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The Effect of Type of Cereal on the Glycaemic Response of Two Traditional Sri Lankan Food Items

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ABSTRACT. *Pittu and roti are two traditional food items consumed by Sri Lankan people mostly for breakfast or dinner. Rice (Oryza sativa L.) and kurakkan (Eleucine coracana L.) are two types of cereal that can be used to prepare them. The determination of blood glucose elevating effect (glycaemic response) of pittu and roti prepared from rice flour and kurakkan flour was the objective of this study. Proximate composition of Bg 403 rice flour and kurakkan flour was determined and the available carbohydrate content of the two types of cereal was calculated. Pittu and roti were prepared from each flour, following traditional methods and given to eight young healthy adult volunteers. Each subject was given a weighed portion of pittu or roti equivalent to 50 g available carbohydrate as the test food. As the standard food 50 g glucose was given orally. After a 12 hrs overnight fast on the assigned day each subject was given either the standard food or the test food and blood glucose was measured in capillary blood at fasting (0), 15, 30, 45, 60, 90 and 120 min after the consumption of food. The incremental area under the glycaemic response curve (IAUC) for each test food was expressed as a percentage of IAUC of the standard food taken by the same subject and the average value of subjects was taken as the glycemic index (GI) for the test food. Proximate analysis revealed that percentage moisture, crude fat, crude fibre, crude protein and minerals of rice flour and kurakkan flour were 13.0, 1.7, 0.42, 10.3, 0.88 and 13.2, 1.9, 4.4, 8.7 and 2.8, respectively. Accordingly the available carbohydrate percentage of rice flour and kurakkan flour were 73.7 and 69.0, respectively. The GI of pittu and roti, prepared using Bg 403 rice flour were 52 and 64 and that of kurakkan flour were 71 and 80 respectively. Based on the GI, it can be suggested that pittu is better for health than roti, while rice flour is better than kurakkan flour to prepare these. The basis of recommending kurkkan flour based products for diabetic people has to be re-examined in the light of these findings.*

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple diet in Sri Lanka and it is processed by different methods for human consumption. *Roti* and *pittu* are two traditional Sri Lankan food items prepared using rice flour and consumed mostly for the breakfast or dinner. Although rice flour is commonly used for these preparations it can be replaced by any other cereal flour *kurakkan*

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(*Eleucine coracana* L.) being one of them. *Kurakkan* is a cereal with a high fibre content, which is mainly cultivated as a chena crop in the dry zone of Sri Lanka. It is popular in Sri Lanka as a safer food in the management of diabetes mellitus.

Diabetes, which is too high glucose level in the blood, is one of the major non-communicable diseases prevalent in Sri Lanka. According to the annual report of the Diabetic Association of Sri Lanka (2002), there are over one million people suffering from this disease in Sri Lanka. There are also many pre-diabetic people in Sri Lanka who have a high risk of being diabetic in the future. Diabetes is also associated with high blood pressure, heart disease and stroke (Jenkins *et al.*, 2002).

The Glycaemic Index (GI) is a measure of the extent to which the carbohydrate in a food can raise the blood glucose concentration after ingestion. It is a ranking of foods based on their glycaemic effects compared with a standard/reference food, which is either glucose or white bread. The GI is measured calculating the incremental area under the blood glucose curve (IAUC) (glycaemic response), following ingestion of a test food containing 50 g available carbohydrate and comparing the same with a reference food with equal amount of available carbohydrate (Jenkins *et al.*, 1981). Dietary carbohydrates with different chemical compositions (*e.g.* sugars, oligosaccharides, starches, and non-starch polysaccharides) and physical structures are digested and absorbed at different rates in the human intestine and give rise to different blood glucose responses. Carbohydrate foods that breakdown quickly during digestion release glucose fast into the blood stream and have high GI values while those that breakdown slowly release glucose gradually into the blood stream having low GI values. The GI is a more useful nutritional concept than the chemical classification of carbohydrate as it gives new views and links between the physiological effects of carbohydrate-rich foods and health.

The GI appears to be useful in the treatment and prevention of chronic diseases (Jenkins *et al.*, 2002). Human studies have shown that the consumption of low GI foods improve insulin sensitivity and glycaemic control (Rizkalla *et al.*, 2004) and reduce the risk of type 2 diabetes (Willett *et al.*, 2002), coronary heart disease (Ford and Liu, 2001), several types of cancer (Augustin *et al.*, 2001) and obesity (McMillan- Price *et al.*, 2006).

