Original Article

Development of an amino acid composition database and estimation of amino acid intake in Japanese adults

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Investigations of the association between an individual's habitual amino acid intake and several types of health outcome require a comprehensive amino acid composition database. The lack of a database of the amino acid content of foods routinely consumed makes estimating daily amino acid intake difficult. The aim of this study was to develop an amino acid database for use in epidemiological studies, and to estimate amino acid intake among a Japanese population. Data were obtained from published food composition data, and when published data were unavailable, calculated data were imputed using established criteria. Adequate data were available for 1100 food items. Using a purpose-developed amino acid composition table, we estimated amino acid intake among a Japanese population (121 women and 109 men aged 30 to 69 years) living in four areas in Japan using a 16-day diet record. All subjects met the estimated average requirements of the nine indispensable amino acids as reported by WHO/FAO/UNU. The major contributors to dietary amino acid intake were cereals, fish and shellfish, and meats, which accounted for approximately 60% of total intake. This database contains amino acid values of foods items frequently consumed in Japan, and represents a valuable tool for use in epidemiological studies.

Key Words: food composition table, amino acid, dietary intake, Japanese adults, diet records

INTRODUCTION

Amino acids, the constituents of protein, act as precursors of many co-enzymes, hormones, nucleic acids, and other molecules essential for life.[1] Twenty amino acids are found in protein, and their balance influences the digestibility of dietary proteins and amino acid catabolism.[2] For example, most plant proteins contain lower concentrations of the indispensable amino acids, particularly lysine and methionine,[3] and are not used with the same efficiency as animal proteins.[4] Thus vegetarianism can lead to subclinical protein malnutrition as no animal protein are consumed.[5] The diet must therefore include not only an adequate amount of protein, but also a suitable combination of each of the individual amino acids.

Estimating an individual's habitual amino acid intake and examining its association with health-related outcomes requires a comprehensive amino acid composition table which contains the values of the foods routinely consumed. Few such databases are available, however; in Japan, for example, among 1878 food items listed in the Standard Tables of Food Composition in Japan -2010-,[6] amino acid values are available for only 337. This limited availability of amino acid databases has meant that studies involving habitual amino acid intake estimation in Asian countries, including Japan, are scarce.[7,8]

Ishihara *et al.* developed a database of the amino acid content of foods in Japan.[7] The process used to develop the database was unclear, however, and the number of food items it contained was not mentioned. The availability of information on the process used to develop the database and the sources of its data would be helpful in evaluating its quality; particularly given that the quality of a nutrient database is a reflection of its data sources,[9] precise documentation of sources is indispensable.

The aim of this study was to develop a comprehensive amino acid composition table for Japanese food with detailed information on its development and data sources, and then to evaluate the usability of the database by estimating amino acid intake among a Japanese population using 16-day diet records (DR).

MATERIALS AND METHODS

Development of the amino acid composition table

Number of food items for imputation

We developed an amino acid food composition table for 1878 foods in the Standard Tables of Food Composition in Japan -2010-.[6] Of these 1878 foods, amino acid values were listed for only 337 (17.9%). Among the remaining 1541 foods with missing values, total protein content of 70 foods was zero, leaving 1471 foods requiring imputation of amino acid composition values. The number of listed and missing food items by food group is shown in Table 1.

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Table 1. The number of foods in the standard food composition tables of Japanese foods by food group†, with and without amino acid and protein value

In the amino acid food composition table	Listed	Missing			Total
Total protein content of food (g/100g portion)		TP = 0	0 < TP ‡	Total	
Cereals	43	0	95	95	138
Potatoes and starches	4	0	36	36	40
Sugars and sweeteners	0	17	6	23	23
Pulses	21	0	52	52	73
Nuts and seeds	12	0	25	25	37
Vegetables	44	0	282	282	326
Fruits	21	4	132	136	157
Mushrooms	5	0	31	31	36
Algae	5	1	41	42	47
Fishes and shellfishes	87	0	301	301	388
Meats	41	0	203	203	244
Eggs	4	0	16	16	20
Milks	12	0	40	40	52
Fats and oils	0	16	6	22	22
Confectioneries	25	10	85	95	120
Beverages	1	18	36	54	55
Seasonings and spices	8	4	72	76	84
Processed foods	4	0	12	12	16
Total	337	70	1471	1541	1878

† Food groups are defined by the Standard Tables of Food Composition in Japan -2010-.[6]
‡ The 1471 foods were selected for substitution of amino acid composition in this study.

Sources of nutrient data
Amino acid values of these 1471 foods were collected using the data gathering strategy of Rand *et al.*[10], as follows.

Step 1: Direct analytical values
To identify possible sources of published food composition data for amino acids, we searched the PubMed, CiNii and Medical Online Library databases for English- and Japanese-language papers reporting analyses of the amino acid content of foods, conducted in Japan. In addition, we manually searched references from relevant articles where necessary. Because analysis of amino acids is generally done by ion-exchange chromatography and high-performance liquid chromatography, which can be applied to all types of food,[11] we limited data to papers which assessed total amino acid composition in foods using an automatic amino acid analyzer (ion-exchange chromatography method) or high-performance liquid chromatography. We searched for data for 18 individual amino acids (isoleucine, leucine, lysine, methionine, cysteine, phenylalanine, tyrosine, threonine, tryptophan, valine, histidine, arginine, alanine, aspartic acid, glutamic acid, glycine, proline, and serine), as well as sulfur-containing (methionine + cysteine) and aromatic (phenylalanine + tyrosine) amino acids.

