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Estimating Glycemic Index of Rice-Based Mixed Meals by Using Predicted and Adjusted Formulae

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Abstract: The estimation of glycemic index (GI) of rice-based mixed meal either by using predicted GI (GI_{pred}) or adjusted GI (GI_{adj}) formula is unclear. This study aimed to determine the glycemic response of rice in rice alone or mixed meals and to identify the appropriate formula for estimating the GI of rice-based mixed meals. The glycemic responses produced by the rice alone (red rice, fragrant white rice or parboiled rice) and the rice-based mixed meals (fried red rice, fried fragrant white rice or fried parboiled rice) which provided 25 g available carbohydrate were assessed in 11 healthy individuals. To determine the measured GI ($GI_{measured}$) of rice alone and rice-based mixed meals, participants underwent three repeated tests of a reference food (Glucolin®). Tests were performed in random order on nine separate visits after an overnight fasting for at least 8 h. Capillary glucose at baseline (0 min), 15, 30, 45, 60, 90 and 120 min from starting the meals was assessed and used to determine the incremental area under the curve ($iAUC_{120}$). The agreement between $GI_{measured}$ and the estimation formulae (GI_{pred} or GI_{adj}) were determined using Bland-Altman analysis. The $iAUC_{120}$ after consuming rice alone was significantly higher than the rice-based mixed meals except for fried fragrant rice, which was comparable to the rice alone ($P > 0.05$). The $GI_{measured}$ values of rice were categorized as medium (61 for parboiled rice, 67 for fragrant white rice, and 68 for red rice). GI_{pred} ($r = 0.40$, $P < 0.01$) and GI_{adj} ($r = 0.41$, $P < 0.01$) were significantly correlated with $iAUC_{120}$. The agreement between $GI_{measured}$ and GI_{adj} is apparent suggesting the usefulness of GI_{adj} in estimating meal GI of rice-based mixed meals.

Key words: glycemic index; mixed meal; glycemic response; rice

The glycemic index (GI) is a method used to classify dietary carbohydrates based on their effect on postprandial blood glucose levels (Wolever, 2013). Low GI foods have been shown to reduce the risk of chronic diseases, in particular, type 2 diabetes mellitus (Bhupathiraju et al, 2014). The GI concept has also been used in the management of type 2 diabetes mellitus to optimise glycemic control (Chen et al, 2015).

Rice (*Oryza sativa* L.) is the staple food for more than half of the world's population mainly from the Asian region. Increased white rice consumption has been associated with increased risk of type 2 diabetes, especially among Asian populations (Hu et al, 2012). In Malaysia, more than 97% of its adult population eats rice twice daily mostly in the form of white rice (Abdul Karim et al, 2008). Many types of rice are available including fragrant white rice, parboiled rice and red rice. GI value of rice shows a wide variation ranging from 48 to 92 with an average of 64, depending on the type of rice (Atkinson et al, 2008). The variation in GI value from country to country is probably due to the botanical effects (Foster-Powell et al, 2002). Hence, it is suggested that each country determines the GI values of its common types of rice (Singh et al, 2010).

The GI concept is a property of individual carbohydrate and its utility in the context of mixed

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meal is controversial. The meal GI should be estimated using appropriate formulae rather than directly measured. And it can be estimated using predicted (GI_{pred}) or adjusted (GI_{adj}) formula (Wolever, 2013). GI_{pred} considers the carbohydrate content of the meal, while GI_{adj} takes into account not only the carbohydrates but also fats and proteins when estimating the meal GI (Wolever, 2013). Adding fat and protein to carbohydrate may reduce its GI value which does not reflect the actual effect of the food's GI (Wolever, 2013). Studies have evaluated the use of GI_{pred} and GI_{adj}. However, results are not consistent. Some studies observed that the GI_{pred} overestimates the GI value of the meals (Dodd et al, 2011; Hatonen et al, 2011). Other studies found that both formulae are useful in estimating the meal GI (Robert and Ismail, 2012; Sun et al, 2014).

The GI values of commonly consumed rice in Malaysia were previously determined (Yusof et al, 2005). However, its applicability in the context of mixed meals is unclear. This study aimed to evaluate the glycemic response of rice-based diets either in the form of rice alone or mixed meal, and to identify the appropriate formula to estimate the GI of the rice-based mixed meal. We hypothesised that the GI value of rice alone could be applied in mixed meals.

MATERIALS AND METHODS

Study design and subjects

This is an experimental crossover study conducted at Universiti Putra Malaysia. The Institution's Committee on Human Studies approved the study protocol and participants provided their informed consent before enrolment. Eligible participants were healthy men and women between age 20 and 30 years, normal body mass index (BMI, 19.0–24.9 kg/m^2) and normal fasting glucose level (less than 5.6 mmol/L). Participants with chronic diseases, smokers, pregnancy or lactation and the used of medication that affects glucose metabolism (steroid) were excluded. A total of 63 individuals were screened for eligibility with 13 of them met our inclusion criteria. All of them enrolled, from which 11 participants completed all study visits. Two participants were unable to complete the study due to medical (n = 1) and personal (n = 1) reasons.

Test meals

The types of rice tested were fragrant white rice (Super fragrant AAA, Thailand), red rice (Jasmine Nutri Rice, Thailand) and parboiled rice (Faiza Basmati, Malaysia). As part of the mixed meal study, these three types of rice were stir-fried individually by adding fat and protein (fried fragrant white rice, fried red rice, and fried parboiled rice). Fried rice is usually consumed during breakfast in Malaysia. Protein and fat sources were kept constant in all the tested meals.

The rice to water ratio followed the cooking instruction from the packaging (Table 1). Nutrition information of the test rice is shown in Table 1. Cooking procedure and duration were consistent for each type of rice. Rice was cooked well using an electronic cooker and cooking time was set as 35 min. For the preparation of the mixed meal, rice was stir-fried using a frying pan. Fried rice was cooked according to a general preparation for fried rice. The ingredients, besides rice, included oil, garlic, onion, oyster sauce, mixed vegetables and egg. All the meals were prepared on the morning of the test day and served warm. All of the meals were served with 220 mL water. A glucose solution was diluted with 220 mL water (Glucolin®, Boots Company, Nottingham, United Kingdom) and used as a reference food. A smaller portion (25 g) rather than 50 g available carbohydrate was used to ensure that participants completed the test meals within the allocated time.

The proximate analysis of rice and the analyses of total dietary fibre content of rice alone were performed by a certified private laboratory. The methods for the

Table 1. Nutrient composition and rice to water ratio of test rice.

Food	Weight (g)	Energy (kcal)	Carbohydrate (g)	Fat (g)	Protein (g)	Fiber (g)	Rice to water ratio
Red rice	84	114	25.00 (88.5)	0.16 (0.6)	3.08 (10.9)	1.50	1:2
Fragrant white rice	77	110	25.00 (91.5)	0.15 (0.6)	2.16 (7.9)	0.53	1:1
Parboiled rice	110	113	25.00 (89.0)	0.22 (0.8)	2.86 (10.2)	0.10	1:1
Fried red rice [a]	135	247	25.20 (55.6)	13.24 (29.2)	6.90 (15.2)	1.07	–
Fried fragrant white rice [a]	129	243	25.10 (56.5)	13.20 (29.7)	6.10 (13.8)	0.32	–
Fried parboiled rice [a]	157	246	25.10 (55.8)	13.20 (29.3)	6.70 (14.9)	0.09	–

[a] Estimated using Nutritionist Pro™ (First Data Bank Inc, Washington, USA).
Values in the parentheses are the contributive percentage for energy.