

<Review Article>

Biotin content table of select foods and biotin intake in Japanese

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Summary The biotin content of 500 select foods was determined by a microbiological assay in this study "Himeji study" and the biotin content of 955 foods was listed in the food composition table for biotin "Biotin content table", based on the combination of published data in Japan and foreign countries. Of these, the biotin contents of some foods such as peanuts, red peppers, liver (cattle, swine, and chicken), kidney (cattle), eggs (yolk), instant coffee, baker's yeast (dried), and royaljelly were over 50 µg/100g per food. The average content of biotin in 98 food group was high in Meats (offals), Nuts and seeds, Spices and others, Whole soybeans and its products, and Eggs. However biotin was not contained in Animal fats, Edible salts and *Sake*. When the dietary intake of biotin was calculated using the average content of biotin determined in Himeji study and the food intake in the National Health and Nutrition Survey in Japan (2012), the biotin intake was estimated to be 50 µg/day for adults in Japan. This biotin content table covers most common foods in Japan and might be useful as a database for the estimation of the dietary intake of biotin from meals.

Key words: Biotin content table, Standard Tables of Food Composition in Japan, Biotin intake, Biotin requirement, Japanese

1. Introduction

Biotin is a water-soluble vitamin that is classified as a B-group vitamin. In mammals, biotin serves as an essential cofactor for four carboxylases in fatty acid synthesis, branched-chain amino acid metabolism and

gluconeogenesis^{1,2}. It is known that biotin deficiency causes the dysfunction of these metabolic pathways, and the resulting biochemical and physiological impairments induce skin disorders such as dermatitis, hair loss, neuritis and susceptibility to infections. Biotin deficiency is also severely teratogenic in

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rodents^{3,4}. Biotin is essential for maintaining pregnancy and fetal development. However, the decrease in urinary biotin is found even in normal gestation in mice and humans⁵. The nutritional state of biotin in pregnancy may be suspected to be marginal⁶. On the other hand, more recently, excessive amount of biotin intake has been reported to induce the inhibited maturation of spermatogenesis^{7,8}.

As biotin is widely contained in various foods, biotin deficiency is rare in humans. For these reasons, there are not many data on the intake and requirement of biotin, the absorption and bioavailability of biotin, and the biomarker to evaluate nutritional state of biotin. The authors determined many kinds of foods including infant formulas and baby foods⁹⁻¹¹. Because biotin was not permitted as a food additive in Japan, with the exception of food with nutrient function claims, biotin could not be supplemented in infant formulas. Biotin deficiency was induced in many cases by feeding infant formulas, especially therapeutic infant formulas made in Japan. So, it was not until this June that biotin could be added to only the infant formulas by the notification of the Ministry of Health and Welfare.

In Japan, the recommended dietary intake of biotin has recently been set at 30 $\mu\text{g}/\text{day}$ for adults by the "Recommended Dietary Allowances for Japanese, 6th Revision - Dietary Reference Intakes -" (DRIs 2000), based on evidence in foreign countries¹². The adequate intake (AI) of biotin has been revised to 4 and 10 $\mu\text{g}/\text{day}$ for infants ages 0-5 and 6-11 months, respectively, 20 μg for infants ages 1-2 years old and 50 $\mu\text{g}/\text{day}$ for adults in the "Dietary Reference Intakes for Japanese, 2010 version" (DRIs 2010)¹³. However there is not much evidence concerning the dietary intake of biotin in Japan yet. It is necessary to determine the exact biotin content of foods to estimate the dietary intake of biotin for Japanese.

The contents of nutrients in 1,878 foods are listed and divided into 18 food groups in the "Standard Tables of Food Composition in Japan, 5th revised and enlarged edition (Japanese Food Composition Table)" published in 2005, but the biotin contents in these foods have not been included¹⁴. We determined the biotin contents of 500 foods and many kinds of meals

by a microbiological assay in several of our studies in Japan (assay data)¹⁵⁻¹⁷. In addition, the biotin contents of 498 of the foods were added to the Japanese Food Composition Table in 2010 for the first time¹⁸. A "biotin content table" was made by combining our assay data and published data such as the biotin contents of foods listed in the Japanese Food Composition Table and analyzed in foreign countries (Table 1). Also the biotin intake was calculated using this biotin content table by a 98 food group calculation method.

2. Biotin determination

Of the foods listed in the Japanese Food Composition Table, 500 were selected in Himeji study. All foods purchased from the grocery stores in Himeji, Japan. Most foods are produced in various districts of Japan and some are imported from America, China and Australia.

