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Effect of Vegetable Mixed Curry on Glycaemic Index and Glycaemic Load of Soy Flour Incorporated Traditional Sri Lankan Breakfast Foods in Healthy Adults

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Abstract: Traditional Sri Lankan breakfast foods such as pittu, rotti, wandu, hopper and thosai made with 75% rice flour (Bg 352) and 25% soy flour (Pb 1) mixture were tested for their Glycaemic Index (GI) and Glycaemic Load (GL). Pittu, rotti, wandu, hopper and thosai showed low GI values of 35.5, 36.0, 43.0, 45.2 and 47.3, respectively. The GL of pittu, rotti, wandu, hopper and thosai were 5.4, 7.5, 5.4, 6.6 and 6.7, respectively and could be considered as low. The GI of foods diminished when incorporated in composite meals. A vegetable mixed curry was prepared mixing *Solanum melongena* (eggplant), *Lycopersicon esculentum* (tomato), *Cucurbita maxima* (pumpkins) and *Ipomoea aquatica* (Kankun/water spinach) in order to study meal GI and meal GL. The amount of fat, protein and available carbohydrate in the vegetable mixed curry were 9.2, 4.3 and 6.6 g/100 g dry weight, respectively. The GI of pittu meal, rotti meal, wandu meal, hopper meal and thosai meal were 30.2, 31.2, 36.5, 38.3 and 43.8, respectively. Pittu meal, rotti meal, wandu meal, hopper meal and thosai meal showed GL values of 3.9, 5.0, 4.1, 4.9 and 6.0, respectively. Addition of vegetable mixed curry showed considerable reduction of GI and GL of all test meals.

Key words: Breakfast foods, vegetable mixed curry, glycaemic Index, glycaemic Load, healthy adults

INTRODUCTION

Sri Lankan cuisine is one of the complex cuisines of South Asia. Rice and curry still comprises the main meal of Sri Lankans. Breakfast foods items like hoppers, string hoppers, thosai, pittu, rotti and wandu are made mainly using either rice flour or wheat flour. Rice and wheat flour have approximately 75 and 78% carbohydrates, respectively (Food Composition Table for South East Asia, 1972). Blood glucose response to the ingestion of carbohydrate containing foods has been shown to vary depending on the particle size, ratio of amylose to amylopectin, starch structure, level of food processing, cooking techniques and the presence of fat and protein in the food (Ragnhild *et al*., 2004). Fat lowers the postprandial glucose response by increasing the viscosity of the intestinal contents and delaying the rate of gastric emptying (Jean *et al*., 1997). Addition of protein to a starch food prevents the action of digestive enzymes by forming a protective network around the carbohydrate molecule and improves overall glycaemic control (Mary *et al*., 2003).

Carbohydrate rich foods can be ranked by their overall effect on postprandial blood glucose concentration using glycaemic index (GI). The GI value of a food is defined as the incremental blood glucose area following ingestion of 50 g of available carbohydrates in the test food as a percentage of the corresponding area following an equivalent amount of available carbohydrate from reference food, typically glucose (Willett *et al*., 2002). High GI (>70) foods produce a higher peak in postprandial blood glucose and a greater overall blood glucose response than do foods with low GI (<55) (Atkinson *et al*., 2008). The glycaemic load (GL) value incorporates the amount of digestible carbohydrates in a serving in order to better gauge the impact of a meal on postprandial blood glucose response. A glycaemic load of 20 or more is high, 11 to 19 is medium and 10 or under is low. The higher the GL, greater is the expected elevation in blood glucose of a food (Atkinson *et al*., 2008). Studies indicated that long term consumption of a diet with a high GI/GL is a significant predictor of the risk of developing chronic diseases such as type 2 diabetes and coronary artery diseases, through stimulation of hyperglycemia and hyper insulinemia (Ahmad *et al*., 2012).

Rotti and Pittu (traditional breakfast foods) made with rice flour or wheat flour had medium (69±7) and high (72±6) GI (Rahal *et al*., 2009). Pittu made with steamed wheat flour and roasted rice flour mixture had low GI (Raguparan *et al*., 2008). Pittu made with roasted finger millet (*Eucenea coracana*/Kurakkan) or whole wheat flour had medium and low GI respectively (Pirasath *et al*., 2010). Kithul (*Caryota urens*) rotti, Madu (*Cycas circinalis*) rotti, Madu (*Cycas circinalis*) pittu and Hal (*Vateria copallifera*) pittu had medium GI (Senevirathna *et al*., 2010).

