre content (~ 1 g containing an increase of IDF by 8.9%, SDF by 3.9% and TDF by 7.2%) compared with meal 1 but also an increase in the portion size of the total meal (bulk by 8%).

The GI of meals 1, 2, 3 were 63±6, 57±5, 61±5 respectively. IAUC values of meals 1-3 were 129±17, 119±17, 128±19. Neither IAUC nor GI values of meals were significantly different from each other ($p>0.05$). All three meals reached the peak level at 30 minutes from ingestion (Figure 1). The peak level of meals 2 and 3 were less compared to meal 1. The peak blood glucose value of meal 2 was reduced by 3% compared with the peak glucose level of meal 1 (Figure 1). Meals 2 and 3 reached the lowest glucose levels at 90 minutes while meal 1 reached near fasting glucose level at 120 min from ingestion.

The results of this study indicate a decline in GI of meal 2 by 9% with an increase of TDF by 7.2% and the bulk of the meal by 8%.

DISCUSSION

Lentils (legume), *Centella asiatica* (a green leafy vegetable –'*gotukola*') and *Lasia spinosa* (a root vegetable – '*kohila*') which are natural sources of dietary fibre (Bazzano *et al*., 2008; Thadhani, Jansz & Peiris, 2000) were included as different sources of fibre with rice meals in the present study. The GI of legumes had been determined in Sri Lanka (Widanagamage *et al*., 2009) and extensively, using foods from other countries

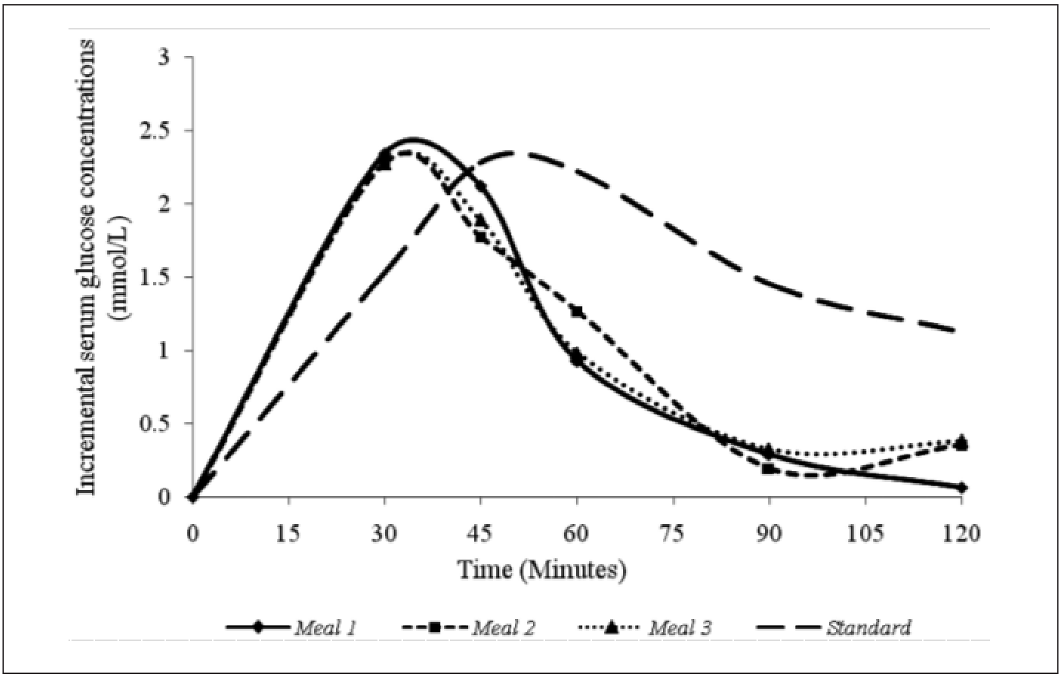

Figure 1. Incremental blood glucose values of rice meals and standard. Each point represents average of 12 samples

(Nishimune *et al.*, 1991). However, the latter two vegetables (*Centella asiatica* and *Lasia spinosa*) which are easily obtainable at a low cost and frequently consumed in Sri Lanka had not been used in a rice mixed meal to determine the GI previously.