We found four papers which used an automatic amino acid analyzer,[12-15] and one which used high-performance liquid chromatography.[16] In addition, we found one paper using “the same analyzing method as the Standard Tables of Food Composition in Japan, fifth revised and enlarged edition”.[17] As the Standard Tables of Food Composition in Japan, fifth revised and enlarged edition used an automatic amino acid analyzer and high-performance liquid chromatography methods,[18] we considered that these methods were used in this paper also. To allow for comparison across all papers, values of each amino acid were converted to mg/100 g of food.

We then considered criteria to use in determining the amino acid content of individual foods. Several articles analyzed similar foods using the same method but provided different mean or median values. To deal with these complexities, the following criteria were conducted.

(1) When only one article existed and this article analyzed the amino acid content in a single example of a food only, this value was assigned.
(2) When only one article existed and this article analyzed the amino acid content of several samples and reported mean or median values, this value was selected. If mean and median values were reported, we selected the median value for the food because the literature used in Step 1 provided little information on the distribution of analyzed data. According to recommendation by Rand *et al.*, [10] we planned to use the median value that is affected less by outliers.
(3) When multiple articles existed but reported different mean (or median) amino acid values for a similar food, we calculated the mean (or median) value by weighting the number of foods analyzed in each article.[11]

In these criteria, we also considered the form (i.e. raw, boiled, baked, and fried) of individual food items when we searched for the reference food item from the literature, and we used only the value of same form of the food.

Step 2: Using data from other food composition tables
For foods whose amino acid values were unavailable from the literature, we used amino acid composition data for the same form of “identical” foods from the United States’ Department of Agriculture (USDA) food compo-

sition tables.[19] All amino acid values available from the USDA were obtained through HPLC; [20] therefore we considered their amino acid values eligible for our database.

To determine the similarity of food items, we examined scientific names and text descriptions of food items, and the similarity of nutrient composition (total energy, water, protein and fat). To correct the data for differences in the nitrogen value of each food item, we adjusted amino acid values by the following equation:

Amino acid value of food of interest (Japanese) = amino acid value of reference (USDA) food × nitrogen of food of interest (Japanese) food/nitrogen of reference (USDA) food

Step 3: Estimation from data on "similar" foods

For a number of food items, published food composition data were either unavailable or inappropriate. We estimated values for missing amino acids using the following procedure:[21]

(1) Calculated values from a different form of the same food (Step 3-a)

When an amino acid value was known for a raw food, but not for a different form of the same food (e.g., boiled, baked, dried, and so on), we calculated values for the cooked food items using the values of the raw food item.

This type of calculation requires consideration of nutrient loss or gain during cooking. To adjust for differences between the raw and cooked items, we assumed that the component ratio of amino acids did not change. Values for cooked foods were therefore calculated from the raw form using change in nitrogen content by the following equation:

Amino acid value of food of interest (cooked) = amino acid value of reference (raw) food × nitrogen of food of interest (cooked) food /nitrogen of reference (raw) food

(2) Calculated values from data for biologically similar foods (Step 3-b)

When nutrient values for a specific item were unavailable, values from another food within the same genus or same family of foods were used instead.

We determined a similar (reference) food by genetic similarity, maturity of the plant crop at harvest or age of animal at slaughter, and part of the food item consumed.[10] To correct for differences in nitrogen values between the food of interest and reference, we adjusted amino acid values using the following equation:

Amino acid value of food of interest = amino acid value of reference (similar) food × nitrogen of food of interest food /nitrogen of reference (similar) food.

Step 4: Calculations for multi-ingredient foods

For multi-ingredient foods (mainly confectionery, sweet buns, breads, and cooked food with seasoning), we estimated amino acid values on the basis of the ingredient list. For confectioneries (n=75), sweet buns (n=4), and breads (n=3), the ingredient lists were obtained from the Standard Tables of Food Composition in Japan -2010-,[6] which described the names and weight ratio of ingredients, and the amount of sucrose per 100 g edible portion. We estimated the amount of individual ingredient per 100 g edible portion of mixed dishes by using the amount of sucrose.[22] We summed the total amino acid content of all prepared ingredients to obtain the total amino acid content of the multi-ingredient food. Because ingredient lists do not contain information on cooking process, cooking and handling losses during preparation could not be considered.[10] We accordingly assumed that the sum of amino acids of the ingredients did not change during cooking. We also calculated energy values, and examined whether a calculated value matched the analyzed value. There is no consensus of the acceptable cut-off line regarding the difference between calculated and analyzed values. In addition, there are few studies comparing the calculated and analytic nutrient values for multi-ingredient foods. Taking account of the study by Murphy *et al.*,[23] we arbitrarily determined 20% as the cut-off line of the difference between calculated and analyzed energy values. According to this criteria, calculated energy values of nine confectioneries (Chatsu (food code; 15026), Hina-arare, Kanto style and Kansai style (food code; 15055, 15056), Waffles, Jam (food code; 15085), Bisbuits, Soft (food code; 15098), Russian cake (food code; 15100), Jelly beans (food code; 15108), Brittle (food code; 15112), and White chocolate (food code; 15115) and one sweet bun (Cornet with chocolate cream (food code; 15072) were quite different from analyzed values (over 20%), and values for these items were accordingly left missing.