The moisture of the foods was determined by the heating dryness method at the normal pressures. Foods were processed by the "analytical manual" recommended in the Japanese Food Composition Table. As for the determination of the biotin contents, solid foods such as meats and vegetables were adequately added in distilled water after being cut with a knife as finely as possible and homogenized for a set amount of time. The liquid foods were provided as a sample after adding distilled water and being diluted as needed. These samples were stored in a freezer at -40°C until analyzed. Each food sample was hydrolyzed with 2.25 M H_2SO_4 by autoclaving at 121°C for 1 hour and then neutralized with 4.5 M NaOH. The biotin contents were micro-biologically measured using *Lactobacillus plantarum* ATCC 8014¹⁹. The biotin in the foods is partially bound to some peptides and proteins. Therefore, it is generally necessary to hydrolyse to release free biotin in foods before a biological assay. The content of free biotin in some foods was presented as a percentage of free biotin to total biotin as well.

In the Japanese Food composition Table¹⁴, 1,878 foods were divided into 18 food group. The nutrient contents of these foods such as vitamins and minerals in addition to major nutrients are shown. Foods

analyzed in Himeji study were divided into 98 food group depending on the table of food groups in the National Health and Nutrition Survey, and the average of the food group was calculated for estimating the dietary biotin intake.

3. Biotin contents in foods

The biotin contents of foods in Denmark²⁰ and Germany^{21, 22} are shown in the food composition tables. The biotin contents of foods in Canada are described in five articles published by Hoppner et al.²³⁻²⁷. The biotin contents in American foods and processed foods were reported by Hardings and Crooks²⁸ and Staggs et al.²⁹. The biotin contents of 498 foods in Japan were added to the Japanese Food Composition Table in 2010¹³. Of these studies the biotin contents were determined by the microbiological assay²⁰⁻²⁸ and the HPLC/avidin-binding assay²⁹.

In Biotin content table, the biotin contents were over 50 µg/100g per food in peanuts, red peppers, liver (cattle, swine, and chicken), kidney (cattle), eggs (yolk), instant coffee, baker's yeast (dried) and royal-jelly (Table 1). As shown in Table 2, the average content of biotin in 98 food group in Himeji study (100 g per food) were highest at 26.1 µg in Meats (offals), relatively high 22.5 µg in Nuts and seeds, 20.9 µg in Spices and others, 19.3 µg in Whole soybeans and its products, and 17.9 µg in Eggs. Moreover, the average contents of biotin were over 10 µg in *Hirakiboshi* and *Tsukudani* in Fishes and Shellfishes products and *Soyou* and *Natto* in Japanese fermenting products, which are popular in Japan. On the other hand, the average biotin contents were low at 0.0 µg in Animal fats and Vegetable fats and oils in Fats and oils, Edible salts in Seasonings, and *Sake* in Alcoholic beverages.

The kinds of analyzed foods are different in every study, which depends on the food culture and dietary habits of each country. In Himeji study, soy foods, seasoning, and spices popular in Japan, as well as many kinds of fishes and shellfishes, algae, and mushrooms were analyzed. On the other hand, the standard tables of food composition in Denmark and Germany include many offal and milk products²⁰⁻²².

Furthermore, the biotin contents of foods listed in the biotin content table are slightly different depending on the study. It was mainly for this reason that there is a difference in the origin of foods or the assay method of biotin. The value of the biotin contents by HPLC/avidin-binding assay tends to be lower compared with that by a microbiological assay²⁹. This may be due to the high specificity to biotin in the HPLC/avidin-binding assay. In contrast, as the microbiological assay has a low specificity for biotin, this may measure with confounding factors such as biotin analogs and catabolites and thereby overestimate biotin containing foods. Also some biotin in foods may be destroyed and lost by a strong acid hydrolysis.

4. Dietary intake of biotin

The biotin intake was estimated by the 98 food group calculation method developed in our study^{30, 31}. Although the biotin content of all foods has not been determined yet, the daily intake of biotin can be easily calculated by the average contents of biotin in the 98 food group and the amounts of food intake of the 98 food group shown in the National Health and Nutrition Survey (2012)³².

The dietary intake in infants ages 1-2 years old was estimated at 25.0 µg/day for males and 24.4 µg/day for females. In adults ages 18-29 years old, daily intake of biotin was estimated at 50.1 µg/day for men and 41.8 µg/day for women (Table 2). The sex difference in biotin intake was detected in adolescence and adults 10-years-of-age and above. These biotin intakes for adults were consistent with 50.7 µg/day in TDS and 54.3 µg/day (arithmetic mean) in duplicate meals in Japan^{30, 33}. Also the estimated intake of biotin was 39.9 µg/day from a 24-hour dietary recall according to data collected in NHANES II in the USA³⁴. The foods contributing to biotin intake were primarily eggs, rices and milk for all ages. The percentage of this contribution was about 35% in adults ages 18-29 years old, which was as the same as infants ages 1-2 years old.

