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Determination of glycemic index for some breads

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Abstract

Glucose-responses and glycemic indices of standard bread, rye bread and mixed bread were studied with 10 healthy subjects. Incremental areas of blood glucose (above fasting levels) were calculated as 81, 58 and 46 mmol/liter×120 min GI values determined as 100, 72, 57 for standard bread, rye bread and mixed bread, respectively. The area under the glucose-response curve and GI value of standard bread were significantly higher than rye bread and mixed bread ($p < 0.05$).

1. Introduction

The glycemic effect of a food is a measure of how fast and how high the blood glucose rises, and how quickly the body responds by bringing it back to normal after food ingestion (Whitney, Hamilton, & Rolfes, 1990). The glycemic index (GI) is a ranking of foods based on the postprandial blood glucose response compared with a reference food, e.g.white bread (Foster-Powell & Brand-Miller, 1995). The effects of different foods on blood glucose apparently depend on many factors. These are digestibility of the starch, interactions of the starch with protein, the amounts and kinds of fat, sugar and fiber, the presence of other constituents, such as molecules that bind starch, and the form of the food (dry, paste, or liquid; coarsely or finely ground; cooking and processing) (Englyst, Veenstra, & Hudson, 1996; Kritchevsky, 1988; Whitney et al., 1990). The glycemic effect of a food may be important to people with abnormalities of blood glucose regulation, notably diabetes or hypoglycemia; these people may benefit from avoiding foods that produce too great a rise, and too sudden a fall, in blood glucose. This would also be important to the general population who might wish to prevent the development of such conditions. There is doubt about the clinical utility of the glycemic index and dietary guidelines for humans suggest that the concept may be helpful, but that more research is required before it can be applied generally. In clinical trials of diets with low glycemic indices, improved blood glucose control was seen when diet glycemic index was reduced by 12–40% (Wolever, Jenkins, Jenkins, & Josse, 1991; Wolever, Nguyan et al., 1994). Food analysis, whether for research or for food labelling, should be based on the measurement of chemically identified components, because such values can be grouped or divided as appropriate when new knowledge of their importance to public health becomes available (Englyst et al., 1996).

Recently, two commercial bread products which are used in this study, have been represented as a healthy choice for diabetic people. But there are no investigations on glycemic index of these products. Thus, the purpose of this study is to determine the influence of standard bread, rye bread and mixed bread on glucose responses of healthy subjects and to calculate glycemic indices of breads.

2. Materials and methods

2.1. Breads

In this study, standard bread (100% wheat flour), rye bread (50% wheat flour + 50% rye flour) and mixed bread (75% wheat flour + 10% rye flour + 15% wheat bran) were studied. All samples were purchased from a local supermarket. Proximate composition (moisture, ash, calorie, protein, fat and carbohydrate) of breads were analyzed according to AOAC (1995). Energy values of breads were determined by Adiabatic Bomb Calorimeter (IKA Kalorimeter C 400).

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2.2. Experimental design

Ten healthy subjects (four male, six female) took part in the study. Their ages ranged from 19 to 35 years and their body mass index (BMI; in kg/m^2) from 20.1 to 26.8 (Table 1). Fifty grammes of carbohydrates (this includes non-starch polysaccharides) of either standard bread, rye bread or mixed bread were consumed by each subject, in random order on separate mornings after a 10–12 h overnight fast. For individual subjects, the tests were given 3 days apart. Breads were consumed over 6 min with tap water. Capillary finger-prick blood samples (3–4 drops) were taken for subjects fasting (0 min) and at 30, 60, 90 and 120 min after the start of the test meal. Blood samples were collected into tubes and frozen at −20°C before glucose analysis by a glucose oxidase (EC 1.1.3.4) method using a Beckman spectrophotometer (Beckman Instruments).

The areas under the glucose-response curves for each bread were calculated geometrically, excluding beneath the fasting level. The GI was calculated by expressing the glycemic response area for the mixed bread and rye bread as a percent of the mean response area of the standard bread taken by the same subjects (Wolever et al., 1991; Wolever et al., 1994). The resulting values were averaged to obtain the GI value for the breads.

2.3. Statistical analysis

Results are expressed as means with their standard errors. Statistical analysis and multiple comparisons between response areas were made by analysis of variance and Student's *t* test.

3. Results and discussion

Proximate compositions of breads are shown in Table 1. Also clinical information for 10 healthy subjects is shown in Table 2.

The mean eating times for the subjects were 6 min (SE 0.26), 6.3 min (SE 1.8) and 6.5 min (SE 2.0) for the standard bread, rye bread and mixed bread, respectively. No statistically significant differences are found between the eating rates of the breads.

The mean incremental blood glucose responses up to 120 min following ingestion of the three breads are shown Table 3 and Fig. 1.

The fasting blood glucose concentrations of the subjects were within the normal range (Whitney et al., 1990) with a mean of 4.1 (SE 0.45, range 3.5–4.8) mmol/liter, 39 (SE 0.16, range 3.4–4.5) mmol/liter and 3.8 (SE 0.19, range 3.4–4.5) mmol/liter for the standard bread, rye bread and mixed bread, respectively. There were similar increases for both standard bread (6.0 mmol/liter) and rye bread (6.1 mmol/liter) at 30 min time intervals. The rye bread produced a significantly lower blood glucose response at 60 min than did the others.