For multi-ingredient foods for which an ingredient list was not available (mainly cooked food with seasoning, pickles, and frozen foods; n=187), we made ingredient lists based on the manufacturer's ingredient list of commercial foods. In Japan, ingredient lists of commercial foods list the ingredient items in order of content by weight. We therefore used a trial-and-error technique to estimate ingredient proportions.[24] We calculated values of energy, carbohydrate, and sodium by assumed ingredient proportions, and compared the calculated values to the known nutrient values. When the calculated energy values substantially differed from analyzed values (over 20%), or amino acid values of ingredient foods were not available, we left the value of these items missing. We calculated amino acid values for 47 foods using a trial-and-error technique.

Documentation of the database

In our amino acid database, we documented food codes and descriptions based on the Standard Tables of Food Composition in Japan -2010-,[6] scientific name of the food item, and data sources by the terms 1, 2, 3-a, 3-b, 4, 0, and L, which indicate Steps 1, 2, 3-a, 3-b and 4, assumed 0, and originally listed value, respectively.

The analytical quality of data values imputed from the literature (Step 1) were evaluated using five criteria, namely the analytical method used, number of samples, sample handling procedures, sampling plan for the selection of foods, and the analytical quality control.[11] These criteria have previously been used to calculate formal scores or ratings of data quality. However, the papers used in Step 1 generally provided little information on sample handling procedures, sampling plan and analytical quality control. Accordingly, we did not calculate ratings of data quality, but rather provided whatever quality control information (information on reference literature, analytical method, number of samples) was available from the references.

We expressed nitrogen values and amino acid values by g and mg per 100 g edible portion, respectively. Nitrogen values were calculated as protein value divided by a nitrogen-to-protein conversion factor. Amino acid values were rounded to two significant figures in the same way as in the Standard Tables of Food Composition in Japan -2010-.[6] Nitrogen values were rounded to the second decimal point.

Estimation of amino acid intake among a Japanese population

We estimated amino acid intake among a Japanese population using a 16-day dietary record (DR).

Study population

The study was conducted in four areas of Japan, namely Osaka, Okinawa, Nagano, and Tottori, in consideration of survey feasibility and potential regional differences in food availability and dietary habits.

In each area, we recruited apparently healthy women aged 30 to 69 years who were willing to participate and were living together with their husbands, such that each 10-year age class (30-39, 40-49, 50-59 and 60-69 years) contained eight women equally (without consideration of the age of the men). Thus, a total of 126 women and 126 men were invited. None of the subjects was a dietitian, was currently receiving or had recently received dietary counseling from a doctor or dietitian, or had a history of educational hospitalization for diabetes or nutritional education from a dietitian. Group orientations for the subjects were held before the study, at which the study purpose and protocol were explained. The protocol of the study was approved by the ethics committee of the University of Tokyo, and written informed consent was obtained from each subject.

Body weight in light indoor clothing was measured to the nearest 0.1 kg. A total of 121 women and 121 men completed the 16-day DR.

For analysis, we excluded men younger than 30 or older than 69 years (n=11), as well as a man with extremely high reported energy intakes (>4000 kcal/day), leaving 121 women and 109 men aged 30 to 69 years for analysis.

Dietary records

Subjects completed a 4-nonconsecutive-day semi-weighed DR four times, once in each season, at intervals of approximately 3 months: DR1 in November or December 2002 (autumn), DR2 in February 2003 (winter), DR3 in May 2003 (spring), and DR4 in August and September 2003 (summer). Each set of 4 recording days consisted of 1 weekend day and 3 weekdays. Details of the diet recording procedure are provided elsewhere.[25] Briefly, during the orientation session, registered dietitians gave the subjects both written and verbal instructions on how to maintain the DR, provided recording sheets and a digital scale, and asked them to record and weigh all foods and beverages consumed on each recording day. All collected records were checked by trained registered dietitians at the respective local center and then again at the study center.

A total of 1320 food and beverages items appeared in the DR. Amino acid intake was estimated based on the database created in the present study. In order to examine if amino acid intake in this population was appropriate; we compared each subject's intake of individual amino acid with the estimated average requirements as reported by WHO/FAO/UAU.[26] We also estimated energy and protein intake based on the Standard Tables of Food Composition in Japan -2010-.[6]

RESULTS

Development of an amino acid database

Table 2 shows the number of foods with imputed amino acid values in the present study. Among the 1471 foods selected for substitution, substitution methods were found for 1100 (74.8%). In contrast, no suitable method could be found for 371, among which 173 foods did not appear in the 16 d-DR, and 54 contained a total protein content of less than 1 g/100 g edible portion. We thus concluded that the contribution of these foods to amino acid intake would be negligible. Most of the 144 remaining foods were multi-ingredient foods (n=45), seasonings (n=23), or edible wild plants (n=20). Finally, the total number of foods with amino acid compositions was 1507, including those listed in the original (listed) amino acid food composition table and the food items assumed to contain no amino acids because their total protein values were zero. Of these, 9.8% of foods were assigned amino acid data by direct analysis (1.7% by Step 1 and 8.1% by Step 2), 55.5% by imputed data (41.1% by Step 3-a, and 14.4% by 3-b), and 7.7% by calculated data (Step 4).

Estimation of amino acid intake among a Japanese population

The mean ages (standard deviation, SD) of women and men were 49.3 (11.3) and 50.3 (10.9) years, respectively. The mean total energy intake (SD) was 1834 (286) kcal/day for women and 2365 (395) kcal/day for men. Mean total protein intake (SD) was 69.2 (11.7) g/day (15.1% total energy) for women and 84.0 (15.3) g/day (14.2 % total energy) for men. Mean total amino acid intake (SD) was 63.6 (11.0) g/day for women and 76.6 (14.0) g/day for men, albeit that these values are underestimated owing to the missing values for 371 foods in the database. To examine the influence of the missing values, we calculated total nitrogen intake by excluding foods with missing amino acid values. The mean rate of decrease in total nitrogen intake was 4.0%, indicating that the influence of missing values was relatively small. Mean total amino acid intake estimated using values of the 337 originally listed foods was 35.3 g/day for women and 43.6 g/day for men. Thus, estimations of amino acid intake using originally listed values only were about 45% underestimated.