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Dietary soy consumption has been shown to have beneficial effects on human health and this has been attributed to dietary fiber, proteins, isoflavons and polyunsaturated fats (Lee *et al.*, 2006). GI of soy beans and soy food products are low (Atkinson *et al.*, 2008) and soy protein and fat decreases LDL cholesterol significantly and are valuable foods to be included into diet. *Solanum melongena* (eggplant), *Lycopersicon esculentum* (tomato) and *Cucurbita maxima* (pumpkin) are low carbohydrate vegetables. Pumpkin is a good source of pro-vitamin A. *Ipomoea aquatica* (water spinach/kankun) has considerable amount of dietary fiber and it is a moderate source of potassium and a good source of iron. Tomato is a moderate source of ascorbic acid, lycopene and total phenolic compounds and a good source of potassium (Food Composition Table for South East Asia, 1972). Those vegetables are economical, popular, non seasonal and listed under more important vegetables grown in Sri Lanka (Muthukuda Arachchi *et al.*, 2008).

To date, none of soy incorporated traditional Sri Lankan breakfast foods have been assessed for their GI and GL values. Therefore a study was conducted to incorporate soy flour into traditional Sri Lankan breakfast foods such as rotti, pittu, thosai, hopper, string hopper and wandu made with 25% soy flour and 75% rice flour (Perera *et al.*, 2014). The present study was conducted to determine the GI and GL of rotti, pittu, thosai, hopper and wandu and the effect of the vegetable mixed curry prepared using eggplant, tomato, pumpkins and water spinach on the meal GI and GL with the aim of providing nutritious low GI and GL breakfast foods.

MATERIALS AND METHODS

Raw Materials: Raw rice (Bg-352) was obtained from Rice Research and Development Institute, Bathalagoda. Soy bean (Pb-1) variety was purchased from Pelwehera farm, Department of Agriculture, Dambulla, Sri Lanka.

Preparation of soy bean flour and rice flour: Preparation of soy bean flour and rice flour was carried out according to the procedure of Perera *et al.* (2014).

Preparation of test foods: Preparation of rotti, pittu, thosai, hoppers and wandu has been described earlier (Perera *et al.*, 2014).

Preparation of vegetable mixed curry: Water Spinach leaves (5 g), eggplant (17 g), pumpkin (20 g) and tomato (14 g) were cleaned, washed well in running tap water and cut into small pieces. Brinjals and pumpkins were tempered with soy oil (1.5 mL), salt (1.5 g), green chilies (7 g), red chilie powder (0.5 g), Bombay onion (10 g), white onion (1.8 g) and required amounts of turmeric powder, fenugreek, mustard, curry leaves and further cooked for about 10 min with 155 mL of water. After 10 min tomato, water spinach leaves and coconut milk (15 g of coconut scraping was extracted with 30 mL of lukewarm water) were added and cooked further for about 10 min.

Determination of proximate composition and available carbohydrate content of vegetable mixed curry: Vegetable mixed curry was analyzed for proximate composition by AOAC methods (1995) and available carbohydrate by using the method of Mc Cleary *et al.* (2006) using Megazyme assay kit (Megazyme International Ireland, Bray, Ireland).

Selection of study subjects for glycaemic study: GI was estimated with non smoking healthy individuals (n = 13) including both sexes, between 20 to 35 years of age and body mass index (BMI) of 22.1±1.8 kg/m^2 at the Food Research Unit, Gannoruwa. Study subjects with extreme obesity, food allergy and treatment with insulin or any other pharmacologic agent were excluded from the study. At baseline, all subjects had normal fasting and random plasma glucose concentrations. Study procedure was explained and informed written consent was obtained. The subjects were instructed to avoid taking alcohol and not to engage in heavy physical activity the day before the test.

Ethical clearance: Approval for the study was obtained from the Ethical Review Committee, Faculty of Medicine, University of Peradeniya, Sri Lanka (2012/EC/09).