The AI of biotin has been set at 50 µg in DRIs 2010 for Japanese¹³ and 30 µg for Americans³⁵. However, the Estimated Average Requirement (EAR)

Table 1 Biotin contents of select foods

18 Food group	Item No.	Food and discription	Assay value		Published value						Notes			
			Water ¹	Himeji study ³	Biotin contents ¹									
					Denmark ⁴	Germany ⁵	Canada ⁶	USA ⁷	USA ⁸	Japan ⁹				
CEREALS	1001	Amaranth	Whole grain, raw								16.3			
	1004	Oats	Oatmeal, raw	9	16.8		20.0*	20.0	24.0	0.2	21.7	[1]		
	1006	Barley	Pressed grain, raw						31.0		2.6			
	1007		Splited grain, raw	62	3.6				31.0		3.5			
	1008	Wheat [Whole grain]	Noodles											
	1013		Imported	Soft, raw			7.0	6.0		16.0		9.6		
	1014		Hard, raw								10.7			
	1015	[Wheat flour]	Soft flour	First grade	13	2.4	1.9			9.0		1.2		
	1016			Second grade								2.5		
	1018		Medium flour	First grade	12	0.9						1.5		
	1019			Second grade								2.6		
	1020		Hard flour	First grade	13	2.5						1.7		
	1021			Second grade								2.6		
	1023		Whole									10.8		
	1024	Premixed flour		For hot cake	10	1.2						1.5		
	1025			For <i>Tenpura</i>	11	2.1								
	1026	[Breads]		White table bread	40	1.6					1.2	2.4		
	1028			Bread type rolls			2.2							
	1030			Hardtack	7	1.1								
	1031			French bread	29	1.0							1.9	
	1032			Rye bread	41	0.8	5.5		6.0			0.1		
	1034			Soft rolls	25	4.8	1.9	1.0	2.0			0.1		
	1035			Croissants	16	7.4	1.9							
	1036			English muffins	45	1.5								
	1037			Nan	39	1.1								
	1038			[Japanese noodles]	<i>Udon</i>	Wet form, raw	29	1.1						0.8
	1039	Wet form, boiled	13			1.0 ^a						0.3		
	1041	<i>Hosi-udon</i>	Dry form, raw		13	0.5						1.3		
	1043	<i>Somen & Hiyamugi</i>	Dry form, raw		11	2.0						1.3		
	1044		Dry form, boiled								0.4			
	1047	[Chinese noodles]	<i>Chinese noodles</i>	Wet form, raw								1.0		
	1048			Wer form, boiled								0.5		
	1056	[Precooked noodles]	Chinese noodles	Dried by frying, seasoned	4	2.4								
	1057			Dried by frying								1.8		
	1058			Dried by hot air								2.2		
	1059			Dried by frying	7	1.0								
	1060			instant cup noodles	8	0.7								
	1063	[Macaroni and spaghetti]	Macaroni and spaghetti	Dry form, raw	12	2.7 ^a	1.0	1.0				4.0		
	1064			Dry form, boiled			0.2					1.4		
	1066	[<i>Fu</i> : gluten products]	Baked type	<i>Kanze-fu</i>	11	4.9								
	1074	[Others]		Chio tzu pastry	32	0.6								
	1079			Bread crumbs	Dry form	10	4.1	6.2						
	1080	Rice [Paddy rice grain]		Brown rice, raw			3.0	12.0				6.0		
	1081			Half-milled rice, raw								3.5		
	1082			Under-milled rice, raw								2.9		
	1083			Well-milled rice, raw	15	2.0*	3.0	3.0	6.0	5.0		1.4	[2]	
	1084			Well-milled rice with embryo, raw								3.3		
	1085	[Cooked paddy rice]		Brown rice	65	3.2	3.0			12.0		2.5		
	1086			Half-milled rice								1.2		
	1087			Under-milled rice								0.9		
1088	Well-milled rice			64	0.6 ^a				1.3		0.5			
1089	Well-milled rice with embryo								58.0		1.0			
1093	[Paddy rice gruels]		Well-milled rice							0.3				
1097	[Paddy rice diluted gruels]		Well-milled rice							0.1				
1101	[Paddy rice thin gruels]		Well-milled rice							0.1				
1112	[Nonglutinous rice products]		<i>Yaki-onigiri</i>								1.1			
1114			Flour	11	0.8	1.0					1.1			
1115			Noodles, raw	14	0.4						0.6			
1116			Rice-koji	10	6.0						4.2			
1117	[Glutinous rice products]		Rice cake	45	0.9						0.6			
1118			<i>Sekihan</i>								0.8			
1120			<i>Shiratamako</i>	11	0.6						1.0			
1122			Buckwheat	Buckwheat flour	Straight								17.0	
1123	Inner layer										4.7			
1124	Middle layer	13			5.3						18.4			
1125	Outer layer									38.2				
1127	Buckwheat noodles			Wer form, raw							5.5			
1128				Wet form, boiled	72	2.3						2.7		
1129	Dried buckwheat noodles		Dry form, raw	13	0.0									
1131	Corn		Whole grain, raw				6.6*		21.0		8.3	[3]		
1132			Corn meal						6.0					
1133			Corn grits									3.1		
1136			Popcorn, oil-popped and salted	6	4.3	6.1								
1137			Cornflakes	5	0.7			1.8				1.6		
1139	Japanese barnyard millet		Milled grain, raw							3.6				
1140	Sorghum		Whole grain, raw							15.4				
1142	Rye		Whole flour			6.0	5.0				9.5			
	[Others]	Wheat	Bran				44.0		14.0					
			Germ				17.0	22.3						
			Flour, Type 405				1.5							
			Flour, Type 550				1.1							
			Flour, Type 630				2.0							
			Flour, Type 812				2.9							
			Flour, Type 1050				2.9							
			Flour, Type 1700				8.3							
			Flour, enriched						5.0					
			Bread	Whole wheat					2.0	1.9				
		Com					6.0							

