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Effect of soy protein isolate preload on postprandial glycemic control in healthy humans

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ABSTRACT

Objective: Premeal consumption of whey protein improves the postmeal glycemic profile, but little information exists on soy protein. The study aim was to examine the effect of consuming different amounts of a soy protein isolate (SPI) before a 75-g oral glucose tolerance test (OGTT) on subsequent glycemic control.
Methods: After overnight fasting, eight healthy young subjects consumed a 400-mL liquid meal containing 0 g (SP0), 20 g (SP20) or 40 g (SP40) SPI. Thirty minutes after SPI consumption, an OGTT was performed to evaluate the individual glycemic response. Blood glucose and plasma insulin concentrations were measured immediately before the SPI preload (i.e., 30 min before the start of the OGTT) and before (−10 min) and during the OGTT (15, 30, 45, 60, 90, and 120 min).
Results: The incremental area under the curve and peak blood glucose response were significantly less for SP40 than those for SP0 and SP20. Insulin secretion was significantly higher for SP20 and SP40 than that for SP0 before and at 15 min after oral glucose consumption. The incremental area under the curve of plasma insulin was significantly higher for SP20 and SP40 than that for SP0.
Conclusions: An SPI preload of 40 g, but not 20 g, improved glycemic control in young healthy subjects. Glycemic control appears to be attributed not only to the exaggerated insulin response to SPI preload, but also to non-insulin dependent mechanism(s), such as delayed gastric emptying.

Introduction

Maintaining a blood glucose level within a normal range by lowering postprandial hyperglycemia is effective at preventing diabetic complications, such as neuropathy, renal failure, blindness, and heart failure [1]. The guidelines for managing postprandial blood glucose caution against sustained postprandial hyperglycemia as a risk factor for accelerating diabetic complication development [1]. Several dietary therapies for preventing postprandial hyperglycemia have been recently proposed [2].

The insulin and increatin hormonal responses following meal ingestion may have a certain role of postprandial glycemic control [3,4]. Specifically, reduced hormonal responses have been often observed in patients with type 2 diabetes [3,4]. To compensate for lack of those hormone secretions, a dietary therapy consisting of protein ingestion before a main meal, called “protein preload”, has been developed. Whey protein consumption (50–55 g) 30 min before consuming a carbohydrate-rich meal reduced the postprandial hyperglycemic response compared with to co-ingestion of whey protein in patients with type 2 diabetes [5,6]. This positive whey protein preload effect on the postprandial hyperglycemic response has been attributed to an enhanced insulin response and delayed gastric emptying with increased glucose-dependent insulinotropic polypeptide, glucagon-like

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peptide-1 (GLP-1), and cholecystokinin secretion preceding the main meal [5–7]. Akhavan et al. [8] reported that even relatively small amounts of whey protein (10–40 g) are still effective at reducing the postprandial glycemic response in healthy subjects. To our knowledge, four previous studies have focused on whey protein preload [5–8]. In contrast, less information exists on other protein types, such as soy protein. Silva Ton et al. [9] reported that soy protein (25 g) preload also attenuated the postprandial glycemic response. However, the amount of protein required to achieve a significant glycemic response has not been clarified. Furthermore, it remains to be resolved as to whether this beneficial effect is dependent on exaggerated insulin secretion.

Recent prospective cohort studies, in which consumption of an animal protein was possibly associated with diabetes onset risk, have recommended eating not only animal protein but also vegetable protein, such as soy [10,11]. Soybean, which is a familiar food in Japan, is routinely consumed as processed foods, such as tofu, miso, and natto. Soybean has a lower lipid (especially saturated fats) to energy ratio than that of milk or meat (i.e., animal protein), which could lead to a reduction in energy intake. Moreover, soybean products can be safely consumed by people with lactose intolerance who often experience gastrointestinal problems after consuming lactose products (e.g., milk products) [12]. In this study, we, therefore, investigated the effect of consuming different amounts of a soy protein isolate (SPI) on subsequent postprandial glycemic control in healthy human subjects.

Materials and methods

Subjects

Eight healthy young Japanese subjects (four females and four males; ages 22 ± 2 y; height, 165 ± 10 cm; weight, 57 ± 7 kg; mean ± SD) participated in this study. The subjects were normotensive, did not smoke or take any medication, and had no history of autonomic dysfunction or cardiovascular disease. The study was approved by the Ethics Committee of the Prefectural University of Hiroshima, Japan, and each subject provided written informed consent to participate before the commencement of the study. Subjects arrived at 08:30 in the laboratory after fasting for 12 h overnight and having abstained from strenuous exercise, alcohol, and caffeine for at least 1 d. Subjects were seated in a chair in a semisupine position in a quiet room, where the temperature and humidity were maintained at 25 ± 1°C and 42 ± 6%, respectively.