Determination of GI: Determination of GI was carried out by using the method of Brouns *et al.* (2005). Blood samples were taken under aseptic conditions. After 12 h overnight fast, a baseline finger prick capillary blood sample was taken. The subjects were given either test foods (rotti, pittu, thosai, hoppers and wandu made with 25% soy flour and 75% rice flour) or test meals (test foods and vegetable mixed curry) containing 50 g of available carbohydrate or D-Glucose 50 g (the reference food, Bio Labs, Veyangoda, Sri Lanka) along with 250 mL of boiled cooled drinking water. The subjects were instructed to consume the food completely and finish within 10 min. Following consumption of the test or reference food, capillary blood samples were collected at 15, 30, 45, 60, 90, 120 min. Capillary blood glucose concentration was measured immediately after collection using a Glucometer (Optium Xceed™; Woodley equipment company Ltd, Lancashire, United Kingdom).

Calculation of GI: The incremental area under the curve (IAUC) was calculated by using the trapezoidal method (Brouns *et al.*, 2005). The GI of each test food was calculated by taking the average of the GI for 13 subjects. GI of each test food for each subject was calculated using the following formula:

$$GI = IAUC_{test\ food}/IAUC_{standard} \times 100$$

Calculation of GL: The GL of a typical serving of food is the product of the amount of available carbohydrate in that serving and the GI of the food. Portion sizes vary markedly from country to country and between people in the same country (Kaye *et al.*, 2002). Therefore in the present study GL values were calculated as per 100 g of test food portions.
GL values were calculated using the following formula:

$$GL = GI \times \text{Available carbohydrates per serving (g)}/100$$

Statistical analysis: IAUC of test foods, test meals and reference food were constructed and calculation of GI was done using Microsoft Office Excel 2007 computer package. GI values of foods were expressed as the mean±SD deviation. The means of the GI values of foods were compared using student 't' test using SPSS statistical software version 14 (SPSS inc., USA) and the difference was considered significant at $p<0.05$.

RESULTS

Demographic data of study subjects: Age, body mass index (BMI), blood pressure, pulse, fasting and random blood glucose concentration of study subjects are given in Table 1. All study subjects had normal BMI, systolic and diastolic blood pressure, fasting and random blood glucose levels. Past medical history and drug history were obtained and no history of non communicable disease was found.

Composition of vegetable mixed curry: Protein and fat content of vegetable mixed curry were determined in triplicate using three replicates and available carbohydrate content in duplicates using 6 replicates. In the present study the amount of fat, protein and available carbohydrate in the vegetable mixed curry were 9.2, 4.3 and 6.6 g/100 g dry weight, respectively.

Glycaemic responses of glucose and test foods: Rotti, pittu, thosai, hopper and wandu were subjected to GI studies and the glycaemic responses are given in Fig. 1. Rotti, pittu, thosai and wandu had peak mean blood glucose concentrations of 120.4, 118.9, 124.6 and 129.1 mg/dL, respectively at 15 min. Pittu and rotti had lower glycaemic response at 15 min compared with wandu and thosai. The peak mean blood glucose concentration of 129.9 mg/dL for hopper was observed at 30 min.

Glycaemic index of rotti, pittu, thosai, wandu and hopper: Glycaemic index of rotti, pittu, thosai, wandu and hopper are given in Table 2. Thosai, hopper and wandu had higher GI compared with pittu and rotti. The incorporation of 25% soy flour reduced the GI of all test foods.

Table 1: Demographic data of study subjects

Criteria	Mean±SD	Range
Age (years)	26.1±1.8	22-30
Body mass index	22.1±1.8	18.5-23.9
Systolic blood pressure (mm/Hg)	118.9±4.8	110-120
Diastolic blood pressure (mm/Hg)	77.2±4.5	70-80
Pulse/minute	75.3±2.3	72-82
Fasting blood glucose concentration (mg/dL)	75.3±2.3	89-100
Random blood glucose concentration (mg/dL)	120.6±1.7	118-124

Table 2: Glycaemic index of pittu, rotti, thosai, wandu and hopper

Food item	GI
Pittu	35.50±9.8[a]
Rotti	36.04±8.1[a]
Wandu	42.97±8.9[b]
Hopper	45.18±8.6[b]
Thosai	47.34±5.3[b]

GI of rotti, pittu, thosai, hopper and wandu made with 25% soy flour and 75% rice flour consumed alone
GI of food items given in a column having common superscript are not significantly different by 't' test (p>0.05)

