Amino Acid Composition of Food in Japan

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The trend in gradual increase of Japanese protein intake has continuously been witnessed in recent years, and it can be assumed that it has practically reached the requirement at present. However, because of the fact that nutritional value of protein differs by amino acid composition which constitutes the protein, a demand has arisen to clarify the amino acid composition of the major foods of the Japanese people.

In order to comply with such a demand 'The Amino Acid Composition of Foods in Japan, 1966' was compiled after several years of actual measurement and study by establishing the Committee for Amino Acid with the Resource Bureau of the Science and Technology Agency and under the cooperation of the Ministry of Agriculture and Forestry, Ministry of Welfare and various related agencies such as universities.

The completion of this table made it possible to fully comprehend more than ever the amino acid composition of the Japanese diet. And it can be safely assumed that the table will benefit in some measure various Southeast Asian countries whose national diets are similar to that of the Japanese.

Foods recorded in the amino acid composition table

Important protein resources in the Japanese foods heretofore were cereals, fishery and soybean products. But commensurate with the change in national diet pattern in consequence to the increase in national income, the increase in livestock products such as meats, egg and dairy products is being witnessed. Among the Amino Acid Composition Table of Japanese foods, the amino acid composition is included not only in those foods which are important protein resource but in the foods normally eaten by Japanese such as fruits, vegetables, fungi, seaweeds and beverages and others. There are 152 foods as recorded hereunder.

(1) Oatmeal, (2) barley, (3) naked barley, (4) soft flour, (5) medium flour, (6) hard flour, (7) white bread, (8) "udon", (9) "fu", dried, (10) fully milled rice, (11) buckwheat flour, (12) corn flakes, (13) sweet potato, (14) dasheen, taro, (15) potato, (16) unrefined sugar, (17) Japanese chestnuts, (18) walnuts, (19) sesame seeds, (20) peanuts, shelled, (21) "azuki" beans, (22) "sarashi-an", (23) kidney beans, (24) peas, (25) "sasage" beans, (26) broad beans, (27) soybeans, (28) soybean curd, "tōfu", (29) congealed soybean curd, (30) "yuba", (31) "okara", (32) "natto", (33) "ama-miso", (34) "kara-miso", (35) "mame-miso", (36) jack mackerel, (37) conger eel, (38) "iwashi", sardine, (39) eel, (40) marlin and swordfish, (41) skipjack, (42) dried strips of skipjack, (43) flatfish, (44) crap, (45) salmon, (46) salmon roe, salted, (47) mackerel, (48) pacific saury, (49) "kamaboko", (50) fish sausage, (51) "satsuma-age", (52) "hanpen", (53) "chikuwa", (54) red sea-bream, (55) cod and pollack, (56) pollack roe, salted, (57) loach, (58) flying fish, (59) herring, (60) goby,

(61) flounder, (62) crucian carp, (63) yellowtail, (64) mullet, (65) tuna, lean meat, (66) tuna, fatty meat, (67) yellow-fin tuna, (68) pink salmon, (69) rainbow trout, (70) ark shell, (71) short-neck clam, (72) abalone, (73) oyster, (74) top shell, (75) corbicula, (76) hen clam, (77) clam, (78) scallop, (79) mysis, (80) squid, (81) paste of sea urchin roe, seasoned, (82) tiger prawn, (83) "shiba-ebi", shrimp, (84) crab, (85) octopus, (86) sea cucumber, (87) rabbit meat, (88) beef, (89) beef liver, (90) whale meat (91) chicken, (92) chicken liver, (93) horsemeat, (94) mutton, (95) pork, (96) pork liver, (97) loin roll ham, (98) bacon, (99) Vienna sausage, (100) whole egg, (101) yolk, (102) egg white, (103) cow's milk, (104) cream, (105) processed cheese, (106) human milk, (107) goat's milk, (108) pumpkin, (109) carrot, (110) spinach, (111) turnip, (112) cabbage, (113) cucumber, (114) burdock, (115) kidney beans with pod, immature, (116) peas with pod, immature, (117) watermelon, (118) broad beans, immature, (119) Japanese radish root, (120) "takuan", salted radish, (121) bamboo shoot, (122) onion, (123) corn, immature, (124) tomato, (125) eggplant, (126) Welsh onion, (127) Chinese cabbage, (128) Chinese cabbage, salted, (129) Indian lotus root, (130) summer orange, (131) citrus Unshiu, (132) strawberry, (133) fig, (134) Japanese persimmon, (135) Japanese pear, (136) banana, (137) loquat, (138) grape, (139) peach, (140) apple, (141) *Lentinus edodes*, fresh, (142) common mushroom, champignon, (143) *Tricholoma matsutake*, (144) purple laver, (145) tangle, (146) *Hijikia fusiformis*, (147) *Undaria pinnatifida*, (148) bitter chocolates, (149) green tea, infusion, (150) "sake", (151) beer, (152) "shoyu", soy sauce.