The mean values of individual amino acid intake are shown in Table 3. Comparing each subject's intake of indispensable amino acid with the estimated average requirement values as reported by WHO/FAO/UAU,[26] all subjects met the estimated average requirement of thenine indispensable amino acids.

Table 2. Number of foods by database development step of amino acid composition and food group †

	Foods selected for substitution						
Result of substitution ‡	Substituted						Not substituted
Step for substitution	Step 1	Step 2	Step 3-a	Step 3-b	Step 4	Total	
Cereals	6	2	64	10	8	90	5
Potatoes and starches	0	1	26	4	0	31	5
Sugars and sweeteners	0	1	0	0	0	1	5
Pulses	1	3	38	4	0	46	6
Nuts and seeds	0	7	10	2	0	19	6
Vegetables	0	31	72	68	8	179	103
Fruits	0	22	60	20	0	102	30
Fungi	3	0	10	5	0	18	13
Algae	1	0	3	27	3	34	7
Fishes and shellfishes	5	12	118	67	19	221	80
Meats	8	27	142	1	0	178	25
Eggs	0	0	11	2	1	14	2
Milks	0	8	23	1	0	32	8
Fats and oils	0	0	4	0	0	4	2
Confectioneries	0	0	6	0	69	75	10
Beverages	1	2	15	2	2	22	14
Seasonings and spices	0	6	18	4	6	34	38
Processed foods	0	0	0	0	0	0	12
Total	25	122	620	217	116	1100	371

† Food groups are defined by the Standard Tables of Food Composition in Japan -2010-.
‡ Step 1: foods determined by analytic values; Step 2: foods determined by data from other food composition table; Step 3-a: foods determined by calculated value from a different form of the same food; Step 3-b: foods determined by calculated value from a biologically similar food; Step 4: foods determined by recipe.

Contribution of food types to amino acid intake is shown in Table 3. The major contributors were cereals, fish and shellfish, and meats, with approximately 60% of intake attributable to these three food groups.

DISCUSSION

We developed a comprehensive database of amino acid values for a wide variety of foods, and then estimated amino acid intake among a group of Japanese adults. Although epidemiological studies have suggested associations between the dietary intake of specific amino acids and health-related outcomes,[27-31] results have remained inconclusive, partly due to a lack of clarity about the quality of the amino acid food composition data used. Our database is an improvement over the Standard Tables of Food Composition in Japan -2010-,[6] which have many missing values, and will be usable in epidemiologic studies.

We were unable to find reliable data for 371 foods. Consumption of most of these foods among the sample population was low, however, and the influence of these missing values will likely be relatively small.

In the present study, mean amino acid intake of the sample population met the estimated average requirement of the nine indispensable amino acids.[26] Thus we considered the intake of indispensable amino acid among this population appropriate.

The mean value of individual amino acid intake estimated by Ishihara *et al.*[7] was around 20% higher than that of this study's population. This difference is partly due to differences in protein intake between Ishihara's population and this study's population. The protein intake of Ishihara's population was around 8% higher than that of this study's population. Additionally, we are concerned that the sum of individual amino acids was underestimated owing to the missing values of our database. We could not examine the magnitude of the missing values because we could not obtain information on whether there are missing values in Ishihara's database or not. The amino acid values of food items in our database could also be underestimated (or those in Ishihara's database were overestimated). To examine whether there is underestimation of the amino acid values or not, we calculated the sum of amino acid intake of each subject and compared it with each subject's intake of protein. If the amino acid values of each food item are underestimated, the sum of amino acid intake of each subject would be far less than the protein intake values. The sum of amino acid intake of each subject is around 10% lower than their protein intake. We considered this difference eligible because the sum of individual amino acids tends to be smaller than protein values, calculated by multiplying the total nitrogen by a certain factor.[12] Although there is no definite method to examine the appropriateness of database used in these studies, we considered the underestimation of the amino acid values in our database relatively small.

Even if amino acid intake is sufficient, unsuitable balance among amino acids may result in a decrease in the digestibility of proteins.[32] The availability of this database will promote research into the balance of amino acid intake and several types of health outcomes.

We acknowledge several limitations of this study. First, amino acid values were not available for all foods, which would result in the underestimation of amino acid intake for subjects who eat these food items. Nevertheless, relevant data were obtained for food items which are frequently consumed in Japan, and thus the influence of missing values would likely be negligible.