Experimental design

This study was conducted as a single-blind, randomized, crossover design. Each subject participated in three trials (i.e., treatments). Female subjects were scheduled during their late follicular phase; menstrual cycle affects gastric emptying and blood glucose, insulin, and GLP-1 concentrations [13]. Male subjects participated at a maximum of once per week. Following fasting blood sample collection, subjects were instructed to consume a 400-mL preload drink containing 0 g (SP0), 20 g (SP20) or 40 g (SP40) SPI powder (HD-101 R, Fuji Oil Co., Ltd, Osaka, Japan) within 1 min. The SPI amino acid composition was determined using an amino acid automatic analysis method (L-8900, Hitachi High-Tech Science Co., Ltd, Tokyo, Japan) (Table 1). Two grams of the artificial sweetener PAL SWEET (Ajinomoto Co., Ltd, Tokyo, Japan) was added to all preload drinks for palatability. At 30 min after ingestion, subjects were subjected to a 75-g oral glucose tolerance test (OGTT) (Trelan-G; Ajinomoto Pharma Co., Ltd, Tokyo, Japan), and then monitored for 120 min.

Blood sampling

Capillary blood samples were collected at baseline (30 min before the start of the OGTT, immediately before consuming the preload drink) and before (−10 min) and during the OGTT (15, 30, 45, 60, 90, and 120 min) by pricking the right index and middle fingers. Blood glucose concentrations were analyzed by a dedicated measurement device (Arkray glucocard Diameter-alpha. GT-1661, Arkray, Inc., Kyoto, Japan). Blood samples were collected into postheparin 75-μl capillary tubes and centrifuged at 10 000 to 12 000 rpm for 5 min to obtain plasma samples. Plasma samples were refrigerated at −20°C. Plasma insulin concentrations were measured using an enzyme immunoassay kit (Mercodia Insulin ELISA, Mercodia Co., Ltd, Uppsala, Sweden).

Table 1
Amino acid composition of soy protein isolate (g/100 g protein)

Alanine	3.7
Arginine	6.7
Aspartic acid	10.2
Cysteine	1.1
Glutamic acid	17.0
Glycine	3.6
Histidine*	2.3
Isoleucine†	4.0
Leucine†	6.9
Lysine*	5.5
Methionine*	1.1
Phenylalanine*	4.6
Proline	4.6
Serine	4.4
Threonine	3.4
Tryptophan*	1.2
Tyrosine	3.4
Valine†	4.2

* Essential amino acids.
† Branched-chain essential amino acids.

Calculations

The peak blood glucose values during the OGTT were evaluated. The blood glucose and plasma insulin responses were calculated as an incremental area under the curve (iAUC) above baseline values following SPI preload.

Data analysis

The data are expressed as mean and standard error of the mean. The effects of time and treatment on blood glucose and plasma insulin concentrations were analyzed by two-way repeated analysis of variance. When a significant effect was detected, Dunnett and Tukey post hoc tests were conducted to reveal the effects of time (the change from baseline) and treatment, respectively. The effect of treatment on the peak values and peak times of blood glucose concentrations, blood glucose iAUC, and plasma insulin iAUC were analyzed by one-way repeated analysis of variance. When a significant effect was detected, Tukey post hoc test was conducted. The level of statistical significance was set at $P < 0.05$. All statistical analyses were performed with SPSS PASW 18 statistics software (SPSS, IBM, Armonk, NY, USA).

Results

Blood glucose and plasma insulin responses

There were no differences in fasting blood glucose and plasma insulin concentrations among the three treatments. During the 15–120 min OGTT period in all treatments, blood glucose concentration significantly increased from baseline (Fig. 1A). Between 15 and 45 min, SP40 preloading resulted in lower blood glucose levels than those of SP0 and SP20. The times at which blood glucose peaked did not differ between the treatments (SP0: 47 ± 7 min, SP20: 45 ± 4 min, SP40: 55 ± 8 min). The blood glucose iAUC was lower for SP40 than those for SP0 and SP20 preloading (Fig. 1B). The blood glucose peak was lower for SP40 (7.7 ± 0.3 mmol/L) than those for SP0 (9.2 ± 0.3 mmol/L) and SP20 (8.7 ± 0.3 mmol/L) preloading. No differences were observed in either the iAUC or the peak blood glucose value between SP0 and SP20.

During the 15 to 120 min OGTT period, plasma insulin concentrations significantly increased from baseline in all treatments (Fig. 2A). At −10 min (before OGTT initiation), plasma insulin concentrations following SP20 and SP40 treatment significantly increased from baseline. SP20 preloading resulted in a higher plasma insulin response than that of SP0 at 15 min.