Because of its high fibre content, it is often believed by the nutritionists and health professionals in Sri Lanka that *kurakkan* is better and a healthy option than rice or wheat for human food preparations. In fact, *kurakkan*-based diets are highly recommended for diabetic people. However, there is not enough evidence in the literature to support that *kurakkan* flour is superior to rice flour in the glycaemic response on human subjects. The advice to eat *kurakkan* over rice for diabetic management is therefore based on inadequate evidence on their physiological effects.

The present study investigates the blood glucose elevating effects on human subjects of *roti* and *pittu* prepared using rice flour and *kurakkan* flour with the objective of comparing the glycaemic responses of the two types of cereal flour and the two preparation methods.

MATERIALS AND METHODS

Study subjects

The study sample consisted of eight healthy individuals (four males and four females) between 24 - 26 yrs and with normal glucose tolerance. The study protocol was explained to the participants and their written consent was obtained prior to the commencement of the study.

Preparation of rice and *kurakkan* flour

Rice variety Bg 403 was selected for the study. It is one of the commonly cultivated, white-pericarp, rice varieties in Sri Lanka. Bg 403 paddy was obtained from the Rice Research and Development Institute at Batalagoda and dehusked with a roller mill. The purified rice was ground into flour using the laboratory blender and passed through a 100 mm sieve.

Kurakkan seeds were purchased from the local market, ground into flour using the laboratory blender and passed through a 100 mm sieve.

Estimation of available carbohydrate

The proximate nutritional composition of rice flour and *kurakkan* flour were determined and their available carbohydrate contents were calculated using the 'by difference' method.

The moisture, crude fat, crude fibre, crude protein and mineral contents were determined by standard Association of Official Analytical Chemist (AOAC) methods and the available carbohydrate content of each cereal was calculated by subtracting the above five values from 100.

Food preparation

Roti or *pittu* were prepared using rice flour or *kurakkan* flour. Based on the available carbohydrate content and the number of subjects participating in the study, the total quantity of rice flour or *kurakkan* flour to be incorporated into *roti* or *pittu* was calculated. After preparation of *roti* or *pittu*, it was weighed using an electronic balance, equally divided into eight portions and given to the eight subjects on assigned days.

Preparation of *roti*

Rice flour (542.4 g) or *kurakkan* flour (580.0 g), without coconut, was put in a bowl and salt (8.0 g) was added. With pouring water the flour was mixed well to a suitable consistency that the dough is moist enough, kneadable and non-sticky. The dough was divided to make two balls and each ball was flattened on a banana leaf to get a round shape and baked on a flat cast iron griddle using a gas cooker. Once a side of the *roti* was baked for about 3 min, it was turned over and baked for another 2 min.

Preparation of *pittu*

Rice flour (542.4 g) or *kurakkan* flour (580.0 g) was roasted in a cast iron wok for 5 min. Eight grams of salt was added to the roasted flour and mixed well with the addition of water to produce a mixture of small breadcrumb-like balls. This mixture was put in the *pittu* mould, closed, placed over a pan of boiling water and cooked using steam until steam emerges from the top of the mould.

Glycaemic index measurement

After a 12 hrs overnight fast, the subjects were given either the standard food (50 g oral glucose) or the test food with 150 mL of water. The subjects were instructed to eat the food completely and finish within 10 min. No other food or drink was allowed and they were confined to the laboratory with minimum physical activity during the 2 hrs testing period on the assigned day.

The blood glucose level was measured in the capillary blood by the finger-prick method, (reference) using a standard glucometer, for 2 hrs, at (fasting) 0, 15, 30, 45, 60, 90 and 120 min after the start of the test or standard food. The 6 day experiment (2 days for the standard food and 1 day each for each test food) was completed within 6 weeks.

All the data were entered in to Microsoft Excel worksheet and the IAUC for a subject, for each test food or the standard food, was calculated. The glycaemic index of each test food for each subject was calculated using the following formula:

$$\text{Glycaemic Index} = \frac{\text{IAUC of test food} \quad \text{x } 100}{\text{IAUC of standard food}}$$

The GI of each test food was calculated by taking the average of the GI for eight subjects.

RESULTS

Available carbohydrate content

The proximate composition of rice flour and *kurakkan* flour is given in Table 1. Based on `by difference' method, the available carbohydrate content of rice flour and *kurakkan* flour are 73.7% and 69.0%, respectively. Accordingly, the quantity of rice flour or *kurakkan* flour received by each subject in the form of *roti* or *pittu* is 67.8 g or 72.5 g, respectively. The low availability of carbohydrate in *kurakkan* flour is mainly due to its high quantity of fibre and minerals compared to the rice flour.