Table 3. Mean intake and contribution of food groups [†] to total amino acid intake about amino acids among Japanese women and men

	Women (n = 121)																			
	Ile[‡]	Leu[‡]	Lys[‡]	Met[‡]	Cys[‡]	SAA[‡]	Phe[‡]	Tyr[‡]	AAA[‡]	Thr[‡]	Trp[‡]	Val[‡]	His[‡]	Arg[‡]	Ala[‡]	Asp[‡]	Glu[‡]	Gly[‡]	Pro[‡]	Ser[‡]
Mean intake per day (mg/day)	2840	5061	4244	1512	999	2492	2943	2274	5230	2586	781	3341	2193	3767	3235	6062	11987	2918	3797	3061
Mean intake per day per weight (mg/kg/day)	53	95	80	28	19	47	55	43	98	49	15	63	41	71	61	114	226	55	72	58
Food groups																				
Cereals (%) [§]	17.9	20.2	9.0	18.4	30.2	22.9	23.4	21.1	22.6	16.6	22.3	19.7	15.4	20.7	17.9	15.1	29.1	19.5	29.1	22.6
	(4.55)	(4.92)	(2.36)	(4.27)	(6.25)	(5.13)	(5.68)	(5.03)	(5.40)	(4.21)	(5.15)	(4.71)	(4.10)	(4.71)	(4.10)	(3.72)	(7.45)	(4.81)	(7.77)	(5.42)
Potatoes and starches (%) [§]	0.6	0.6	0.7	0.6	0.9	0.7	0.8	0.6	0.7	0.8	0.9	0.9	0.5	0.8	0.7	1.6	0.6	0.6	0.5	0.8
	(0.30)	(0.27)	(0.30)	(0.27)	(0.41)	(0.32)	(0.38)	(0.29)	(0.34)	(0.39)	(0.42)	(0.39)	(0.23)	(0.38)	(0.35)	(0.72)	(0.30)	(0.31)	(0.24)	(0.41)
Sugars and sweeteners (%) [§]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Pulses (%) [§]	8.9	8.6	8.4	5.1	8.3	6.4	10.0	9.4	9.8	8.4	9.7	7.9	7.0	10.7	7.4	10.6	8.9	8.0	7.9	9.2
	(3.87)	(3.75)	(3.66)	(2.39)	(3.94)	(3.02)	(4.32)	(4.11)	(4.25)	(3.65)	(4.22)	(3.48)	(3.17)	(4.51)	(3.29)	(4.40)	(3.95)	(3.63)	(3.60)	(4.00)
Nuts and seeds (%) [§]	0.6	0.6	0.4	0.7	0.9	0.8	0.7	0.7	0.7	0.6	0.8	0.7	0.7	1.4	0.6	0.7	0.7	0.8	0.5	0.7
	(0.67)	(0.65)	(0.46)	(0.87)	(1.03)	(0.89)	(0.76)	(0.77)	(0.76)	(0.63)	(0.93)	(0.74)	(1.37)	(1.46)	(0.67)	(0.74)	(0.74)	(0.90)	(0.51)	(0.68)
Vegetables (%) [§]	3.4	3.2	3.6	2.5	3.5	2.9	3.8	3.5	3.6	4.0	4.6	3.8	3.2	4.9	4.3	5.5	4.9	3.7	2.9	4.0
	(1.13)	(1.10)	(1.16)	(0.83)	(1.20)	(0.97)	(1.25)	(1.17)	(1.20)	(1.29)	(1.45)	(1.27)	(1.09)	(1.54)	(1.41)	(1.71)	(1.65)	(1.23)	(1.09)	(1.32)
Fruits (%) [§]	0.6	0.6	0.6	0.5	1.0	0.7	0.6	0.4	0.5	0.7	0.8	0.7	0.9	1.0	1.0	1.9	0.6	0.7	1.1	0.8
	(0.37)	(0.36)	(0.37)	(0.30)	(0.60)	(0.41)	(0.36)	(0.21)	(0.29)	(0.43)	(0.46)	(0.42)	(0.75)	(0.62)	(0.57)	(1.20)	(0.34)	(0.45)	(0.65)	(0.47)
Mushrooms (%) [§]	0.3	0.3	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.5	0.3	0.3	0.3	0.2	0.3
	(0.19)	(0.18)	(0.19)	(0.12)	(0.17)	(0.14)	(0.21)	(0.20)	(0.21)	(0.26)	(0.29)	(0.21)	(0.17)	(0.20)	(0.32)	(0.18)	(0.18)	(0.23)	(0.16)	(0.22)
Algae (%) [§]	0.6	0.5	0.4	0.5	0.6	0.6	0.5	0.4	0.5	0.6	0.6	0.6	0.3	0.5	1.0	0.6	0.4	0.7	0.4	0.5
	(0.31)	(0.31)	(0.25)	(0.30)	(0.39)	(0.33)	(0.30)	(0.24)	(0.27)	(0.37)	(0.34)	(0.36)	(0.17)	(0.26)	(0.57)	(0.38)	(0.29)	(0.42)	(0.27)	(0.28)
Fishes and shellfishes (%) [§]	22.1	21.2	28.5	27.4	15.8	22.9	18.7	20.7	19.3	23.9	19.7	20.9	29.9	22.6	25.4	22.6	16.9	26.7	15.0	18.1
	(7.22)	(7.05)	(8.68)	(8.61)	(5.56)	(7.52)	(6.29)	(6.82)	(6.45)	(7.57)	(6.57)	(6.89)	(9.70)	(6.80)	(7.81)	(6.88)	(6.07)	(8.25)	(5.72)	(6.08)
Meats (%) [§]	17.0	16.6	21.5	18.3	12.9	16.2	14.3	15.5	14.7	18.1	15.3	15.7	21.8	16.9	19.6	16.4	13.2	21.0	12.7	13.6
	(6.98)	(6.77)	(8.95)	(7.43)	(5.11)	(6.50)	(5.91)	(6.44)	(6.09)	(7.42)	(6.33)	(6.45)	(8.87)	(7.09)	(7.89)	(7.08)	(5.27)	(8.26)	(4.97)	(5.65)

Table 3. Mean intake and contribution of food groups † to total amino acid intake about amino acids among Japanese women and men (cont.)