[1] ; Rolled oats, [2] ; free biotin: 2.1%, [3] ; corn flour

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			Wheat whole-meal bread						3.5	3.0						
			Wheat (flour) bread						2.9							
			Wholemeal				6.0									
			Graham					1.7								
			Crispbread					7.0								
			Roll				19.0									
			Oats													
			Rice								8.0					
			Converted								10.0					
			Parboiled								6.6					
			Cereals, refined, cooked								60.0					
			Cornmeal, White								57.0					
			Cereal concentrates, raw													
			Rice, Bran													
			Rice, Polishings													
POTATOS AND STARCHES	2001	<POTATOES>	Tuber, raw											3.7		
	2002	Jerusalem-artichoke	Fine powder											4.5		
	2004	Konjac	Block	Made from corm	97	0.1								0.1		
	2005			Noodles	96	0.4										
	2006	Sweet potatoes	Tuberous root, raw		67	3.5*		4.3		4.3			4.0	(4)		
	2007		Tuberous root, steamed								1.5		4.8			
	2010	(Tarus)	Satoimo	Corn, raw	79	2.1							3.1			
	2011			Corn, boiled										2.8		
	2012			Corn, frozen	81	2.9										
	2013		Mizuimo	Corn, raw									2.4			
	2014			Corn, boiled										2.1		
	2015		Yatsugashira	Corn, raw									3.1			
	2016			Corn, boiled										2.6		
	2017	Potatoes	Tuber, raw		73	1.8	0.5	0.4						0.4		
	2019		Tuber, boiled							0.1				0.3		
	2020		Fried potato		64	0.6				0.1						
	2022	(Yams)	Chinese yam <i>Ichoimo</i>	Tuberous root, raw										2.6		
	2023		Chinese yam <i>Nagaïmo</i>	Tuberous root, raw	84	2.2								2.2		
	2024			Tuberous root, boiled										1.6		
	2025		Chinese yam <i>Yamatoimo</i>	Tuberous root, raw										4.0		
	2026		Japanese yam	Tuberous root, raw										2.4		
	2027		White yam	Tuberous root, raw										3.0		
	2034	<STARCHES AND STARCH PRODUCTS>	Potato starch		17	2.9				0.1						
	2035	(Starches)	Corn starch		13	0.0			6.6					0.1		
	2039	(Starch products)	Harusame :	Ryokuto-harusame, Dried, raw	12	0.5										
	2040	(Others)	starch noodles	Harusame, Dried, raw	14	0.1										
SUGERS AND SWEETENERS	3001	(Sugars)	Brown sugar lump		3	14.7					0.1			33.6		
	3003		Soft sugars													
	3004			White	0	0.1										
	3005			Yellow	0	3.7										
	3016	(Starch sweeteners)	Glucose syrup		18	0.0								0.0		
	3021		High fructose syrup											0.0		
	3022	(Others)	Honey		11	2.2					9.0			0.5		
	3023		Maple syrup		37	0.5								0.1		
PULSES	4001	Adzuki beans	Whole, dried, raw		14	10.1								9.6		
	4002		Whole, dried, boiled											3.5		
	4003		Boiled, canned in syrup		45	1.4										
	4004		An : bean paste	Koshi-an	33	1.0										
	4005			Sarashi-an											7.4	
	4007	Kidney beans	Whole, dried, raw		13	8.1								9.4		
	4008		Whole, dried, boiled											3.8		
	4012	Peas	Whole, dried, raw				34.0	19.0						16.0		
	4013		Whole, dried, boiled							9.0				5.7		
	4014		Oil-roasted and salted				114.0									
	4017	Cowpeas	Whole, dried, raw		9	10.0			7.5		21.0			11.1		
	4018		Whole, dried, boiled											4.8		
	4019	Broad beans	Whole, dried, raw											12.5		
	4020		Oil-roasted and salted		4	7.3										
	4023	Soy beans [Whole beans and its products]	Whole beans	Domestic, dried, raw	13	21.9	60.0	60.0	3.0	61.0				28.5		
	4024			Domestic, dried, boiled											11.1	
	4025			U.S.A., dried, raw											33.6	
	4026			China, dried, raw											32.6	
	4027			Brazil, dried, raw											32.9	
	4028			Canned in water	69	3.7										
	4029		Kinako	Whole bean type	10	32.4				70.0						
	4032	[Tofu and Abura-age]	Momen-tofu		85	5.0*								3.8		
	4033		Kinugoshi-tofu		89	5.0*										
	4038		Yaki-tofu		85	2.5										
	4039		Nama-age		39	4.2										
	4040		Abura-age		43	2.4										
	4041		Ganmodoki		64	5.1								7.6		
	4042		Kori-dofu		8	17.5										
	4043		Tofu-yo													
	4044		Tofu-chikuwa	Steamed type										4.2		
	4046	[Natto]	Itohiki-natto		61	13.1								18.2		
	4047		Hikiwari-natto		62	10.3										
	4048		Goto-natto											14.7		
	4049		Tera-natto											19.1		
	4051	[Others]	Okara	Modern product	78	2.9*								4.1		
	4052		Soy milk	Regular type	87	0.5*				1.4				3.9		
	4053			Reconstituted type	89	4.8					1.5					
	4059		Yuba	Wet type	75	3.5								14.3		
	4060			Dried type	7	29.6										
	4061		Kinzanji-miso											8.1		
	4062		Hishio-miso											7.1		
	4063		Tempeh											19.9		
	4064	Rice beans	Whole, dried, raw											9.7		
	4065	Chickpeas	Whole, dried, raw		9	25.5					10.0			21.4		

