Nucleic Acid Contents of Japanese Foods

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Nucleic acid contents of 29 kinds of Japanese foods, including 7 kinds of meats and poultries, 3 kinds of eggs, 11 kinds of seafoods, 2 kinds of cereals, 2 kinds of legumes, 2 kinds of fungus, 1 kind of fruit and 1 kind of yeast, were determined by SCHMIDT-THANNHAUSER-SCHNEIDER method or ion-exchange chromatography. The nucleic acid contents of almost all samples were in the range of 200 to 400 mg per 100 g of fresh weight. The samples with high nucleic acid content were pork liver, salmon roe, purple laver and baker's yeast. Although proportion ratio of nucleic acid nitrogen to total nitrogen of almost all the samples was 2%, that of the samples containing high nucleic acid was more than 10%.

Purine and pyrimidine bases of nucleic acid in foods arouse interest in human nutrition by several reasons. One is that purine base causes the gout on humans.¹⁾ The intake from food should be limited from this point. On the contrary, in recent years, high nucleic acid commodities are sold as a healthy food, even though its academic background is not established.

In this paper, we describe the nucleic acid content of Japanese foods. The nucleic acid content of Japanese foods was reported by NOZAKI *et al.* in 1971.²⁾ However, the reported value was not recognized as accurate because of their analytical method. In 1977, 1981 and 1982, MATSUMOTO³⁾ and SHINODA *et al.*⁴⁾⁵⁾ reported the nucleic acid contents of meats, fishes, cereals, beans, eggs, milk and vegetables. However, they estimated the purine bases only.

In this study, we estimated not only purine bases but also pyrimidine bases, because the nucleic acid contents affect the nitrogen-factor in calculation for protein content of foods from Kjeldahl-nitrogen. The sum of the content of purine and pyrimidine bases corresponds to some part of non-protein nitrogen.

Experimental

Materials

Twenty-nine kinds of food samples listed below were analyzed.

Meats and poultries ; beef (cattle), pork (swine), chicken (hen), pressed ham, pork liver, liver paste, organs of chicken

Eggs ; whole egg, yolk, egg white

Seafoods ; tuna, flatfish, maiwashi (anchovy), short-necked clam, kegani (crab), tiger prawn, salmon roe, salmon milt, jellyfish, oyster, dried purple laver

Legumes ; soybean, adzuki bean

Cereals ; rice, wheat

Fruit ; banana

Fungus ; Shiitake (*Lentinus edodes*), common mushroom (*Agaricus bisporus*)

Yeast ; dried baker's yeast (*Saccharomyces cerevisiae*)

All samples were collected from the market in Tokyo.

Preparation of samples

On all samples only edible parts were analyzed according to the description of the Standard Tables of Japanese Foods⁶⁾. Samples were washed by tap-water, wiped by cloth and

cut into small pieces.

Analytical methods

Moisture content was determined by drying under reduced pressure (20-30 mmHg) at 90-100°C⁷⁾. Nitrogen content was determined by semi-micro Kjeldahl method.⁸⁾

Nucleic acid contents of the samples from animal origin were determined by SCHMIDT-THANNHAUSER-SCHNEIDER method (STS method) with slight modification.⁹⁾ Perchloric acid was used as extraction reagent in place of trichloroacetic acid. Although the extract of 5% perchloric acid solution contained free bases, nucleosides, nucleotides and other non-nucleic acid acid-soluble compounds, we estimated this fraction as acid-soluble nucleic acid fraction by measuring O.D. at 260 nm. In order to confirm this assumption was proper or not, the comparative analysis between STS method and ion-exchange chromatography was carried out. The results were described in the Results section.

Nucleic acid contents of the samples from plant origin were determined by ion-exchange chromatography after the fractionation by STS method. The column used was Dowex-1 (X-8) 200-400 mesh) and eluted by diluted hydrogen chloride solution containing sodium chloride⁹⁾.

Amino acid contents of some samples were determined by amino acid analyzer (Hitachi KLA-5) after hydrolysis by 6 N hydrogen chloride at 105°C for 22 h.