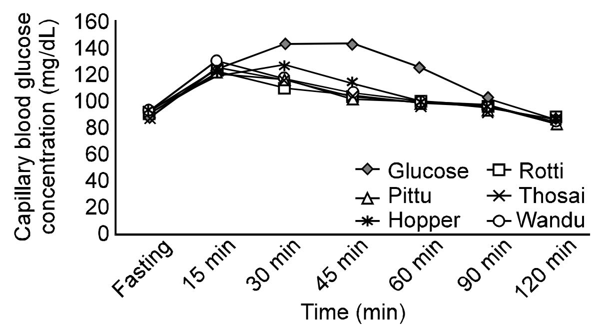

Fig. 1: Glycaemic responses of D-Glucose, rotti, pittu, thosai, hopper and wandu

Blood glucose responses to D-glucose, rotti, pittu, thosai, wandu, hoppers with vegetable mixed curry: The mixed meal postprandial blood glucose responses of rotti, pittu, thosai, wandu, hoppers consumed with vegetable mixed curry in healthy adult study subjects are given in Fig. 2a-e, respectively. Rotti and rotti-vegetable mixed curry meal had peak blood glucose concentrations of 120.4 and 120.1 mg/dL, respectively at 15 min (Fig. 2a). Pittu and pittu-vegetable mixed curry meal had peak blood glucose concentrations of 118.9 and 116.1 mg/dL, respectively at 15 min (Fig. 2b). Thosai and thosai-vegetable mixed curry meal had peak mean blood glucose concentrations of 124.6 and 119.8 mg/dL respectively at 15 min (Fig. 2c). Hopper had peak mean blood glucose concentration of 125.9 at 30 min and hopper-vegetable mixed curry meal had peak mean blood glucose concentration of 125.2 at 15 min (Fig. 2d). Wandu had significantly higher peak mean blood glucose concentrations of 129.1 mg/dL compared with wandu-vegetable mixed curry meal (118.7 mg/dL) at 15 min (p = 0.0042).

Food GI and meal GI: Food GI and Meal GI of pittu, rotti, wandu, hopper and thosai prepared with 25% soy flour

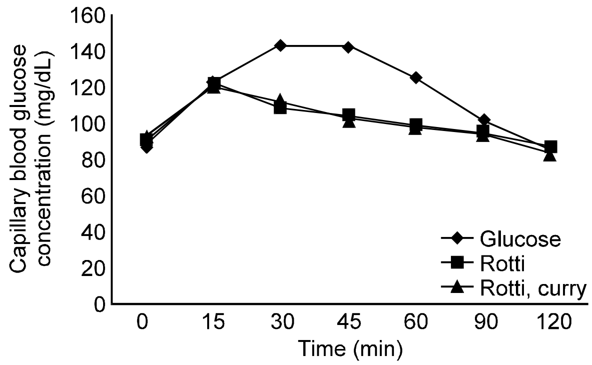

Fig. 2a: Capillary blood glucose response curve for D-Glucose, rotti and rotti consumed with vegetable mixed curry

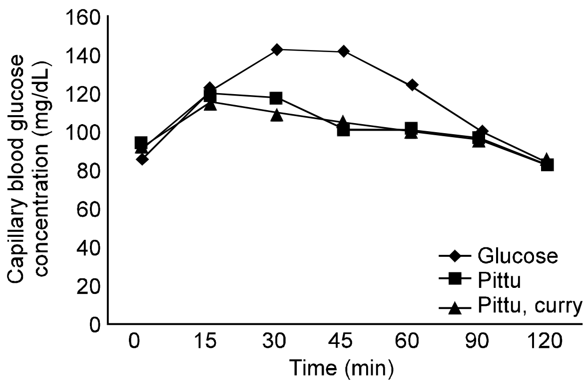

Fig. 2b: Capillary blood glucose response curve for D-Glucose, pittu and pittu consumed with vegetable mixed curry

and 75% rice flour mixture in healthy subjects are given in Table 3. The meal GI of, wandu, hopper and thosai were significantly higher than pittu and rotti. The GI of all test foods was higher than the GI of test meals.

Cooked weights of test foods and test meals: Cooked weights of test foods and test meals are given in Table 4. Cooked weight of all test meals was higher than the cooked weight of test foods.

Glycaemic load values of test foods, per 100 g serving: Glycaemic load values of test foods are given in Table 5. Pittu and wandu had lower GL values compared to rotti, hoppers and thosai.