	Women (n = 121)																			
	Ile‡	Leu‡	Lys‡	Met‡	Cys‡	SAA‡	Phe‡	Tyr‡	AAA‡	Thr‡	Trp‡	Val‡	His‡	Arg‡	Ala‡	Asp‡	Glu‡	Gly‡	Pro‡	Ser‡
Eggs (%) §	7.8	7.1	7.7	9.3	10.7	10.0	7.7	8.7	8.3	8.1	8.3	8.3	5.2	7.5	7.7	7.8	4.8	5.1	4.7	10.7
	(3.00)	(2.77)	(3.03)	(3.52)	(3.88)	(3.68)	(2.97)	(3.32)	(3.18)	(3.12)	(3.18)	(3.19)	(2.10)	(2.87)	(2.96)	(3.06)	(1.90)	(2.00)	(1.91)	(3.94)
Milks (%) §	10.9	11.1	11.2	9.9	5.2	7.8	9.2	10.3	9.8	8.9	9.5	11.1	7.5	5.0	5.8	7.5	9.5	3.8	14.6	8.9
	(5.51)	(5.59)	(5.75)	(5.13)	(2.79)	(4.08)	(4.68)	(5.17)	(4.94)	(4.64)	(4.85)	(5.56)	(3.97)	(2.67)	(3.13)	(3.95)	(4.79)	(2.09)	(6.91)	(4.54)
Fats and oils (%) §	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Confectioneries (%) §	3.6	3.7	2.9	3.5	4.9	4.1	4.1	3.7	4.0	3.4	3.9	3.8	2.8	3.4	3.3	3.2	4.4	3.4	4.9	4.4
	(1.77)	(1.81)	(1.49)	(1.77)	(2.46)	(2.06)	(2.04)	(1.85)	(1.96)	(1.71)	(1.92)	(1.87)	(1.42)	(1.68)	(1.64)	(1.61)	(2.21)	(1.83)	(2.42)	(2.14)
Beverages (%) §	0.9	1.2	0.7	0.6	0.8	0.7	1.1	1.0	1.0	0.9	0.3	0.9	0.7	0.5	0.5	1.0	1.2	1.2	1.2	0.9
	(0.54)	(0.74)	(0.50)	(0.51)	(0.54)	(0.37)	(0.59)	(0.57)	(0.58)	(0.57)	(0.34)	(0.51)	(0.47)	(0.26)	(0.34)	(0.61)	(0.59)	(0.67)	(0.70)	(0.57)
Seasoning and spices (%) §	4.7	4.3	4.0	2.5	3.8	3.0	4.5	3.3	3.9	4.4	2.8	4.5	3.9	3.9	4.4	5.0	4.4	4.1	4.3	4.4
	(1.41)	(1.30)	(1.23)	(0.90)	(1.23)	(1.00)	(1.40)	(1.24)	(1.29)	(1.31)	(1.09)	(1.34)	(1.36)	(1.32)	(1.26)	(1.44)	(1.32)	(1.26)	(1.37)	(1.31)

Table 3. Mean intake and contribution of food groups † to total amino acid intake about amino acids among Japanese women and men (cont.)