All those foods stated above are important normal foods of the Japanese people and the foods which have actually been analyzed have been selected as to be close as much as possible to consumption pattern; for instance, in the case of rice, fully milled rice and for oat, oatmeal. Because Japanese eat many kinds of fishery products, about one-third of recorded foods accounting for 51 items are fish and shellfish, and in these fishery products edible portions are being used.

In the case of fruits and vegetables, the ratio of free amino acid content in the total amino acid content is considerably high and as it has been assumed that free amino acid fluctuates by ripening stage, etc., it is necessary to conduct further study on those foods by using more materials.

Analysis method of amino acid

The quantitative determination of amino acid has been made on 18 kinds: isoleucine, leucine, lysine, methionine, cystine, phenylalanine, tyrosine, threonine, tryptophan, valine, arginine, histidine, alanine, aspartic acid, glutamic acid, glycine, proline and serine. Among them, amino acids other than tryptophan, cystine and tyrosine have been measured by microbiological assay or ion exchange chromatography using amino acid analyzer after HCl hydrolysis. For the measurement of tryptophan microbiological assay[1] has mainly been used after alkaline hydrolysis, for cystine, performic acid oxidation method,[2] and for tyrosine, colorimetric method[3] using 1-nitroso-2 naphtol.

Based upon the measured values of each amino acid obtained by the above analysis methods and with the reference data[4,5] practical value of the amino acid content of each food has been determined. The practical value of the amino acid composition table has been indicated by the following two methods:

1. Amino acid grams per gram nitrogen in edible portion.
2. Amino acid grams in 100 gram edible portion.

Table 1 is the samplings of 30 selected foods from the Japanese Amino Acid Composition Table.