Glycaemic load values of test meals, per 100 g food portion: Glycaemic load values of test meals are given in Table 6. Pittu meal had the lowest GI value.

DISCUSSION

The glycaemic response of rotti and pittu were lower than thosai, hopper and wandu. Rotti and pittu are prepared with scraped coconut whereas thosai and wandu are prepared with coconut extract. Therefore rotti and pittu contain more dietary fiber than thosai and wandu which could have contributed to the lowering of glycaemic response. The glycaemic response is low if the food contain significant amount of dietary fiber (Raguparan *et al*., 2008).

All test foods made with 25% soy flour and 75% rice flour mixture had low GI and GL values. Rahal *et al*. (2009) reported pittu made with either wheat flour or rice flour or Kurakkan flour had high GI (101±8, 103±7 and 85±6, respectively). Jayasinghe *et al*. (2013) reported a GI value of 79±5 for pittu made of industrial millet flour and 67±4 for pittu made of stone ground millet flour. Thathvasuthan *et al*. (2007) reported a GI value of 52 for pittu made with rice flour (Bg 403) and 71 for pittu made with kurakkan flour. Raguparan *et al*. (2008) reported the GI value as 43±9.1 for pittu made with steamed wheat flour and roasted rice flour mixed in 2:1 ratio. Rotti made of wheat flour or kurakkan flour had high GI (72±6 and 70±8, respectively) and rotti made of rice flour or atta

Table 3: Comparison between food GI and meal GI

Food item	*Food GI (A)	**Meal GI (B)	Difference (A-B)
Pittu	35.50±9.8^a	30.20±6.5^a	5.30
Rotti	36.04±8.1^a	31.15±4.6^a	4.89
Wandu	42.97±8.9^b	36.46±5.4^b	6.51
Hoppers	45.18±8.6^b	38.30±5.6^b	6.88
Thosai	47.34±5.3^b	43.78±3.7^c	3.56

*GI of rotti, pittu, thosai, hopper and wandu made with 25% soy flour and 75% rice flour consumed alone

**GI of rotti, pittu, thosai, hopper and wandu made with 25% soy flour and 75% rice flour consumed with vegetable mixed curry

GI of test food items and test meals given in a column having common superscript are not significantly different by 't' test (p>0.05)

Table 4: Cooked weights of test foods and test meals

Test food item	Cooked weight (g)	Test meal	Cooked weight (g)
Pittu (4 medium size pittu)	330.0	Pittu meal	386.2
Rotti (4 medium size rotti)	244.1	Rotti meal	311.7
Wandu (8 wandu)	400.0	Wandu meal	446.9
Hopper (8 hoppers)	340.0	Hopper meal	394.9
Thosai (7 thosai)	353.0	Thosai meal	406.1

Table 5: Glycaemic load values of test foods (100 g food portion)

Food item	Food GI*	Available carbohydrates (100 g of food portion)	Food GL*
Pittu	35.50±9.8	15.15	5.38
Rotti	36.04±8.1	20.74	7.47
Wandu	42.97±8.9	12.5	5.37
Hoppers	45.18±8.6	14.70	6.64
Thosai	47.34±5.3	14.16	6.70

*GI and GL of rotti, pittu, thosai, hopper and wandu made with 25% soy flour and 75% rice flour consumed alone

Table 6: Glycaemic load values of test meals (100 g food portion)

Test meal	Meal GI	Available carbohydrates/ 100 g of test meal	Meal GL
Pittu meal	30.20±6.5	12.95	3.91
Rotti meal	31.15±4.6	16.04	5.00
Thosai meal	43.78±3.7	12.31	5.39
Hopper meal	38.30±5.6	12.66	4.85
Wandu meal	36.46±5.4	11.19	4.08

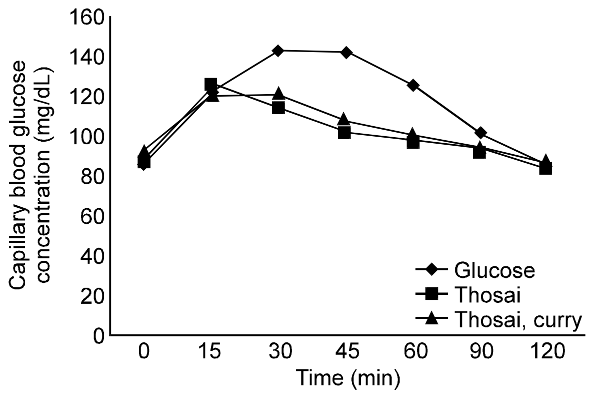

Fig. 2c: Capillary blood glucose response curve for D-Glucose, thosai and thosai consumed with vegetable mixed curry