[4] ; free biotin: 42.9%

	4066		Whole, dried, boiled									8.9
	4068	Scarlet runner beans	Whole, dried, raw									8.4
	4069		Whole, dried, boiled									3.0
	4070	Lima beans	Whole, dried, raw									9.2
	4071	Mung beans	Whole, dried, raw					7.5				11.2
	4072		Whole, dried, boiled									3.3
	4073	Lentils	Whole, dried, raw						13.2			22.9
		Others										
		Beans	White, dried			0.5						
			Brown, dried			0.5						
		Legumes	Split peas							18.4		
			Lima beans					3.0		9.8		
NATS AND SEEDS	5001	Almonds	Dried	2	32.9	0.4		48.1	18.0	4.4		
	5002		Oil-roasted and salted									61.6
	5003	Hemp seeds	Dried									27.3
	5004	Perilla seeds	Dried				1.5					34.6
	5005	Cashew nuts	Oil-roasted and salted	4	15.4			14.3				19.0
	5006	Pumpkin seeds	Roasted and salted									12.9
	5008	Ginkgo nuts	Raw	58	6.0							
	5009		Boiled									2.7
	5010	(Chestnuts)	Japanese chestnuts	Raw	3	15.5						3.9
	5012			Kanroni	56	0.9						
	5013		Chinese chestnuts	Roasted	51	5.6						6.0
	5014	Walnuts	Roasted	3	15.5	19.0		17.3	37.0	2.6		
	5015	Poppy seeds	Dried									47.1
	5016	Coconut	Coconut powder	3	13.8	0.5*		0.7				[5]
	5017	Sesame seeds	Dried	4	5.3							11.7
	5018		Roasted	2	11.4			10.7				
	5019		Hulled									10.6
	5021	Watermelon seeds	Roasted and salted									9.1
	5024	Lotus seeds	Mature, dried									26.9
	5025	Water chestnuts	Raw									11.3
	5026	Pistachio nuts	Roasted and salted	8	27.4			32.0				
	5027	Sunflower seeds	Oil-roasted and salted					68.7		7.8		80.1
	5028	Brazil nuts	Oil-roasted and salted				2.0	9.2				
	5029	Hazel nuts	Oil-roasted and salted				2.0					81.8
	5030	Pecan nuts	Oil-roasted and salted						27.0	2.0		
	5031	Macadamia nuts	Roasted and salted	5	3.8		34.0					6.5
	5034	Peanuts	Dried									92.3
	5035		Roasted	2	81.0			82.0	34.0	17.5		
	5036		Oil-roasted and salted	4	81.0			91.1	39.0			95.6
	5037		Peanut butter					39				
		Others	Chestnut, raw			1.3						
VEGETABLES	6003	Asatsuki	Leaves, raw			0.4						
	6007	Asparagus	Shoots, raw	93	3.6	0.2	2.0	0.8	1.7			1.8
	6008		Shoots, boiled	93	2.0							
	6009		Canned in brine			0.2	1.7					
