Note

Comparison of Analyzed and Calculated Values of Gamma-Aminobutyric Acid (GABA) Intake from Hospital Diet

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Summary

Intake of gamma-aminobutyric acid (GABA) from nutritionally controlled hospital diet was analyzed and compared with those estimated by calculation. Thirty meals provided at a hospital in Okinawa were sampled. GABA content per meal were measured by HPLC and calculated from GABA content data in foods as much as available. As a result, out of a total of 30 meals, only 49.3% of the weight of food that appeared in the meals could be calculated. The analyzed and calculated median daily GABA intake was 67.3 mg and 30.0 mg. Overall, the calculated values were lower than the analytical values, but there was a significant positive correlation (rs=0.618, p<0.001). The more complete the database on GABA content, the more accurate the GABA intake could be estimated by calculation.

Key Words hypertension, functional ingredients, nutritionally controlled diet, direct measured, calculated values

Hypertension is the greatest risk factor for cardiovascular diseases such as stroke, ischemic heart disease, and arteriosclerosis (1). In addition to genetic factors, environmental factors are intricately associated with the development of hypertension. Dietary improvements have been shown to be effective strategies for the prevention of hypertension (1).

Currently, the use of functional foods that are expected to have some health effects, including the prevention of hypertension, is gaining considerable traction (2). GABA (gamma-aminobutyric acid) is one of the components expected to have the functionality of preventing hypertension through the inhibition of noradrenaline release from sympathetic nerve endings (3). Several animal and human intervention studies have reported the hypotensive effect of GABA (3).

GABA is a non-essential amino acid and widely distributed in nature and is mainly contained in vegetables and fruits, so it is presumed to be taken from the daily diet (4). However, the GABA content in foods is not listed in the Standard Tables of Food Composition in Japan, so it is difficult to estimate, and there are no reports on daily GABA intake.

The purpose of this study was to quantify the intake of GABA from nutritionally controlled hospital diet by comparing the analyzed and calculated values.

Materials and Methods

Meal sampling. Ten days’ regular meals (i.e., 30 meals consumed for breakfast, lunch or dinner) provided at a hospital in Okinawa between December 2018 and January 2019 were sampled for each dish. After measuring the weight of each dish, samples were stored frozen. We also obtained information on the ingredients and their weights used for all sampled dishes.

GABA content measurement. Frozen meals were thawed, 1/4 of the total weight of purified water was added and homogenized with a food processor for each meal. Two grams were taken from the homogenized sample, 1 mL of a theanine solution (1 mg/mL) and 17 mL of purified water were added, and the mixture was centrifuged (4,000 rpm, 5 min at 4˚C). The supernatant was filtered to prepare an analytical sample. We added 90 μL of analytical sample solution or GABA standard solution to 0.1 m boric acid buffer 120 μL, 0.1% of 3-mercaptopropionic acid (MPA) solution in 0.1 m boric acid 540 μL, and o-phthalaldehyde (OPA) solution 264 μL mixture, stir, and 1 μL of the mixture was then immediately analyzed by HPLC with a fluorescence detector (Shimadzu RF-20A). GABA content was

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Table 1. Nutrient content, number and weight of food used for menu, and GABA analysis and calculation values of the sampled diet.

|                  | Breakfast/meal | Lunch/meal | Dinner/meal | Total/d |
|------------------|----------------|------------|-------------|---------|
|                  | n=10           | n=10       | n=10        | n=10    |
| Energy (kcal)    | 448±47         | 663±58     | 586±56      | 1,698±105 |
| Protein (g)      | 13.8±2.5       | 23.8±4.2   | 23.1±2.6    | 60.8±6.0  |
| Fat (g)          | 9.6±2.8        | 22.9±6.9   | 16.8±6.2    | 49.3±10.7 |
| Carbohydrate (g) | 74.5±7.4       | 87.4±7.2   | 81.8±4.4    | 243.8±10.7 |
| Total foods (g)  | 432            | 551        | 513         | 1,479   |
| Plant foods (g)  | (334–679)      | (445–667)  | (470–550)   | (1,412–1,825) |
|                  | (47–198)       | (115–298)  | (137–210)   | (382–645) |
| Number of total foods | 16          | 32         | 30          | 77      |
| Number of plant foods | 5         | 11         | 10          | 26      |
| Ratio of weight of foods calculated for GABA (%) | (26.6–66.1) | (45.9–66.0) | (36.7–75.5) | (43.1–55.2) |
| Ratio of weight of plant foods calculated for GABA (%) | (23.1–100.0) | (62.8–97.9) | (38.2–99.2) | (65.1–98.4) |
| Ratio of number of foods calculated for GABA (%) | 42.9         | 42.0       | 42.1        | 40.3    |
| Ratio of number of plant foods calculated for GABA (%) | (28.6–52.9) | (32.3–48.1) | (31.3–54.2) | (37.2–45.0) |
| GABA content     |                |            |             |         |
| Analyzed (mg)    | 14.3           | 18.6       | 23.5        | 67.3    |
| Calculated (mg)  | 6.1            | 8.7        | 11.2        | 30.0    |

Average±SD or median (minimum–maximum value).

calculated by the ratio of the peak area of GABA/theanine derivatives, then the GABA content per meal was finally derived.