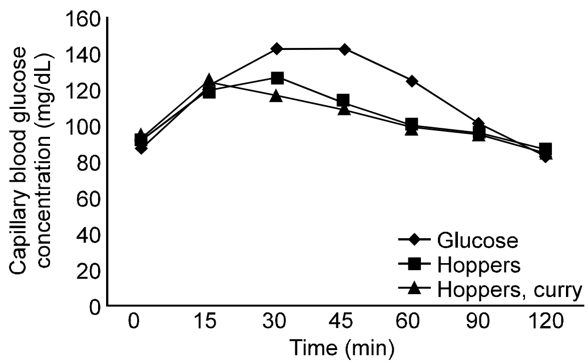

Fig. 2d: Capillary blood glucose response curve for D-Glucose, hopper and hopper consumed with vegetable mixed curry

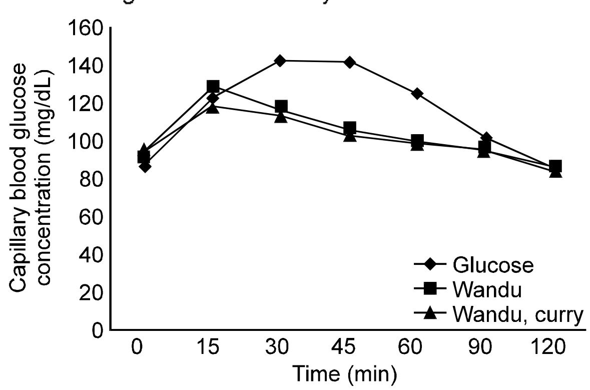

Fig. 2e: Capillary blood glucose response curve for D-Glucose, wandu and wandu consumed with vegetable mixed curry

flour (69±7 and 67±9, respectively) had medium GI (Rahal *et al*., 2009). Rotti made of industrial millet flour had medium GI (59±7) and of stone ground millet flour had low GI (44±5) (Jayasinghe *et al*., 2013). Thathvasuthan *et al*. (2007) reported GI value of 64 for rotti made from rice flour (Bg 403) and 80 for rotti made with kurakkan flour. Protein and fat could reduce glycaemic response of foods and there by GI (David *et al*., 1981; Jean *et al*., 1997; Mary *et al*., 2003). The amount of fat and protein in soy flour used to make all test food items were 21.7 and 38.4 g/100 g dry weight respectively (Perera *et al*., 2014). Available carbohydrate content of soy flour used in the present study was 2.2 g/100 g (Perera *et al*., 2014). Hence, the entire foods tested had low GI and GL values compared to the values reported by previous investigators.

Postprandial blood glucose responses of all test meals were lower than test foods. Consuming a food with dietary fiber and other carbohydrates has a lower glycaemic response than the food alone (Ragnhild *et al*., 2004). Pirasath *et al*. (2013) reported GI of parboiled rice with green leafy curry as 47.47±11.20. Hettiaratchil *et al*. (2009) reported presence of dietary fiber and a legume reduces glycaemic response of red rice (AT 353) mixed meal. Pirasath *et al*. (2010) studied the effect of dietary curries on blood glucose response and reported consumption of parboiled rice (*Mottaikarupan* variety) with vegetable mixed curry significantly reduced the rise of blood glucose concentrations. The incorporation of vegetable mixed curry to the test foods show a slow rise in postprandial blood glucose concentrations which may be attributed to low available carbohydrate content and presence of dietary fiber in the vegetable mixed curry.

Conclusion: The glycaemic index and glycaemic load of traditional Sri Lankan breakfast foods such as pittu, rotti, wandu, hopper and thosai made with 25% soy flour and 75% rice flour mixture can be categorized as low. Consumption of pittu, rotti, wandu, hopper and thosai with vegetable mixed curry made of *Solanum melongena* (eggplant), *Lycopersicon esculentum* (tomato), *Cucurbita maxima* (pumpkins) and *I pomoea aquatica* (Kankun/water spinach) further reduced the GI and GL values.

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