	Men (n =109)																			
	Ile‡	Leu‡	Lys‡	Met‡	Cys‡	SAA‡	Phe‡	Tyr‡	AAA‡	Thr‡	Trp‡	Val‡	His‡	Arg‡	Ala‡	Asp‡	Glu‡	Gly‡	Pro‡	Ser‡
Mean intake per day (mg/day)	3406	6081	5143	1863	1210	3048	3520	2745	6276	3136	940	4012	2733	4671	4012	7310	14179	3641	4388	3669
Mean intake per day per weight (mg/kg/day)	51	91	77	28	18	46	53	41	94	47	14	60	41	70	60	109	212	55	66	55
Food groups																				
Cereals (%) §	19.7 (4.53)	22.4 (4.93)	10.2 (2.58)	20.5 (4.54)	32.9 (6.07)	25.1 (5.20)	25.8 (5.52)	23.6 (5.08)	25.1 (5.34)	18.4 (4.26)	25.0 (5.30)	22.1 (4.81)	16.4 (4.24)	23.3 (4.93)	19.8 (4.29)	17.5 (4.00)	30.9 (6.97)	21.0 (4.60)	31.2 (7.35)	25.1 (5.37)
Potatoes and starches (%) §	0.6 (0.32)	0.5 (0.27)	0.6 (0.32)	0.5 (0.28)	0.7 (0.41)	0.6 (0.33)	0.7 (0.39)	0.6 (0.31)	0.6 (0.36)	0.6 (0.39)	0.8 (0.43)	0.7 (0.42)	0.4 (0.23)	0.7 (0.40)	0.5 (0.34)	1.3 (0.77)	0.6 (0.33)	0.5 (0.29)	0.4 (0.26)	0.7 (0.42)
Sugars and sweeteners (%) §	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)
Pulses (%) §	7.2 (3.61)	7.0 (3.49)	6.8 (3.47)	4.0 (2.15)	6.6 (3.58)	5.1 (2.74)	8.2 (4.02)	7.7 (3.82)	8.0 (3.94)	6.8 (3.41)	7.9 (3.92)	6.4 (3.19)	5.5 (2.77)	8.6 (4.29)	5.8 (3.06)	8.6 (4.12)	7.3 (3.72)	6.3 (3.29)	6.7 (3.48)	7.6 (3.81)
Nuts and seeds (%) §	0.8 (1.01)	0.8 (0.99)	0.5 (0.79)	0.7 (0.80)	1.1 (1.19)	0.8 (0.93)	0.9 (1.19)	0.9 (1.15)	0.9 (1.17)	0.7 (0.83)	0.9 (1.15)	0.8 (1.15)	0.9 (2.55)	1.6 (1.80)	0.7 (0.90)	1.0 (1.25)	0.9 (1.14)	1.0 (1.36)	0.7 (0.85)	0.8 (1.02)
Vegetables (%) §	3.0 (0.98)	2.8 (0.93)	3.1 (1.02)	2.2 (0.71)	3.1 (0.97)	2.5 (0.81)	3.3 (1.07)	3.1 (1.01)	3.2 (1.03)	3.5 (1.13)	4.1 (1.28)	3.4 (1.10)	2.8 (0.98)	4.2 (1.32)	3.7 (1.22)	4.9 (1.58)	4.4 (1.39)	3.2 (1.07)	2.6 (0.87)	3.6 (1.12)
Fruits (%) §	0.4 (0.34)	0.4 (0.32)	0.4 (0.34)	0.3 (0.25)	0.7 (0.55)	0.5 (0.37)	0.4 (0.32)	0.2 (0.19)	0.3 (0.26)	0.5 (0.39)	0.5 (0.39)	0.5 (0.37)	0.6 (0.56)	0.6 (0.55)	0.6 (0.51)	1.2 (1.02)	0.4 (0.30)	0.5 (0.40)	0.7 (0.64)	0.5 (0.44)
Mushrooms (%) §	0.3 (0.18)	0.2 (0.16)	0.3 (0.17)	0.2 (0.11)	0.2 (0.16)	0.2 (0.13)	0.3 (0.20)	0.2 (0.18)	0.3 (0.19)	0.4 (0.24)	0.4 (0.27)	0.3 (0.19)	0.2 (0.15)	0.3 (0.18)	0.4 (0.29)	0.3 (0.17)	0.2 (0.17)	0.3 (0.21)	0.2 (0.15)	0.3 (0.21)
Algae (%) §	0.5 (0.31)	0.5 (0.30)	0.4 (0.25)	0.5 (0.29)	0.5 (0.35)	0.5 (0.31)	0.5 (0.28)	0.4 (0.25)	0.4 (0.27)	0.6 (0.36)	0.5 (0.31)	0.6 (0.36)	0.3 (0.16)	0.4 (0.26)	0.9 (0.58)	0.6 (0.34)	0.4 (0.24)	0.6 (0.38)	0.4 (0.25)	0.4 (0.27)
Fishes and shellfishes (%) §	24.1 (8.20)	23.1 (7.99)	30.7 (9.67)	29.0 (9.36)	17.1 (6.50)	24.4 (8.38)	20.4 (7.28)	22.5 (7.80)	21.0 (7.44)	25.8 (8.56)	21.4 (7.55)	22.8 (7.87)	31.6 (10.07)	24.1 (7.93)	26.8 (8.72)	24.5 (8.00)	18.8 (7.02)	28.0 (9.00)	17.2 (6.59)	19.9 (7.10)
Meats (%) §	20.4 (8.21)	19.8 (8.00)	25.5 (10.14)	21.3 (8.52)	15.3 (5.98)	19.0 (7.52)	17.2 (7.00)	18.5 (7.51)	17.6 (7.18)	21.4 (8.51)	18.2 (7.40)	18.8 (7.64)	25.3 (9.92)	19.4 (7.78)	22.6 (8.80)	19.4 (8.04)	16.1 (6.49)	24.2 (9.22)	15.8 (6.47)	16.3 (6.64)
Eggs (%) §	7.9 (2.98)	7.2 (2.76)	7.7 (2.95)	9.2 (3.41)	10.8 (3.86)	9.9 (3.60)	7.9 (2.97)	8.8 (3.30)	8.4 (3.17)	8.2 (3.08)	8.4 (3.16)	8.4 (3.18)	5.1 (1.98)	7.3 (2.77)	7.6 (2.84)	7.9 (3.01)	5.0 (1.92)	4.9 (1.87)	4.9 (1.95)	10.8 (3.98)

Table 3. Mean intake and contribution of food groups † to total amino acid intake about amino acids among Japanese women and men (cont.)