Table 1
Proximate composition of breads

Analysis	Standard bread	Rye bread	Mixed bread
Moisture (%)	36.50	37.00	38.75
Calories (kcal)	251	260	212
Protein (%)	5.71	8.41	9.00
Fat (%)	1.07	4.01	0.9
Carbohydrate (%)	54.7	46.0	48.0

Table 2
Clinical information for 10 healthy subjects

Subject	Gender	Age (years)	Weight (kg)	Body mass index (kg/m^2)
1	Male	19	62.3	25.0
2	Female	23	50.5	20.1
3	Female	23	54.0	21.5
4	Male	25	60.4	20.8
5	Male	28	68.0	24.6
6	Female	35	58.7	22.3
7	Female	33	59.0	22.0
8	Female	30	60.1	21.4
9	Female	28	64.3	26.7
10	Male	35	71.2	26.8
Mean (SE)		27.9(1.72)	60.85(1.92)	23.12(0.77)

Table 3
Blood glucose responses and area under the curve of blood glucose responses and GI of samples[a]

Breads	Blood glucose (mmol/liter)					Area under the curve(mmol/L min)[b]	GI
	0 min	30 min	60 min	90 min	120 min		
Standard bread	4.1 ± 0.45	6.0 ± 0.08	4.9 ± 0.11	3.9 ± 0.60	4.0 ± 0.20	81 ± 6.0	100 ± 0
Rye bread	3.9 ± 0.16	6.1 ± 0.24	3.3 ± 0.09	3.4 ± 0.24	3.2 ± 0.08	58 ± 3.2	72 ± 5[c]
Mixed bread	3.8 ± 0.19	5.0 ± 0.03	4.2 ± 0.42	3.6 ± 0.61	3.8 ± 0.08	46 ± 2.4	57 ± 4[c]

[a] × ± SEM.
[b] Incremental area under the glucose response curve, ignoring the area below fasting, as used for calculating the GI.
[c] Mean values were significantly different from those for standard bread.

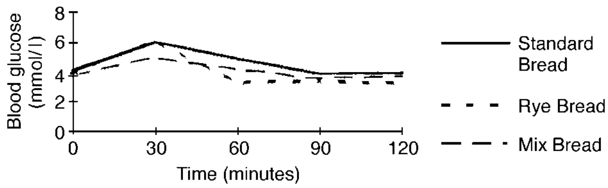

Fig. 1. Blood glucose responses (× ± SE) of 10 healthy subjects to breads.

The peak rise was reduced from 6.1 ± 0.24 to 3.3 ± 0.09 mmol/liter ($p < 0.05$). Blood glucose responses at 90 min of breads were under the fasting levels.

Incremental areas of blood glucose (above fasting levels) for three breads were calculated as 81 (SE 6.0) mmol/liter×120 min, 58 (SE 3.2) mmol/liter×120 min and 46 (SE 2.4) mmol/liter×120 min for standard bread, rye bread and mixed bread, respectively. The area under the glucose-response curve for standard bread was significantly higher when compared with the corresponding meals of rye bread and mixed bread ($p < 0.05$) (Table 3). The area under the glucose-response curve for each sample was expressed as a percent of the mean response to the standard bread taken by the same subjects, and the resulting values were averaged to obtain the GI values for breads (Table 3). GI values of standard bread (100 ± 0), rye bread (72 ± 5) and mixed bread (57 ± 4 were significantly different from each other ($p < 0.05$).

The results of the present investigation indicate that standard bread exhibited the highest glycemic response, mixed bread least and rye bread an intermediate response. These values are similar to those of wheat pasta and porridge, which are recognized as low GI foods (Sumathi, Vishwanatha, Malleshi, & Venkat Rao, 1997). From Table 1, it can be observed that the mixed bread contains 15% level of wheat bran which could have exerted a hypoglycemic effect (Nishimune et al., 1991; Wolever, 1990). Previous studies suggested that dietary fiber and enzyme inhibitors reduce postprandial blood glucose responses. The mechanism of action of fiber is thought to be a reduction in the rate of absorption of dietary carbohydrate by the formation of a viscous gel in the small intestine. Also the encapsulation of nutrients within plant cell walls may be the most important mechanism for many foods. (Wolever et al., 1991; Wolever, Jenkins, Ocana, Venketeshwer, & Gregory, 1988). Thus the degree to which the fiber is mixed with carbohydrate foods may influence the degree to which the rate of absorbtion of dietary carbohydrate is reduced (Foster-Powell & Brand-Miller, 1995). Miller, Pang, and Bromall (1992) reported that rice bran which is rich in fiber and oil had an extremely low GI and may be a useful supplement in diabetic diets.

There are a number of factors that can influence the absolute amounts of glucose appearing in the blood during the test period of 2 h following the meal. These include the rate of gastric emptying and the magnitude of the insulin response, the degree of chewing, the amylase concentration in the gut and the presence of other food components (Englyst et al., 1996).

It is concluded that determining the potential glycemic index of a food is a useful supplement to chemical analysis of a food. Also, GI index should be represented on the label of packaged breads that have been manufactured under standard conditions.

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