Characteristics of Japanese foods

The Amino Acid Composition of Japanese foods bring nothing quite new but it

Table 1. Amino acid composition of selected 30 Japanese foods

	Iso leucine	Leucine	Lysine	Methionine	Cystine	Phenylalanine	Tyrosine	Threonine	Tryptophan	Valine	Arginine	Histidine	Alanine	Aspastic acid	Glutamic acid	Glycine	Proline	Serine
Fully milled rice	0.28	0.52	0.21	0.14	0.13	0.29	0.38	0.22	0.080	0.37	0.36	0.14	0.37	0.67	1.1	0.27	0.32	0.23
Oatmeal	0.24	0.48	0.20	0.11	0.16	0.36	0.25	0.22	0.071	0.33	0.31	0.13	0.31	0.58	1.3	0.32	0.34	0.27
Barley	0.20	0.41	0.18	0.098	0.15	0.32	0.37	0.19	0.073	0.27	0.20	0.10	0.21	0.29	1.5	0.21	0.73	0.22
Hard flour	0.24	0.44	0.13	0.090	0.12	0.29	0.19	0.16	0.070	0.28	0.23	0.11	0.15	0.25	2.0	0.20	0.80	0.30
Buckwheat flour	0.23	0.39	0.39	0.10	0.10	0.26	0.10	0.23	0.093	0.32	0.68	0.14	0.26	0.58	1.0	0.33	0.34	0.29
Corn flakes	0.23	0.96	0.043	0.12	0.13	0.33	0.12	0.21	0.037	0.30	0.11	0.17	0.35	0.35	1.4	0.19	0.74	0.31
Sweet potato	0.25	0.40	0.26	0.067	0.076	0.26	0.30	0.31	0.079	0.38	0.22	0.12	0.36	1.1	0.87	0.26	0.21	0.31
Dasheen, Taro	0.24	0.41	0.21	0.17	0.098	0.36	0.25	0.46	0.068	0.43	0.21	0.078	0.14	0.62	1.1	0.23	0.21	0.39
Potato	0.24	0.39	0.33	0.070	0.059	0.21	0.17	0.24	0.091	0.36	0.33	0.11	0.25	0.82	1.9	0.22	0.24	0.22
Unrefined sugar	0.12	0.18	0.086	0.039	0.006	0.10	0.31	0.13	0.052	0.17	0.10	0.042	0.19	0.53	1.1	0.16	0.11	0.13
Sesame seeds	0.28	0.44	0.18	0.14	0.050	0.35	0.23	0.29	0.091	0.34	0.67	0.14	0.33	1.1	1.2	0.38	0.38	0.30
Peanuts	0.21	0.37	0.22	0.052	0.077	0.29	0.24	0.14	0.066	0.24	0.77	0.15	0.23	0.66	1.1	0.33	0.22	0.28
"Azuki" beans	0.25	0.50	0.50	0.086	0.067	0.35	0.26	0.22	0.050	0.32	0.43	0.21	0.27	0.67	1.1	0.24	0.29	0.32
Kidney beans	0.24	0.37	0.32	0.057	0.049	0.33	0.17	0.25	0.085	0.33	0.28	0.18	0.17	0.61	1.1	0.21	0.24	0.33
Peas	0.29	0.44	0.37	0.043	0.052	0.28	0.14	0.25	0.057	0.33	0.58	0.15	0.28	0.61	1.0	0.26	0.35	0.32
Soy beans	0.30	0.45	0.43	0.071	0.080	0.33	0.23	0.27	0.092	0.31	0.43	0.15	0.25	0.66	1.1	0.26	0.42	0.33
Flatfish	0.31	0.52	0.62	0.13	0.039	0.24	0.25	0.29	0.075	0.35	0.39	0.15	0.38	0.69	1.1	0.28	0.19	0.27
Mackerel	0.31	0.45	0.45	0.12	0.047	0.24	0.18	0.25	0.094	0.30	0.34	0.27	0.35	0.51	0.76	0.33	0.24	0.22
Clam	0.28	0.46	0.47	0.13	0.088	0.26	0.21	0.29	0.073	0.29	0.46	0.14	0.39	0.66	0.93	0.32	0.24	0.28
Beef	0.30	0.55	0.57	0.14	0.075	0.28	0.22	0.28	0.011	0.34	0.39	0.22	0.40	0.58	1.1	0.28	0.26	0.21
Chicken	0.34	0.46	0.58	0.19	0.081	0.24	0.20	0.28	0.078	0.34	0.38	0.17	0.35	0.59	1.0	0.26	0.29	0.31
Pork	0.32	0.53	0.58	0.17	0.073	0.26	0.22	0.28	0.050	0.34	0.38	0.26	0.37	0.60	0.92	0.28	0.24	0.22
Whole egg	0.33	0.53	0.44	0.21	0.17	0.32	0.24	0.29	0.10	0.41	0.40	0.16	0.35	0.57	0.79	0.20	0.25	0.45
Cow's milk	0.32	0.59	0.48	0.15	0.050	0.28	0.35	0.27	0.092	0.41	0.18	0.16	0.21	0.52	1.4	0.12	0.59	0.34
Spinach	0.18	0.38	0.32	0.034	0.027	0.24	0.20	0.22	0.084	0.24	0.32	0.12	0.28	0.62	1.0	0.26	0.23	0.21
Onion	0.17	0.21	0.21	0.025	0.15	0.14	0.14	0.075	0.056	0.21	0.52	0.092	0.19	0.25	0.95	0.30	0.20	0.21
Tomato	0.081	0.16	0.19	0.031	0.008	0.15	0.14	0.12	0.031	0.087	0.083	0.086	0.14	0.77	3.0	0.11	0.10	0.13
Citrus Unshiu	0.16	0.14	0.30	0.17	0.056	0.18	0.28	0.11	0.075	0.29	0.47	0.14	0.22	0.64	0.50	0.62	0.27	0.25
Banana	0.11	0.29	0.23	0.036	0.042	0.14	0.22	0.16	0.072	0.17	0.21	0.42	0.29	0.80	1.0	0.20	0.19	0.20
"Shoyu" soy sauce	0.27	0.43	0.35	0.049	0.057	0.21	0.29	0.19	0.030	0.29	0.11	0.054	0.29	0.48	1.2	0.20	0.52	0.41

Table 2.

