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The Effect of Low Glycemic Index Bread Eaten with Different Fillings on Blood Glucose Response in Healthy Individuals

(Kesan Pengambilan Roti Indeks Glisemik Rendah dengan Pelbagai Inti ke Atas Aras Glukosa Darah di Kalangan Individu Sihat)

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ABSTRACT

White and whole meal breads have been classified as high glycemic index (GI) foods which in turn produce the greatest rise in blood glucose. One of the commercial bread products in Malaysia known as Brown breads (BB) has been recently marketed as a healthy choice for diabetics due to its low GI value. This study was conducted to examine the effect of BB when eaten with different fillings on blood glucose response among healthy individuals and to describe the influences of these fillings in reducing blood glucose response. Five test meals using BB (BB eaten with baked beans, BB eaten with vegetable, BB eaten with apple, BB eaten with roast chicken and BB eaten with seaweeds) had been prepared for this study. Postprandial blood glucose response was determined for each test meal and reference food (glucose) that contained 50 g carbohydrate respectively. A total of 21 healthy subjects were recruited by advertisement to participate. Only 20 subjects (15 males, 5 females, Mean ± SD Age : 24.4 ± 3.7 years; BMI 23.4 ± 3.0 kgm^{-2}) completed this study. After an overnight fast, subjects consumed BB eaten with fillings according to the assigned group given and three repeated tests of reference food (glucose). Fasting capillary blood glucose samples were taken at time 0 and at 15, 30, 45, 60, 90 and 120 min respectively after the meal began. The blood glucose response was obtained by calculating the incremental area under the curve (AUC). Blood glucose response after consuming reference food (251.8 ± 12.1 mmol.min/L) was significantly higher than all the test meals ($p < 0.05$). Among the test meals, BB eaten with baked beans produced the highest rise in blood glucose (97.0 ± 16.9 mmol.min/L) whereas BB eaten with seaweeds demonstrated the lowest response in blood glucose (33.3 ± 6.5 mmol.min/L) and the difference was statistically significant ($p < 0.05$). The postprandial blood glucose response after ingestion of BB when eaten with vegetable was 73.3 ± 19.1 mmol.min/L followed by BB eaten with apple (58.9

± 12.2 mmol.min/L) and BB eaten with roast chicken (56.5 ± 10.1 mmol.min/L). Generally, BB when eaten with fillings produced a slow rise in blood glucose response than the reference food. Combining this BB with fillings had the effect of reducing the postprandial blood glucose further.

Key words: Blood glucose response, Whole grain bread, Glycemic index

ABSTRAK

Roti putih dan mil penuh dikelaskan sebagai makanan tinggi indeks glisemik (GI) yang mana akan meningkatkan aras glukos dalam darah. Salah satu produk roti komersial di Malaysia iaitu roti perang (RP) telah dipasarkan sebagai pilihan sihat untuk pesakit diabetes disebabkan nilai GInya yang rendah. Kajian ini telah dijalankan untuk menentukan kesan RP ini apabila dimakan dengan inti terhadap aras glukos darah di kalangan individu sihat dan menilai bahan-bahan tertentu yang boleh menurunkan aras glukos darah. Lima hidangan kajian menggunakan RP (RP dimakan dengan kacang panggang, RP dimakan dengan sayuran, RP dimakan dengan epal, RP dimakan dengan ayam panggang dan RP dimakan dengan seaweeds) telah disediakan untuk kajian ini. Aras glukos posprandial ditentukan untuk setiap hidangan kajian dan makanan rujukan yang setiap satunya mengandungi 50 g karbohidrat. Seramai 21 orang subjek sihat telah terpilih untuk menyertai kajian ini melalui iklan. Hanya 20 orang subjek (15 lelaki, 5 perempuan, Min ± SP; Umur : 24.4 ± 3.7 tahun; IJT 23.4 ± 3.0 kgm^{-2}*) yang berjaya menamatkan kajian ini. Selepas semalaman berpuasa, subjek dikehendaki mengambil makanan kajian iaitu RP dimakan dengan inti berdasarkan kepada kumpulan yang diberikan dan juga makanan rujukan (glukos) yang diulang sebanyak tiga kali. Sampel darah kapilari berpuasa telah diambil pada masa 0 dan 15, 30, 45, 60, 90 dan 120 min selepas makan. Respons glukos darah diperolehi dengan mengira luas kawasan di bawah graf (AUC). Aras glukos darah selepas mengambil makanan rujukan (251.8 ± 12.1 mmol.min/L) adalah tinggi secara bererti berbanding semua hidangan kajian (*$p < 0.05$*). Di antara hidangan kajian, RP dimakan dengan kacang panggang (97.0 ± 16.9 mmol.min/L)menghasilkan respons glukos darah tertinggi manakala RP dimakan dengan seaweeds (33.3 ± 6.5 mmol.min/L) menunjukkan respons glukos darah terendah dan ia berbeza secara bererti (*$p < 0.05$*). Respons glukos darah posprandial selepas mengambil RP dimakan dengan sayuran adalah 73.3 ± 19.1 mmol.min/L diikuti oleh RP dimakan dengan epal (58.9 ± 12.2 mmol.min/L) dan RP dimakan dengan ayam panggang (56.5 ± 10.1 mmol.min/L). RP ini apabila dimakan dengan inti tertentu menghasilkan respons glukos darah yang lebih rendah berbanding makanan rujukan. Kombinasi RP dengan bahan-bahan tersebut akan menurunkan lagi aras glukos darah posprandial.*