Results

Comparison of the data obtained by two

methods, STS method and ion-exchange chromatography

To determine nucleic acid contents in foods, STS method is very convenient. However, in this method nucleic acid can be examined by UV absorption, so, it may cause over-estimation of the contents if the sample contains non-nucleic acid acid-soluble UV-absorbed compounds. To confirm this possibility, we estimated some samples by both methods, STS method and ion-exchange chromatography.

As the results listed in Table 1, the samples from animal origin, such as beef and pork, showed almost the same value (96 and 92% each) between two methods. On the contrary, the samples from plant origin, such as rice, soybean and banana, showed relatively different value (8.6, 61 and 7.0%, respectively) between two methods. From these results, we concluded that STS method was effective to analyze the samples from animal origin and the chromatographic method to that from plant origin.

Nucleic acid contents of Japanese foods

Table 2 shows the nucleic acid contents of 29 kinds of Japanese foods. The values listed in the Table express the weight of bases moiety of nucleic acids. Acid soluble fraction contains free bases, nucleosides and nucleotides. RNA or DNA fraction corresponds to bases of RNA or DNA, respectively. Nucleic acid nitrogen was calculated from the total nucleic acid with the assumption that average nitrogen content of bases was 15.3%.

Proportion ratio of nucleic acid nitrogen

Table 1 Acid soluble nucleic acid content of some samples determined by STS method and ion-exchange chromatography

Name of sample	STS method	Ion-exchange chromatography
Beef (Cattle)	265 ¹⁾	254 ²⁾
Pork (Swine)	125	115
Rice	349	30
Soybean	190	116
Banana	243	17

¹⁾ The values were calculated from the UV absorption at 260 nm.

²⁾ The values were estimated from the area of the chromatogram.

Table 2 Nucleic acid content of selected foods*

Name of sample	Fractions			Total
	Acid soluble	RNA	DNA	
Meats and poultries				
Beef (cattle)	265	130	78	473
Pork (swine)	125	77	40	242
Chicken (hen)	332	147	47	526
Pressed ham	153	43	50	246
Pork liver	262	452	164	878
Liver paste	233	215	111	559
Organs of chicken	156	192	112	460
Eggs				
Whole egg	37	40	33	110
Yolk	14	102	19	135
Egg white	28	21	13	62
Fishes				
Tuna	343	72	30	445
Flatfish	257	110	59	426
Maiwashi (sardine)	267	126	77	469
Short necked clam	242	307	494	1043
Kegani (crab)	193	59	45	297
Tiger prawn	309	58	27	394
Jelly fish	32	250	32	314
Oyster	387	382	133	902
Purple laver	621	2551	335	3507
Salmon roe	104	45	19	168
Salmon milt	138	219	897	1254
Cereals				
Rice	30	145	60	235
Wheat	25	96	72	193
Legumes				
Soybean	116	620	216	952
Adzuki bean	35	311	32	378
Fruit				
Banana	17	31	4	53
Fungus				
Shiitake (<i>Lentinus edodes</i>)	27	43	13	83
Common mushroom (<i>Agaricus bisporus</i>)	45	90	4	134
Yeast				
Baker's yeast (<i>Saccharomyces cerevisiae</i>)	1561	5054	267	6882

* The value expressed the mg of bases per 100 g of fresh weight.

to total nitrogen

Table 3 shows the contents of nucleic acid nitrogen and total nitrogen estimated by

Kjeldahl method and the proportion ratio of nucleic acid nitrogen to total nitrogen.

Table 3 Nucleic acid and total nitrogen contents of selected foods (%)