**GABA content calculation.** The energy and nutrients content were calculated from the ingredients and the weights used for each dish using a computer program with the Standard Tables of Food Composition in Japan (5). GABA content was calculated only for foods with reported amount of GABA in Japan. In addition to the data published by the National Agriculture and Food Research Organization (http://www.naro.afrc.go.jp/laboratory/nfri/contents/lfdb/fldb.html), we performed a literature search in PubMed and ICHUSHI (Japan Medical Abstracts Society; https://search.jamas.or.jp/) in July 2018. Search term was “GABA” or “aminobutyric acid” and after that, the literature was collected by hand search (6–15). If more than one GABA amount was shown for the same food, the mean was calculated and used in the calculation. Although GABA is hardly decomposed by heating, it is known that GABA is transferred to boiled juice by cooking operations such as boiling (16). However, since there is no data on cooking loss for each food, in the case of boiling spilled cooking, the amount of GABA was tentatively calculated to be 50%. The GABA amount for each meal was calculated by adding the GABA amount of each dish. Since GABA is mainly contained in plant foods (vegetables, fruits, potatoes, bean products, seaweeds and mushrooms), the number and weight of them used in each meal and also percentage of them for which GABA content could be calculated and were derived. Water used for cooking is not considered as food, but the soup stock is counted as one food.

**Statistical analysis.** Data normality was checked and shown as average±SD for normal distribution and median (minimum–maximum value) for non-normal distribution. Spearman’s rank correlation coefficient was used for the relationship between the two variables of the non-normal distribution. Data were analyzed using SPSS Statistics version 24 (IBM Japan, Ltd., Tokyo). A p-value of <0.05 was considered statistically significant.

**Results**

Table 1 shows the calculated values of energy and nutrient content and the data such as the number of foods of 30 meals sampled for each meal and one day total. The median percentage of total food weight and plant food weight for which GABA could be calculated were 49.3% and 73.1%, respectively. The median ratio of the number of foods for which GABA could be calculated to the total number of foods and plant foods were 40.3% and 58.7%, respectively. The median GABA analytical value was 67.3 mg/d and the calculated value was 30.0 mg/d.

Figure 1 shows the relationship between the calcu-
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lated and analyzed values of GABA for 30 meals. Overall, the calculated values were lower than the analytical values, but Spearman’s rank coefficient correlation between the two variables was 0.618 ($p<0.001$).

Discussion

In this study, the intake of GABA from nutritionally controlled hospital diet was examined. The median analysis of GABA intake was 67.3 mg/d. The estimated GABA intake by calculation was about half of the analytical value. This is largely due to the lack of data that can be used to calculate GABA. However, there was a significant positive correlation between the calculated and analyzed values of GABA.

In this study, in 2 of the 30 meal samples, the analytical value was much higher than the calculated value. The reason for this might be that both menus included a dish of yogurt or banana mixed with other fruits. GABA is produced from glutamate by the action of glutamate dehydrogenase (17). GABA may increase in cooking operations that meet the conditions for glutamate dehydrogenase to function without inactivation (16). If more knowledge about the increase or decrease in GABA amount due to cooking is accumulated, the estimation accuracy of GABA intake will be further improved.

Currently, many foods with health claims including GABA are distributed in Japan. For people with mild hypertension, a significant decrease in blood pressure has been observed by consuming functional foods containing 10–12 mg/d of GABA for 12 wk (18). In this study, 67.3 mg/d of GABA can be taken from nutritionally controlled hospital food, which is several times higher than the expected intake of GABA from functional foods. Eating a balanced diet may be more important than choosing functional foods to prevent high blood pressure.

In this study, GABA intake from beverages such as tea were not measured. Since the types and amounts of drinks vary from person to person, it is necessary to estimate GABA intake from beverages in consideration of them.

In order to quantify the current state of GABA intake in Japan, the data on GABA amount especially for plant foods will be enriched and the knowledge of increase and decrease due to cooking will be accumulated, and it is necessary to estimate the amount of GABA in the diet of many free-living people.

The limitation of this study is that meals were sampled in one hospital and the number of meals is small. GABA intake from nutritionally controlled diet was shown, and it was also shown to be higher than expected from functional foods. The result of this study will be useful for considering the role of functional foods as well as estimating GABA intake from daily diet.

Authorship

Research conception and design: SI, KT and HT; experiments: SI, KS, CN and KT; interpretation of the data: SI and HT; writing of the manuscript: SI, KT and HT.

Disclosure state of COI

No conflicts of interest to be declared.

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