Kata kunci: Respons glukos darah, Roti bijirin penuh, Indeks Glisemik

INTRODUCTION

Bread is an essential carbohydrate component of the diet. It has been shown to be the most popular substitute for rice, the staple diet of Malaysians. Bread, in most instances, comes quite handy when a quick meal is desirable. It is usually consumed for breakfast or as a replacement for rice in the main meals. In Malaysia, the bread industry has undergone many changes in the last decade (Rydings 2002). The emphasis now is on healthy bread particularly on whole meal products because of their high dietary fibre content (Chin 2006). However, despite their different fibre content, the GI of both white and whole meal breads are similarly high which produce the greatest rise in blood glucose levels (Jenkins et al. 2002).

The glycemic index (GI) is the classification of carbohydrate foods according to their effects on postprandial blood glucose (Jenkins et al. 1981). Foods with high GI elicit a higher and more rapid elevation in blood glucose as well as greater demand for insulin (Augustin et al. 2002). Recent evidence has suggested that increased postprandial blood glucose and insulin concentration are risk factors for diabetes and cardiovascular disease (Ludwig 2003). On the other hand, the consumption of low GI foods may be beneficial in preventing and managing diabetes (Opperman et al. 2004).

In Malaysia, a commercial bread product known as Brown breads (BB) has been marketed as a healthy choice for diabetics due to its low GI value (Gardenia 2004). Although bread is not a major staple food for Malaysians, the recent Malaysian Adult Nutrition Survey indicated that in general Malaysians consume bread at least twice a week (Norimah et al. 2007). Bread is usually consumed as a source of carbohydrate in combination with other ingredients such as spread or fillings and very rarely by itself. Therefore, Bourdan et al. (1999) emphasised the importance of understanding the more typical pattern associated with eating a meal. Thus, the objective of the present study is to determine the postprandial blood glucose response after consuming BB when eaten with fillings among healthy individuals. In addition, the possible influence of the fillings which were baked beans, vegetable, apple, roast chicken and seaweeds in reducing blood glucose responses was also described.

EXPERIMENTAL METHODS

SUBJECTS

A total of 21 healthy subjects (16 males and 5 females) were recruited by advertisement. One subject was excluded as he was unable to comply with the study protocol. The remaining 20 healthy subjects were equally assigned into two groups (A and B). This was necessary to enable the subjects to complete the prescribed test meals within the time-limit allocated. Group A was assigned three test meals whereas group B were given two test meals. Subjects were non-smokers, not on any medication and had not known chronic diseases or illness. They were requested to maintain their usual daily food intake and activity throughout the study period. The purpose and protocol of the study were explained to the subjects and written consent was obtained. This study had been approved by the ethics and research committee of our institution (Project Code: FF-138-2005).