Name of sample	Nucleic acid N (A)	Total N (B)	(A)/(B) × 100
Meats and poultries			
Beef (cattle)	0.0724	2.31	2.19
Pork (swine)	0.0371	2.57	1.44
Chicken (hen)	0.0805	3.88	2.08
Pressed ham	0.0375	2.03	1.86
Pork liver	0.1343	2.95	4.55
Liver paste	0.0855	1.44	5.94
Organs of chicken	0.0704	2.58	2.73
Eggs			
Whole egg	0.0168	1.92	0.88
Yolk	0.0206	2.29	0.90
Egg white	0.0094	1.53	0.62
Fishes			
Tuna	0.0680	3.66	1.86
Flatfish	0.0651	3.43	1.90
Maiwashi (sardine)	0.0769	2.76	2.61
Short necked clam	0.160	2.13	7.51
Kegani (crab)	0.0454	2.13	2.13
Tiger prawn	0.0603	2.88	2.05
Jelly fish	0.0480	0.96	5.00
Oyster	0.138	1.52	9.05
Purple laver	0.537	6.29	8.53
Salmon roe	0.0257	2.38	1.08
Salmon milt	0.192	1.23	15.6
Cereals			
Rice	0.360	0.953	3.78
Wheat	0.0295	2.07	1.43
Legumes			
Soybean	0.146	6.45	2.26
Adzuki bean	0.0578	3.12	1.85
Fruit			
Banana	0.008	0.165	4.87
Fungus			
Shiitake (<i>Lentinus edodes</i>)	0.0127	0.521	2.44
Common mushroom (<i>Agaricus bisporus</i>)	0.0205	0.685	2.99
Yeast			
Baker's yeast (<i>Saccharomyces cerevisiae</i>)	1.053	7.51	14.0

Discussion

The nucleic acid contents of Japanese foods were shown in Table 2. Almost all of the foods from animal origin contained several-

hundred mg of nucleic acid per 100 g of fresh weight. Furthermore, it was interested that cereals and legumes also contained such amount of nucleic acids.

Comparing our data with those of MATSU-

Table 4 Total nucleic acid and amino acids contents of the foods which have high nucleic acid contents¹⁾

Name of sample	Nucleic acids(A)	Amino acids ²⁾ (B)	(A)+(B)	Amide-N ³⁾
Short-necked clam	7.5	72.9	80.4	5.5
Purple laver	8.5	72.7	81.7	4.2
Baker's yeast	14.0	80.1	94.1	5.6

¹⁾ The values expressed as nitrogen % of each fraction of total nitrogen content.

²⁾ Cystine and tryptophan were not included.

³⁾ Reported by YAMAGUCHI, M.; "Report of the Research on Analysis of Minor-component of Foods", p. 269 (Science and Technology Agency, Japan) (1979)

MOTO and SHINODA⁴⁾⁵⁾, it was found that our data were slightly higher than those of them. This result was reasonable because our data include purine and pyrimidine bases on the contrary to that their data include purine base only.

Proportion ratio of nucleic acid nitrogen to total nitrogen was listed in Table 3. It can be seen that the ratio of almost all the samples not only from animal origin but also plant origin is around 2%. This fact indicates that "nitrogen-protein factor" used in determination of protein content by Kjeldahl method must consider nucleic acid nitrogen. If we estimate protein content by calculation of Kjeldahl nitrogen multiplied by nitrogen-protein factor, usually 6.25, it would be overestimated. We must subtract nucleic acid nitrogen from total nitrogen.

In order to confirm the suggestion, total amino acid content of some samples were determined. Table 4 showed the total nucleic acid and total amino acid contents of the foods which have high nucleic acid content. The sum of the nucleic acid nitrogen and the amino acid nitrogen was 80.4, 81.7 and 94.1% of total nitrogen, respectively. This figures indicate the existence of the other nitrogenous compounds in these foods, one of which is amide-nitrogen. The contents of amide-nitrogen in these foods reported by YAMAGUCHI were shown in Table 4. The fact that sum of the content of these compounds does not exceed 100 % indicates the following conclusion. Protein contents in foods should be estimated by total amino acid contents.

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日本食品の核酸含量

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日本食品 29 点(鳥獣肉類 7 点, 卵類 3 点, 魚介類 11 点, 海藻 1 点, 穀類 2 点, 豆類 2 点, きのこと類 2 点, 果実 1 点, 酵母 1 点)の全核酸含量を, SCHMIDT-THAN-

NHAUSER-SCHNEIDER 法ならびにイオン交換クロマトグラフィーにより測定した。分析した試料の全核酸含量は、植物性食品を含め、大部分のものは 200~400 mg/100 g の範囲であった。核酸含量の高いものは、豚レバ

ー、鮭白子、乾燥海苔、パン酵母などであった。全窒素に占める核酸態窒素の割合は、大部分の試料では 2% 前後であったが、これらの高いものでは 10% を越えるものがあった。