	Fully milled rice	Oatmeal	Barley	Hard flour	Buckwheat flour	Corn flakes	Sweet potato	Dasheen, Taro	Potato	Unrefined sugar	Sesame seeds	Peanuts	"Azuki" beans	Kidney beans	Peas	Soy beans	Flatfish	Mackerel	Clam	Beef	Chicken	Pork	Whole egg	Cow's milk	Spinach	Onion	Tomato	Citrus Unshiu	Banana	"Shoyu" soy sauce
Fully milled rice		.987	.921	.876	.953	.910	.948	.842	.976	.693	.956	.953	.977	.973	.968	.979	.966	.958	.973	.970	.964	.961	.957	.956	.983	.927	.795	.862	.927	.939
Oatmeal	.987		.953	.929	.951	.929	.916	.793	.971	.636	.960	.955	.972	.983	.963	.977	.953	.940	.956	.963	.954	.942	.934	.965	.982	.948	.855	.840	.931	.964
Barley	.921	.953		.985	.874	.937	.795	.665	.885	.481	.913	.877	.898	.917	.888	.919	.864	.848	.860	.888	.878	.854	.839	.963	.908	.907	.863	.716	.843	.950
Hard flour	.876	.929	.985		.845	.920	.740	.578	.858	.425	.885	.857	.860	.895	.856	.883	.825	.797	.814	.849	.837	.805	.785	.936	.877	.900	.907	.661	.828	.940
Buckwheat flour	.953	.951	.874	.845		.845	.899	.816	.959	.630	.974	.980	.975	.959	.994	.980	.961	.960	.979	.965	.968	.960	.952	.916	.969	.964	.749	.915	.907	.917
Corn flakes	.910	.929	.937	.920	.845		.797	.700	.860	.476	.888	.828	.875	.883	.871	.889	.852	.857	.855	.883	.864	.856	.855	.930	.884	.840	.766	.691	.827	.939
Sweet potato	.948	.916	.795	.740	.899	.797		.892	.968	.865	.853	.892	.936	.938	.922	.935	.936	.923	.945	.918	.924	.924	.926	.878	.951	.817	.716	.877	.936	.878
Dasheen, Taro	.842	.793	.665	.578	.816	.700	.892		.828	.701	.793	.760	.840	.829	.839	.845	.835	.864	.862	.823	.848	.854	.912	.779	.816	.684	.433	.825	.750	.755
Potato	.976	.971	.885	.858	.959	.860	.968	.828		.761	.923	.953	.980	.985	.972	.980	.976	.951	.973	.968	.967	.959	.941	.944	.992	.915	.828	.873	.962	.943
Unrefined sugar	.693	.636	.481	.425	.630	.476	.865	.701	.761		.526	.653	.673	.677	.653	.670	.673	.642	.687	.629	.643	.649	.640	.578	.708	.508	.514	.703	.774	.587
Sesame seeds	.956	.960	.913	.885	.974	.888	.853	.793	.923	.526		.967	.949	.943	.972	.960	.928	.938	.950	.944	.940	.930	.932	.919	.948	.968	.755	.868	.862	.912
Peanuts	.953	.955	.877	.857	.980	.828	.892	.760	.953	.653	.967		.959	.953	.975	.960	.936	.921	.953	.937	.931	.922	.911	.895	.965	.974	.809	.880	.916	.891
"Azuki" beans	.977	.972	.898	.860	.975	.875	.936	.840	.980	.673	.949	.959		.987	.987	.994	.989	.977	.988	.990	.988	.984	.970	.960	.990	.933	.788	.874	.939	.946
Kidney beans	.973	.983	.917	.895	.959	.883	.938	.829	.985	.677	.943	.953	.987		.974	.988	.971	.953	.967	.971	.970	.959	.950	.966	.988	.930	.841	.850	.951	.962
Peas	.968	.963	.888	.856	.994	.871	.922	.839	.972	.653	.972	.975	.987	.974		.991	.973	.970	.986	.976	.978	.970	.965	.939	.970	.951	.758	.898	.921	.938
Soy beans	.979	.977	.919	.883	.980	.889	.935	.845	.980	.670	.960	.960	.994	.988	.991		.980	.972	.985	.982	.985	.975	.967	.968	.989	.939	.787	.881	.932	.961
Flatfish	.966	.953	.864	.825	.961	.852	.936	.835	.976	.673	.928	.936	.989	.971	.973	.980		.983	.992	.995	.994	.993	.969	.946	.984	.914	.773	.873	.924	.933
Mackerel	.958	.940	.848	.797	.960	.857	.923	.864	.951	.642	.938	.921	.977	.953	.970	.972	.983		.988	.988	.988	.995	.975	.926	.965	.901	.695	.905	.913	.913
Clam	.973	.956	.860	.814	.979	.855	.945	.862	.973	.687	.950	.953	.988	.967	.986	.985	.992	.988		.990	.992	.990	.978	.930	.984	.925	.738	.911	.923	.925
Beef	.970	.963	.888	.849	.965	.883	.918	.823	.968	.629	.944	.937	.990	.971	.976	.982	.995	.988	.990		.994	.995	.969	.955	.982	.925	.774	.866	.923	.940
Chicken	.964	.954	.878	.837	.968	.864	.924	.848	.967	.643	.940	.931	.988	.970	.978	.985	.994	.988	.992	.994		.994	.980	.954	.976	.919	.751	.883	.914	.944
Pork	.961	.942	.854	.805	.960	.856	.924	.854	.959	.649	.930	.922	.984	.959	.970	.975	.993	.995	.990	.995	.994		.977	.938	.970	.901	.720	.883	.916	.918
Whole egg	.957	.934	.839	.785	.952	.855	.926	.912	.941	.640	.932	.911	.970	.950	.965	.967	.969	.975	.978	.969	.980	.977		.926	.947	.886	.664	.875	.877	.911
Cow's milk	.956	.965	.963	.936	.916	.930	.878	.779	.944	.578	.919	.895	.960	.966	.939	.968	.946	.926	.930	.955	.954	.938	.926		.954	.898	.829	.769	.895	.978
Spinach	.983	.982	.908	.877	.969	.884	.951	.816	.992	.708	.948	.965	.990	.988	.980	.989	.984	.965	.984	.982	.976	.970	.947	.954		.937	.831	.877	.956	.951
Onion	.927	.948	.907	.900	.964	.840	.817	.684	.915	.508	.968	.974	.933	.930	.951	.939	.914	.901	.925	.925	.919	.901	.886	.898	.937		.827	.848	.869	.902
Tomato	.795	.855	.863	.907	.749	.766	.716	.433	.828	.514	.755	.809	.788	.841	.758	.787	.773	.695	.738	.774	.751	.720	664	.829	.831	.827		.568	.836	.839
Citrus Unshiu	.862	.840	.716	.661	.915	.691	.877	.825	.873	.703	.868	.880	.874	.850	.898	.881	.873	.905	.911	.866	.883	.883	.875	.769	.877	.848	.568		.839	.793
Banana	.927	.931	.843	.828	.907	.827	.936	.750	.962	.774	.862	.916	.939	.951	.921	.932	.924	.913	.923	.923	.914	.916	.877	.895	.956	.869	.836	.839		.901
"Shoyu" soy sauce	.939	.964	.950	.940	.917	.939	.878	.755	.943	.587	.912	.891	.946	.962	.938	.961	.933	.913	.925	.940	.944	.918	.911	.978	.951	.902	.839	.793	.901	