CHARACTERISTIC OF BROWN BREAD (BB)

The brown bread (BB) used in this study are specially formulated to be high in fibre and low in GI (GI = 36) (Gardenia 2004). The GI of BB was previously tested locally by a group of researcher from UKM (unpublished report). This bread was enriched with functional ingredients such as oats fibre and fructo-oligosaccharides (FOS) in addition to the common ingredient of basic bread which were whole grain wheat flour, water, yeast and salt (Gardenia 2004; McKevith 2004). The nutrient composition of the BB was provided by the Gardenia Bread (KL) Sdn. Bhd. and verified by the American Institute of Baking (AIB) (Table 1).

TABLE 1. Nutrient composition of Brown bread (BB) per 100 g portion

Nutrient Composition of BB for per 100 g portion	
Calories (kcal)	174
Protein (g)	12.9
Total fat (g)	3.0
Total Carbohydrate	40.1
• Dietary fiber	17.8
• Sugar	2.5

Source: Gardenia Bread (KL) Sdn. Bhd. 2004 and verified by the American Institute of Baking (AIB)

TEST MEALS AND REFERENCE FOOD

The five test meals using BB consisted of BB with baked beans, BB with vegetable, BB with apple, BB with roast chicken and BB with seaweeds have been prepared for this study. All the test meals were prepared to contain 50 g of carbohydrates in order to compare with the 50 g of carbohydrate from the reference food (glucose-Glucolin™). The test meals were also iso-caloric and had similar fat and protein content. The nutrient composition was calculated based on the Malaysian Food Composition Table (Tee et al. 1997) and shown in Table 2.

TABLE 2. Nutrient composition of test meals

Test meals	Weight (g)	Energy (kcal)	CHO (g)	Protein (g)	Fat (g)	Fibre (g)
BB eaten with roast chicken	270	477	49	31	16	31
BB eaten with seaweeds	288	487	50	32	16	31
BB eaten with baked beans	275	454	50	22	16	22
BB eaten with mix vegetable pie	194	442	51	22	15	32
BB eaten with apple	236	441	49	22	15	26
Total (mean)	253	460	50	26	16	28

EXPERIMENTAL PROTOCOL

Subjects were required to go through the study protocol (test meals and reference food) according to the assigned groups (A or B). Each test meal was conducted on separate morning after a 10-12 h overnight fasting. The reference food was repeated three times in order to reduce the variability within the subjects (Wolever 2003). After fasting blood sample was taken, subjects were requested to consume the test meals with 250 ml plain water (during the protocol of the test meals) or the glucose in 500 ml water (during the protocol of the reference food) in random order at a comfortable pace within 15 minutes. Further blood samples were taken at 15, 30, 45, 60, 90 and 120 minutes respectively after the meal began. Whole blood samples (32 μl) were obtained by finger-prick with a lancet (Hemocue Safety Lancet® USA) and were collected into a capillary tube (Selzer® Reflotron, Germany). Blood glucose was assayed using the glucose oxidase method (Wolever 2003) by an automatic glucose analyzer (Reflotron-Plus, Roche, Germany).

DATA ANALYSIS

The blood glucose responses for every point of time over two hours were used to calculate the incremental area under the curve (iAUC), ignoring area beneath the baseline for each test by encoding with Lotus software (123; CA USA). The iAUC calculation used was described by the Food and Agriculture Organization of the United Nations (FAO/WHO 1998). The blood glucose response is largely determined by within-subject variation (Wolever 2003). Therefore, the coefficient variation or CV (CV = 100 × SD/Mean value) of the iAUC after the repeated test of reference food was calculated to ensure the precision of the result obtained.

The response of blood glucose were expressed as mean ± SEM. Blood glucose levels and the iAUC values were subjected to ANOVA followed by Tukey's multiple range test. Differences were considered significant if $p < 0.05$. The statistical computations were performed using the Statistical Packages for Social Sciences (SPSS) software (Version 11.5).

RESULTS

BMI of the subjects did not differ significantly between the two groups but difference in age was significant (Table 3). The differences in fasting blood glucose at time 0 and at 120 min were not significant. The postprandial blood glucose responses to the test meals were significantly lower than the reference food ($p < 0.05$) at 15, 30, 45, 60 and 90 minutes postprandially ($p < 0.001$) with no difference between each test meals. Blood glucose response reached the peak at 30 min after consuming all the test meals including the reference food with the reference food achieved the maximal glucose response (Figure 1).