Meal 1 contained boiled rice, lentil curry, boiled egg, gravy made with coconut milk (*'kiri hodi'*) and *Centella asiatica* leaves salad. Meal 2 was prepared by including *Lasia spinosa* rhizome salad with other components of meal 1. Meal 2 had increased fibre content (1%) and portion size of the total meal (bulk by 8%) compared to meal 1. The bulk of the meal is also reported to influence the glycaemic response to foods (Bornet *et al.*, 1997). Thus a third meal with similar meal size as meal 2 was prepared. Meal 3 replaced *Lasia spinosa* with *Trichosanthes cucumerina* (snake gourd) salad. *Centella asiatica, Lasia spinosa and Trichosanthes cucumerina* were prepared as salads to minimise the processing of these vegetables. A further increase of the fibre content (or inclusion of another fibre rich meal accompaniment) was not attempted as participants (90%) indicated the portion size of meal 2 as the maximum edible portion with adequate dietary fibre.

Fibre contents, GI, IAUC, incremental peak blood glucose concentrations of meals (1-3) analysed are presented in Table 2. Neither IAUC nor GI values of meals were significantly different from each other ($p>0.05$) and the three meals belonged to a low GI category.

Low GI, high fibre diets have shown beneficial effects in lowering post-prandial glycaemic and insulin responses, improving lipid profile and reducing insulin resistance (Björck & Elmstahl, 2003; Riccardi, Rivellese & Giacco, 2008). The availability of low GI foods varies from country to country. Thus, the emphasis is on the need for each country to recognise low GI foods available in the market as well as the processes to convert high / medium GI foods to low GI. Although low GI products are being produced by including cereal kernels, sour dough fermentation or addition of organic acids in developed countries (Ostman, Liljeberg & Bjorck, 2002; Björck & Elmstahl, 2003), none of the said processes are taking place in developing countries such as Sri Lanka. So the researchers in developing countries need to explore measures to widen the range of low GI foods by using food items commonly available and affordable in their respective countries.

Data of the present study indicate that the amount of *Lasia spinosa* included in meal 2 was not adequate to a significantly lower GI compared with meal 1. This might be due to the high moisture content of natural *Lasia spinosa* preparation (88% fresh weight). Thus, incorporation of processed flour of *Lasia spinosa* might be beneficial in terms of increasing fibre content when making cereal based foods such as noodles, biscuits etc. Further studies are needed to confirm the suitability of inclusion of processed fibre on GI.

The American Diabetes Association recommends a 25-35 g of dietary fibre intake for a healthy adult per day (Chandalia *et al.*, 2000). When considering the meals in the present study, all three meals contained a minimum of 15 g TDF (~40-60% daily requirement). In addition to fibre, the *Centella asiatica* as well as other green leafy vegetables are good sources of vitamins and minerals while *Lasia spinosa* contains polyphenolic antioxidants (Shefana & Ekanayake, 2009). Thus, consumption of at least two rice mixed meals of this nature could easily fulfil the daily fibre requirement of an adult cost effectively while providing other beneficial nutrients.

Studies carried out in other countries with basic foods have shown an inverse association between the amounts of dietary fibre on GI (Bjorck *et al.*, 1994; Liljeberg & Bjorck, 1994) However, the more practical approach would be to study the effect of dietary fibre in a mixed meal on the subsequent GI. One factor that might restrict the study of effect of dietary fibre of a meal on GI would be the limited availability of naturally occurring sources of fibre except for cereals and legumes in many western countries. That is further proven with the decline in the average fibre intake in Britain to 13 g / day due to the reduction in their main source of fibre (cereal) (Bingham, Williams & Cummings, 1985).

Thus, the traditional way by which rice meals are constituted by including a variety of meal accompaniments prepared from legumes, different vegetables, fish / meat in Sri Lanka and South Asia should serve as an example to the rest of the world. The preparation of the curries with various spices is now becoming popular with other countries also due to the natural flavouring of spices as well as their other known health benefits (Hlebowicz *et al.*, 2007).

During a previous study carried out by the authors (unpublished data), Meal 1 served in the present study was given to type 2 diabetic patients and the results indicated a lower incremental area under curve (IAUC:– 264-382) as well as lower incremental glucose peaks (2.5-3.3 mmol / L) compared with the standard (IAUC:- 547 ± 45, Peak:- 4.09 mmol / L). General studies that aim at preventing diabetes focus on the increase in dietary fibre content of the respective meals as part of the intervention process (Riccardi *et al*., 2008). Therefore, the other two rice meals given in the present study (meal 2 and 3) will also be useful in dietary management of diabetics.

Increased portions of fibre sources which are more than the amounts given in the present study (>25 g) might further contribute to a decrease in the GI. However, consumption of such a meal will only be possible when the carbohydrate load is reduced to decrease the bulk of the meal. Meals of this nature which are low in GI and contain high fibre content are not only beneficial in reducing the post-prandial glycaemic response but also reducing the intake of food by increasing satiety (Havel 2001) and fulfilling the daily dietary fibre requirement of an adult.

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