	6010	Kidney beans	Sayaingen	Immature pods, raw	92	4.9	0.7	7.0		1.3		3.9
	6011			Immature pods, boiled	91	4.6	0.5*					[6]
	6012	(Udo)	Udo	Stem, raw								0.5
	6015	Edamame	Raw	76	6.0							11.1
	6017		Frozen	69	4.2							9.2
	6020	(Peas)	Sayaendo	Immature pods, raw								5.1
	6022		Snap peas	Immature pods, raw	91	5.3						
	6023		Green peas	Raw			3.0	5.3	0.5	9.4		6.3
	6025			Frozen	74	2.5	0.7					6.0
	6026			Canned in brine				1.5		2.1		
	6032	Okra	Pods, raw	91	1.3					0.0		6.0
	6034	Turnip	Leaves, raw	94	1.9	0.1	2.0					2.7
	6035		Leaves, boiled	94	1.0							
	6036		Root, with skin, raw	95	1.1	0.1	0.1					
	6037		Root, with skin, boiled					0.1				
	6038		Root, without skin, raw									1.0
	6043		Pickles <i>Nukamiso-zuke</i>	Leaves	90	0.9						
	6044			Root with skin	89	1.0						
	6046	(Pumpkins and squashes)	Japanese pumpkin	Fruit, raw	77	0.9						1.7
	6048		European pumpkin	Fruit, raw	78	1.1	0.4	0.4	1.7			1.7
	6049			Fruit, boiled			0.4*					[7]
	6054	Cauliflower	Inflorescence, raw	92	10.0	1.5	1.5	7.5	17.0			8.5
	6056	<i>Kanpyo</i>	Raw	25	2.2					0.2		8.0
	6061	(Cabbages)	Cabbage	Head, raw	93	2.2	1.2	3.1	0.8	2.4		1.6
	6062			Head, boiled	96	1.6			0.2			1.2
	6064		Red cabbage	Head, raw	94	1.7	0.1	2.0	0.9			
	6065	Cucumber	Fruit, raw	95	1.9*	0.4	0.9	0.2				1.4
	6066	Cucumber Pickles	Salted pickles	94	0.4							
	6068		<i>Nukamiso-zuke</i>		94	1.5						1.2
	6069		Pickles	Sweet type			0.4					
	6070			Sour type	79	0.3	0.4					
	6072	<i>Kyona</i>	Leaves, raw									3.1
	6077	Watercress	Stems and leaves, raw	94	3.5	0.4						4.0
	6078	Arrowhead	Tuber, raw	66	10.9							7.2
	6080	Kale	Leaves, raw			36.0	0.5					4.0
	6084	Edible burdock	Root, raw	81	2.2							1.3
	6085		Root, boiled	90	0.9							
	6086	<i>Komatsuna</i>	Leaves, raw	95	1.1							2.9
	6087		Leaves, boiled	96	0.6							
	6093	Sweet peppers	Fruit, raw	92	2.7							4.2
	6094		Fruit, sauted									3.7
	6095	Perilla	Leaves, raw	90	2.7							5.1
	6099	Garland chrysanthemum	Leaves, raw	95	1.3							3.5
	6100		Leaves, boiled	96	1.2							

[5] ; raw, [6] ; canned, [7] ; canned

(Continued on page 115)