TABLE 3. Baseline characteristic of the subjects according to the two groups of test meals

	Subjects		Total/Mean ± SD (Range)
	*Group A	**Group B	
n (gender)	10 (all males)	10 (5 males, 5 females)	20
Age (Years)	21.0 ± 7.9	26.9 ± 3.7 [a]	24.4 ± 3.7 (21-34)
BMI (kgm^{-2})	22.6 ± 1.6	24.2 ± 3.8	23.4 ± 3.0 (19-29)

[a]$p < 0.05$ significant different using Independent *T*-test

* Group A involved two test meals : BB eaten with seaweeds and BB eaten with roast chicken

** Group B involved three test meals : BB eaten with mix vegetable, BB eaten with apple and BB eaten with baked beans

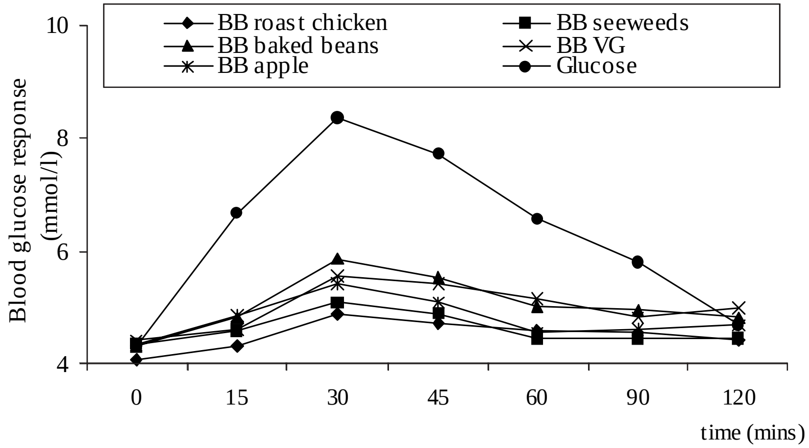
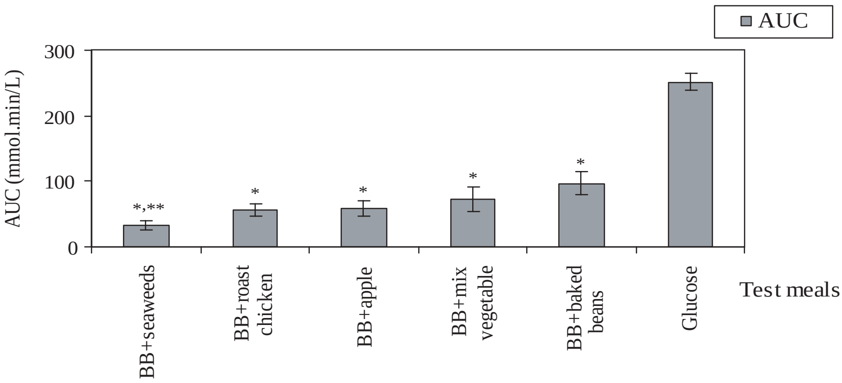


FIGURE 1. Mean blood glucose concentration after consuming the BB (BB) eaten with various fillings

The iAUC, which reflects the changes occurring in blood glucose level after consuming test meals were calculated for the blood glucose response over the 2 hour period (Wolever 2003). The iAUC of the reference food (251.8 ± 1.2 mmol.min/L) was significantly higher than all the test meals ($p < 0.05$). Among the test meals, BB eaten with baked beans (97.0 ± 16.9 mmol.min/L) produced the highest rise in blood glucose whereas BB eaten with seaweeds (33.3 ± 6.5 mmol.min/L) demonstrated the lowest response in blood glucose and the difference was statistically significant ($p < 0.05$). The iAUC of BB when eaten with vegetable was 73.3 ± 19.1 mmol.min/L followed by BB eaten with apple (58.9 ± 12.2 mmol.min/L) and BB eaten with roast chicken (56.5 ± 10.1 mmol.min/L) (Figure 2). The degree of within- subject variation, assessed by the mean CV of blood glucose response to three repeated tests of reference food for the 20 subjects was 27.1 + 9.1 % (Range: 15.2 – 50.8%) and this is acceptable result as recommended by the Glycmic Index Limited i.e. must be less than 30% (SUGiRS 1995).