substantiates quantitatively what has been said of protein nutrition of Japanese heretofore, that is, it is necessary to intake animal protein in each meal or soybean products as the substitute. As the lysine and methionine are essential amino acids usually lacking in vegetable foods, it is rational to supplement by animal foods.

The soybean and Azuki bean used by Japanese for eons of age are high in lysine content compared with other vegetable foods and such beans have played a complementary role to supplement amino acid composition of protein in rice. Therefore, it can be said that Japanese were clever in their art of living.

About half of the animal protein intaken by Japanese is from fish and shellfish. Because the protein of fish meat has practically the same amino acid composition as animal meat, it has been clarified that fish meat has the same nutrition value as animal meat. Japanese are polyphagia and as the diet pattern is expected to become more diversified. In consequence those 152 kinds of food can not be termed as sufficient and it is necessary to further determine a practical value of amino acid composition of more foods.

Recently the similarity of amino acid patterns mutually among those 152 foods were calculated and printed.[6]. In the pattern similarity rate the pattern composed by numerical value group has been assumed as the direction of a vector of high dimensional space and the cosine of (θ) between two vectors is used. Accordingly, the pattern similarity rate S (A, B) between the pattern A ($a_1, a_2 \ldots a_n$) and the pattern B ($b_1, b_2 \ldots b_n$) is:

$$S(A, B)=\cos\theta=\frac{\sum_{i=1}^{n} a_i b_i}{\sqrt{\sum_{i=1}^{n} a_i^2}\sqrt{\sum_{i=1}^{n} b_i^2}}$$

The pattern similarity rate becomes 1 when two patterns are the same and when the patterns do not contain any same component it becomes O, and the more the patterns are similar the value approaches 1. Table 2 indicates the pattern similarity rate of 30 selected foods listed in Table 1. For instance, the most similar amino acid patterns among 30 foods are between beef and pork and beef and flatfish. In both cases the pattern similarity rate is 0.995. The most unsimilar pattern is between hard flour and unrefined sugar, and the similarity rate is 0.425.

Since the Amino Acid Composition of Japanese Foods and the Amino Acid Pattern Similarity Table was completed, we have reached the stage to distinguish food with respect to amino acid. That is, in the case of ordinary foods it is possible to comprehend the amino acid content of a food; and on the other hand, if there is amino acid analysis value of food it is possible to estimate what kind is that food.

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