11074		Plank or short plate	Lean and fat, raw	59	1.2								
11075		Inside round	Lean and fat, raw	67	1.6			4.6		2.6			
11082		Rump	Lean and fat, raw					3.8					
11085		Fillet	Lean, raw	64	1.4			4.6					
11086	[Veals]	Rib loin	Without subcutaneous fat, raw							2.0			
11089	[Ground meat]		Raw	61	0.6								
11090	[Offals]	Tongue	Raw	38	0.9	2.0	3.3						
11091		Heart	Raw			2.0	7.3						
11092		Liver	Raw	71	61.2	33.0	100.0			96.0	41.6*	76.1	[32]
11093		Kidney	Raw	80	56.4	24.0	58.0					89.6	
11096		Omasum	Raw	84	3.5								
11097		Abomasum	Boiled	66	0.5								
11098		Small intestine	Raw	31	0.7								
11099		Large intestine	Raw	81	1.0								
11101		Sinew	Boiled	53	0.6			3.0					
11103		Tail	Raw	74	0.3								
11104	[Beef products]		Roast beef			1.2*			3.0				[33]
11105			Corned beef, canned	65	1.7			2.0					
11106			Canned with seasonig	72	1.4								
11107			Beefjerky	36	0.7								
11109	Horse		Meat, lean, raw					2.6					1.1
11110	Whale		Meat, lean, raw										1.6
11119	Swine [Porks, large type breeds]	Boston butt	Lean and fat, raw	66	6.7								
11123		Loin	Lean and fat, raw	66	1.5	2.6				5.2		3.7	
11124			Lean and fat, baked	49	0.6							5.2	
11125			Lean and fat, boiled	55	0.3							4.3	
11126			Without subcutaneous fat, raw				2.6						
11127			Lean, raw				2.6					3.0	
11128			Fat, raw									6.9	
11129		Belly	Lean and fat, raw	63	2.2	2.6			4.0				
11130		Inside ham	Lean and fat, raw	67	1.7	2.6							
11134			Lean, raw			2.6							
11151	[Porks, medium type breeds]	Loin	Lean, raw									3.6	
11152			Fat, raw									7.1	
11163	[Ground meat]		Raw	67	1.7								
11164	[Offals]	Tongue	Raw			2.0							
11165		Heart	Raw			18.2	4.0						
11166		Liver	Raw	69	54.5	44.0	27.0	100.0	100.0			79.6	
11167		Kidney	Raw			32.0						99.5	
11172		Feet	Boiled	69	1.6	2.6	5.1						
11175	[Hams]		Boneless	74	4.1	2.6			5.0	5.0			
11176			Loin	70	2.8	2.6							
11180			Chopped				5.5				4.5		
11181		Uncooked ham	Fresh	60	2.6								
11183	[Bacon]	Bacon		56	6.5	14.0			7.0	7.6			
11186	[Sausages]	Vienna		49	1.7				3.0				
11187		Semi-dry		23	9.0*	3.7							[34]
11188		Dry				3.0*							[35]
11189		Frankfurter		47	0.9	5.2							
11190		Bologna		58	3.5				3.0				
11194		Fresh sausage				3.7							
11198	[Others]		Gelatin	15	0.0								
11200	Sheep [Muttons]	Leg	Lean and fat, raw			1.0							
11201	[Lambs]	Shoulder	Lean and fat, raw			1.0							
11202		Loin	Lean and fat, raw			1.0						2.0	
11203		Leg	Lean and fat, raw			1.0	6.0			5.9			
11205	<POULTRIES> <i>Aigamo</i>		Meat, with skin, raw			6.0							
11206	Duck, domesticated		Meat, with skin, raw									4.9	
11210	Turkey		Meat, without skin, raw			2.0					0.7*		[36]
11213	Chicken [Fowl meats]	Breast	With skin, raw	62	0.3		2.0	10.0	11.3				
11218	[Broiler meats]	Wing	With skin, raw	66	2.6								
11221		Thigh	With skin, raw	51	2.9*	2.0			10.1			3.5	[37]
11222			With skin, baked									5.1	
11223			With skin, boiled									4.4	
11224			Without skin, raw									3.6	
11227		<i>Sasami</i>	Raw	75	5.5							3.0	
11230	[Ground meat]		Raw	70	0.9								
11231	[Offals]	Heart	Raw	80	3.5								
11232		Liver	Raw	74	227.4	210.0				187.2*		232.4	[38]
11233		Gizzard	Raw	80	4.3	1.0							
11235		Skin	Thigh, raw									2.9	
11236		Cartilage bone	Raw	47	1.5								
	Others	Hare	Raw			0.1							
		Beef	Steak						3.0				
		Ox	Brain					6.1					
			Lungs					5.9					[39]
			Spleen					5.7					
		Calf (Veal)	Brain					6.1					
			Lungs					5.9					
			Tongue, raw			3.3	3.3						
			Heart, raw			7.3	7.3						
			Liver, raw			39.0	75.0						
			Kidney, raw			24.0	80.0						
		Pork	Collar with rind, raw			2.6							
			Tenderloin, trimmed, raw			2.6							
			Ham, cured, canned			2.6							
			Collar, defatted, raw			2.6	5.0						
			Muscles only										
		Mutton	Brisket				2.0						
		Lambs	Liver				130.0						[40]
			Chops						3.0				
			Sweatbread, raw			3.0							

[32] ; cooked, [33] ; sliced, [34] ; kalpas, [35] ; salami, [36] ; cooked, [37] ; free biotin: 23.4%, [38] ; cooked, [39] ; Lights, [40] ; Sheep's liver

(Continued on page 120)