Glycaemic response of *roti* and *pittu* made from rice

Roti and *pittu* made from Bg 403 rice flour showed a lower glycaemic response compared to the standard food glucose. The comparison of glycaemic response curves of *roti* and *pittu* showed that the peak rise in blood glucose is higher in *roti* than *pittu* and it occurs within the first hour of consumption in both types of foods (Figure 1). There is a smoother rise and fall in the blood glucose response curve of *pittu* than *roti*.

Table 1. Proximate composition and available carbohydrate content of rice flour and *kurakkan* flour.

Constituent (%)	Bg 403 rice flour (mean ± sd)*	Kurakkan flour (mean ± sd)*
Moisture	13.02 ± 0.40	13.18 ± 0.46
Crude fat	1.70 ± 0.14	1.91 ± 0.12
Crude fibre	0.42 ± 0.03	4.41 ± 0.25
Crude protein	10.30 ± 0.08	8.73 ± 0.07
Minerals	0.88 ± 0.03	2.80 ± 0.15
Available carbohydrate (by difference)	73.7	69.0
Weight of flour containing 50 g available carbohydrate (g)	67.8	72.5

Note: * number of samples = 3

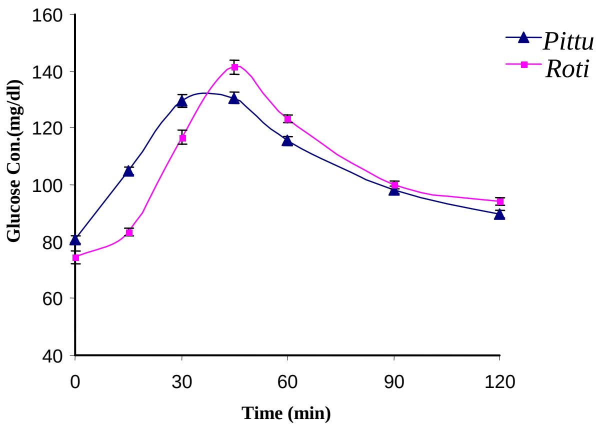

Figure 1. The blood glucose rise (mean ± SE) after consumption of *roti* or *pittu* made from rice flour (n = 8).

Glycaemic response of *roti* and *pittu* made from *kurakkan*

The pattern of glycaemic response of *roti* and *pittu*, made from *kurakkan* flour was similar to those made from rice flour. The high peak was observed for *roti* while *pittu* showed a more gradual rise and fall (Figure 2).

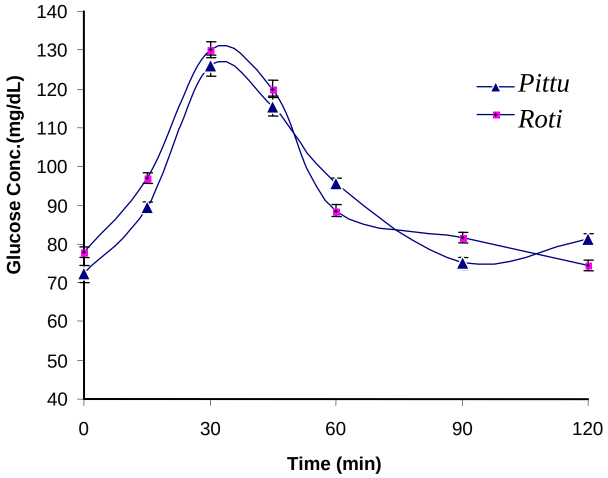

Figure 2. The blood glucose rise (mean ± SE) after consumption of *roti* or *pittu* made from *kurakkan* flour (n=8).

Glycaemic Indices

The IAUC of *pittu* and *roti* made from rice flour and *kurakkan* flour are given in Figures 3 and 4. From these figures, the GI were calculated. The GI values of *pittu* and *roti* made from rice flour, calculated using Figure 3 were 52 and 64 respectively while the GI values of *pittu* and *roti* made from *kurakkan* flour, calculated using figure 4 were 71 and 80, respectively.