	Men (n =109)																			
	Ile‡	Leu‡	Lys‡	Met‡	Cys‡	SAA‡	Phe‡	Tyr‡	AAA‡	Thr‡	Trp‡	Val‡	His‡	Arg‡	Ala‡	Asp‡	Glu‡	Gly‡	Pro‡	Ser‡
Milks (%) §	7.2	7.4	7.4	6.4	3.4	5.1	6.2	6.9	6.6	5.8	6.2	7.4	4.9	3.2	3.7	4.9	6.5	2.5	10.1	5.9
	(5.16)	(5.22)	(5.30)	(4.68)	(2.58)	(3.74)	(4.39)	(4.83)	(4.64)	(4.25)	(4.47)	(5.21)	(3.60)	(2.39)	(2.78)	(3.60)	(4.57)	(1.89)	(6.81)	(4.23)
Fats and oils (%) §	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Confectioneries (%) §	2.1	2.2	1.7	2.0	3.0	2.5	2.5	2.2	2.4	2.0	2.4	2.3	1.7	1.9	1.9	1.9	2.9	1.9	3.2	2.6
	(1.65)	(1.71)	(1.30)	(1.57)	(2.33)	(1.89)	(1.94)	(1.75)	(1.86)	(1.56)	(1.85)	(1.75)	(1.29)	(1.43)	(1.41)	(1.45)	(2.36)	(1.49)	(2.64)	(1.97)
Beverages (%) §	1.0	1.3	0.8	0.8	0.8	0.8	1.2	1.1	1.1	1.0	0.5	1.0	0.8	0.6	0.5	1.1	1.3	1.2	1.4	1.0
	(0.74)	(0.95)	(0.67)	(0.68)	(0.69)	(0.58)	(0.80)	(0.76)	(0.78)	(0.73)	(0.58)	(0.74)	(0.60)	(0.47)	(0.46)	(0.76)	(0.81)	(0.81)	(1.00)	(0.74)
Seasoning and spices (%) §	4.6	4.1	3.8	2.4	3.7	2.9	4.4	3.2	3.8	4.3	2.7	4.4	3.6	3.7	4.2	4.9	4.3	3.9	4.3	4.3
	(1.32)	(1.22)	(1.13)	(0.88)	(1.15)	(0.95)	(1.30)	(1.15)	(1.20)	(1.23)	(1.02)	(1.27)	(1.24)	(1.22)	(1.20)	(1.37)	(1.25)	(1.17)	(1.31)	(1.23)

† Food groups are defined by the Standard Tables of Food Composition in Japan -2010-.
‡ Abbreviations: Ile = isoleucine, Leu = leucine, Lys = lysine, Met = methionine, Cys = cysteine, SAA = sulfur-containing amino acid (methionine + cysteine), Phe = phenylalanine, Tyr = tyrosine, AAA = aromatic amino acid (phenylalanine + tyrosine), Thr = threonine, Trp = tryptophan, Val = valine, His = histidine, Arg = arginine, Ala = alanine, Asp = aspartic acid, Glu = glutamic acid, Gly = glycine, Pro = proline, Ser = serine.
§ Values in parenthesis are standard deviations.

Second, values calculated by Steps 3-a, 3-b and 4 may bias the estimation of amino acid intake. These used the difference between nitrogen values (Steps 3-a and 3-b) or the ingredient list of the Standard Tables of Food Composition in Japan -2010- as the reference recipe (Step 4).[6] In previous studies, the difference between the calculated values and directly analyzed values were examined.[23, 33] According to these reports, nutrient values calculated by the same food or biologically similar food (similar to Step 3-a, and 3-b in this study) are comparable. Thus we considered the bias introduced by the values calculated by steps 3-a, and 3-b is relatively small. On the other hand, the difference between calculated (like Step 4 in this study) and directly analyzed values of multi-ingredient foods tended to be large.

As we were unable to obtain information about cooking, losses during the preparation and cooking of these foods could not be reflected in the calculation. Given reported loss rates due to cooking of 5-10%,[34] however, the influence of cooking effects is considered relatively small. In addition, most of foods calculated by Step4 were confectioneries, and the contribution of confectioneries was around 3-4% for women, and around 2% for men. Thus we considered the bias by multi-ingredient foods was not large.

Third, among foods produced by industrial processing, the amount of glutamic acid, alanine, and glycine added as ingredients of food additives is unclear, and intake may be underestimated when such foods are eaten. We were also unable to obtain information on the manufacturers of the processed foods listed in the Standard Tables of Food Composition in Japan -2010-,[6] and were thus unable to detect differences among manufacturers.

Fourth, although the use of DRs allows detailed assessment of the dietary intake of individuals, self-reported dietary assessment is nevertheless subject to measurement error. Moreover, as this DR was not collected for the purpose of estimating amino acid intake, unpredictable measurement bias may also be present.

Finally, our subjects were volunteers, and may therefore have been more nutritionally conscious than others who did not participate in the study. Accordingly, they might not be representative of the general Japanese population, and our results might thus not be generalizable to the Japanese population.

We developed an amino acid food composition table for use in nutritional epidemiologic studies, and estimated amino acid intake among a Japanese population using 16-day diet records. This amino acid database may be valuable in studies of the association between amino acid intake and health status among Japanese populations. For amino acid intake estimation, further investigation in other populations is needed.

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AUTHOR DISCLOSURES

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Original Article

Development of an amino acid composition database and estimation of amino acid intake in Japanese adults

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胺基酸成分資料庫的發展與日本成人胺基酸攝取量評估

研究個人日常胺基酸攝取與各種健康結果的相關性，一個詳盡的胺基酸成分資料庫是必備的。日本人經常攝取的食物，其胺基酸含量數據不足，以至於評估每日胺基酸攝取量有困難。此研究的目的為發展一個應用於流行病學研究的胺基酸資料庫，並以此評估日本族群的胺基酸攝取量。胺基酸數值來自已經發表的食物成分表；當缺乏現成的數據時，則使用已建立的標準，以插補的方式估算數據。共計 1100 個食物項目有適當的數據可使用。採用 16 天的飲食記錄並使用目的導向發展的胺基酸成分表，以評估居住在日本 4 個區域的族群(121 名女性及 109 名男性，年齡介於 30-69 歲)，其胺基酸攝取量。所有對象的 9 項必需胺基酸攝取量符合 WHO/FAO/UNU 報告的平均需求量。膳食胺基酸攝取主要的來源為穀類、魚貝類及肉類，占了近 60%的總攝取。這個資料庫涵蓋日本經常攝取的食物項目之胺基酸數值，在流行病學研究的運用上為有價值的工具。

關鍵字：食物成分表、胺基酸、膳食攝取、日本成人、飲食記錄