*Significant difference from glucose.
**Significant difference from BB eaten with Baked Beans ($p < 0.05$, ANOVA)

FIGURE 2. Mean (± SEM) incremental area under the curve (AUC) for glucose changes calculated over 2 hours in healthy volunteers after consumption of test meals in ascending order

DISCUSSION

This study showed that the ingestion of BB with fillings had the effect of significantly reducing postprandial blood glucose than the reference food. In this study, the main ingredient of the test meals was BB. The higher soluble fibre content (oat fibre) and enrichment with functional food namely fructo-oligosaccharide (FOS) in the BB has been suggested to be responsible for the glucose lowering effect. This result is consistent with previous study where the addition of oats fibre and incorporation of FOS into food do not lead to a rise in serum glucose, insulin secretion and may contribute to the cholesterol-lowering ability (Bourdan et al. 1999).

Combining bread with other foods such as dairy products, vinegar and bean products could reduce postprandial blood glucose response (Sugiyama et al. 2003). In this study, BB eaten with seaweeds was found to have the lowest glycemic response among the other test meals. It could be due to the addition of 5.6g of seaweeds per meal. This finding is in agreement with the study by Goni et al (2000) who found that addition of 3 g of seaweeds (*Nori*) to white bread reduced blood glucose response from 100 to 68%. Seaweed is particularly rich in dietary fibre with a high proportion of soluble fraction and could acts as a physical barrier to starch digestion (Goni et al. 2000). Also, the lower response of blood glucose after ingestion of BB eaten with apple could be explained by the apple in the meal which is a low GI fruit (Foster-Powell et al. 2002).

Previous study showed that beans, legume and lentils had low GI values (Foster-Powell et al. 2002). Attenuated blood glucose responses after ingestion of these foods products have been attributed to their high-fibre and their anti-nutrients content (Schafer et al. 2003). However, BB eaten with baked beans did not produce the lowest iAUC value in this study. This could be explained by the cooking process. Some studies have demonstrated that when foods are consumed in grounded state, the blood glucose response is increased (Araya et al. 2002). In the case of BB eaten with baked beans, the beans were simmered until thickened, a method which may increase the gelatinization of the bean, producing a higher iAUC value than the other test meals.

When mixed meals are consumed, other food and macronutrients will be present. It is noted that fat and protein influence the blood glucose response (Owen & Wolever 2003). Nonetheless, it has been reported that the amount and type of carbohydrate account for about 90% of the total variability in blood glucose response, whereas protein and fat in mixed meals scarcely contribute to the variance in blood glucose and insulin responses (Wolever et al. 2006). In this study, however, controlling the magnitude by which fat and protein disrupt the glycemic response of mixed meals is not apparent and requires different investigation in a dose response manner (Moghaddam et al. 2006).

This study has several limitations that could impact the study findings. First, the small number of subjects may not allow the findings to be generalised to other different fillings when eaten with BB. Second, the test meals studied were prepared according to the study protocol and therefore, the calories and nutrient content were quantitatively larger to be consumed as part of the daily intake. Besides, because of large between and within subject variation on blood glucose response, the blood glucose response of a subject on a single occasion cannot be used to determine the absolute effect of the test meals. However, this still can provide a guide to the relative blood glucose effect or the rank order of the average blood glucose responses elicited by different mixed meals eaten

(Wolever et al. 2006). Indeed, because little data is available on blood glucose response of foods, the findings from this study could serve as a basis for future studies on the effect of other local meals on blood glucose response.

In conclusion, the effect of BB when eaten with filling produced a slow rise in blood glucose response than the reference food. The combination of the BB with carbohydrate foods that have glucose lowering effects further enhanced the reduction in postprandial blood glucose response. Studies that determine the magnitude effect of fat and protein to the mixed meals should be undertaken.

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