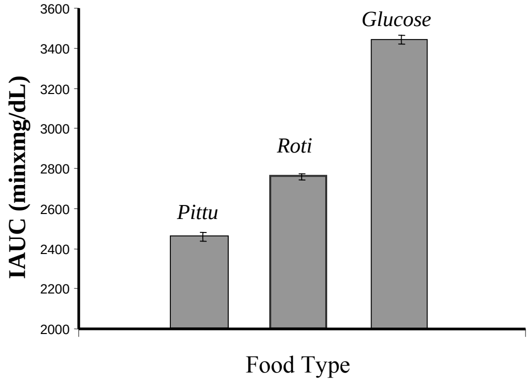

Figure 3. Incremental area (mean ± SE) under the blood glucose response curves of *pittu* and *roti* made from rice flour and glucose.

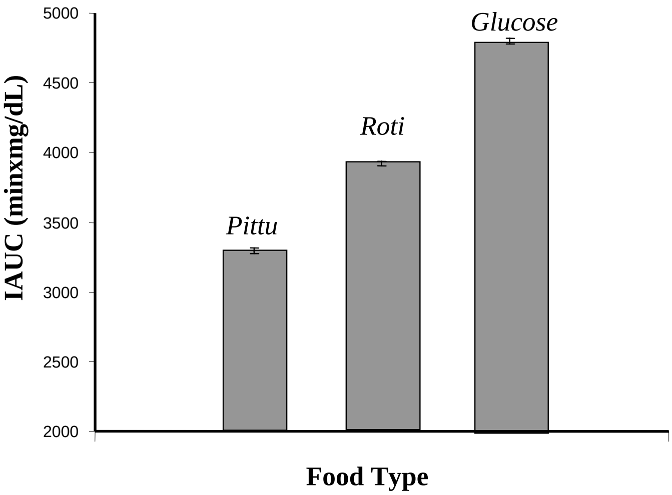

Figure 4. Incremental area (mean ± SE) under the blood glucose response curves of *pittu* and *roti* made from *kurakkan* flour and glucose.

DISCUSSION

GI of *pittu* and *roti*

It is evident that *pittu* has a lower GI than *roti* when prepared with both types of cereal flours. The lower glycaemic response of *pittu* over *roti* can be explained when the preparation methods of the two types of food are considered. When making *pittu*, roasting of flour under mild heat for 5 min may have initiated the Maillard reaction and caramelization, but at very low levels. Prominent effect comes from the steam. With steaming in the *pittu* mould, starch exposed to moist heat may undergo gelatinization and subsequently they may have retrograded causing a lowering of GI. On the other hand, the Mailard reaction and caramelization are most possible on the surface of the *roti* where the direct heat is applied. Starch molecules in *roti* may have broken down by heat (thermolysis) causing easy digestion and consequently high GI, but the gelatinization would be limited due to lower water content. When compared to *roti*, *pittu* undergoes a greater degree of hydration as it is heated under the steam. Higher volume expansion and increase in weight after cooking were observed in *pittu* than *roti*. However, further studies are needed to find out the exact mechanism on how the GI is lowered by the method of preparation of *pittu*.

GI of *kurakkan* flour and rice flour

It is evident from this study that the GI is lower in rice flour (Bg 403) than *kurakkan* flour, when *pittu* or *roti* is made using traditional preparation methods. According to the GI classification, *roti* and *pittu* made from *kurakkan* flour belonged to the high GI food (GI ≥ 70) category and the same products made from rice flour belonged to either the low GI food (*pittu*: GI ≤ 55) or the intermediate GI food (*roti*: GI 56-69) category.

The general belief that *kurakkan*-based products are better for blood glucose control was based on its high fibre content. Although *kurakkan* had higher fibre content than rice, its effect on lowering the glycaemic response was not evident in this study. Fibre is only one among many factors that affect the glycaemic response of a carbohydrate and other factors such as amylose, amylopectin, resistant starch, granular size, gelatinization and retrogradation characteristics (Trout *et al*., 1993; Panlasigui *et al*., 1991) may have affected more in the glycaemic response of these food preparations. Moreover, the action of fibre on carbohydrate digestion and absorption may have been altered due to the breakdown of seed coat into very small particles in the preparation of flour. Further research is needed to understand the chemistry behind the high GI of *kurakkan* flour.

CONCLUSIONS

This study indicated that the glycaemic index was lower in *pittu* compared to *roti* when made from Bg 403 rice flour or *kurakkan* flour, using traditional Sri Lankan preparation methods. The comparison of GI with respect to rice flour and *kurakkan* flour showed that rice flour has lower GI than *kurakkan* flour. The popular belief that *kurakkan* flour based products are better for diabetic people over rice has to be re-evaluated in the light of these findings.

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