17023		<i>Niboshi</i> extract	100	0.1						
17027		Consomme, cubes	1	1.1						0.5
17028		Seasoning mix, granule								3.8
17029		<i>Mentsuyu</i> Straight	89	0.9						
17034	(Tomato processed goods)	Puree	94	5.0	1.5					8.9
17036		Ketchup	65	4.0	1.5		1.8		0.1	5.9
17039	(Dressings)	Japanese style dressing	62	2.7						
17041		Thousand Island dressing	42	1.1						
17042		Mayonnaise								
17043		Whole egg type	17	0.5 ^a	12.0				0.2	3.8
17044	(Miso)	Egg yolk type								7.3
17045		Rice-koji miso								5.4
17046		Sweet type	42	20.4 ^b						11.9
17047		Light yellow type								13.7
17048		Dark yellow type								8.4
17049		Barley-koji miso	35	7.7						16.8
17050		Soybean-koji miso								
17051	(Roux)	Instant miso								
17052		Powdered type	13	4.5						
17053	(Others)	Paste type	63	4.9						
17054		Curry roux	3	2.8						
17055		<i>Sakekasu</i>	56	6.5						
17056		<i>Mirinfu-chomiryo</i>	51	0.0						
17057	<SPICES>	Mustard								158.1
17058		Powder								
17059		Paste	30	23.9						24.7
17060		Prepared mustard								22.5
17061		Grain mustard	67	16.4						27.8
17062		Curry powder	7	30.7						19.5
17063		Pepper								4.7
17064		Black, ground	12	3.0						15.0
17065		White, ground								27.1
17066		Mixed, ground								1.4
17067		Japanese pepper	13	9.5						9.6
17068		Cinnamon	8	4.4						0.3
17069		Ginger								49.1
17070		Dried, ground								3.5
17071		Paste	84	0.7						1.0
17072		Red pepper	7	48.6						61.5
17073		Garlic								23.5
17074		Garlic powder								38.7
17075		Paste	64	0.9						23.6
17076		Basil								
17077		Ground								
17078		Parsley								
17079		Dried								
17080		Paprika								
17081		Ground								
17082	<OTHERS>	<i>Wasabi</i>								
17083		Powder, mixed with mustard powder								
17084		Paste	36	3.3						
17085		Yeast				60.0	33.0		20.2	
17086		Baker's yeast, compressed								
17087		Baker's yeast, dried	6	88.2	200.0					309.7
17088	Others	Miscellaneous								
17089	Others	Yeast, brewer's				115.0		200.0		
17090	OTHERS	Royaljelly	4	460.1				410.0		

(): Type category.

[] : Middle category.

< > : Sub category in fishes and shellfishes, meats, milks, beverages, seasonings and spices.

Others: Not described foods in the Standard Tables of Food Composition in Japan.

Italic: Japanese food name (no name in English).

[] : in Notes points at Biotin contents with the asterisk (*).

a : average of two products.

b : average of three products.

c : percentage of free biotin to total biotin (free and protein-bound biotin).

¹⁾ %.

²⁾ µg/100g per food.

³⁾ The present study (Himeji study).

⁴⁾ The Danish Food Composition Databank is on the Web - Now revision 6.0 (2007)²⁰.

⁵⁾ Food Composition and Nutrition Tables 6th revised and completed edition (2000)²¹.

⁶⁾ Hoppner K et al. (1978; 1983; 1989; 1992; 1994)²³⁻²⁷.

⁷⁾ Hardinge MG and Crooks H (1961)²⁸.

⁸⁾ Staggs CG et al. (2004)²⁹.

⁹⁾ Standard Tables of Food Composition in Japan¹⁸.

Food groups			Average content of biotin ¹	Biotin intake ²								
Large category (18 food group)	Middle category (33 food group)	Small category (98 food group)		Males				Females				
				1-2 ³	8-9	10-11	18-29	1-2	8-9	10-11	18-29	
Beverages	Alcoholic beverages	Others	0.4	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	
		Other beverages	0.4	0.1	0.3	0.4	1.0	0.2	0.4	0.4	1.1	
	Others	Coffes and cocoas	2.1	0.0	0.1	0.2	1.9	0.0	0.1	0.2	1.5	
		Others	0.2	0.2	0.3	0.3	0.4	0.2	0.3	0.3	0.2	
Seasonings and Spices	Seasonings	Sauces	5.7	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	
		<i>Syovu</i> ⁴	12.7	0.6	1.3	1.3	1.7	0.7	1.3	1.4	1.5	
		Edible salts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
		Mayonnaise	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
		Miso	9.4	0.5	0.9	1.0	0.9	0.4	0.8	0.9	0.8	
		Others	1.5	0.4	0.6	0.7	1.2	0.4	0.7	0.7	0.8	
		Spices	Spices and others	20.9	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1
			Total amount (biotin intake ¹⁰)	—	25.0	47.0	48.9	50.1	24.4	42.5	45.5	41.8

Itaric: Japanese food name (no name in English).

¹Determined in this study (Himeji study). µg/100g per food.

²Multiplied "average content of biotin" by "food intake" in the 98 food group in the National Health and Nutrition Survey in Japan (2012). µg/day.

³Age: years.

⁴Fried thin slices of pressed tofu.

⁵Japanese radishes.

⁶Pickled with rice bran and salt.

⁷Salted and semi-dried split.

⁸Simmered in soy sauce and suger.

⁹Soy sauce.

¹⁰µg/day.

of biotin is not set as of yet in either country, because evidence concerning the dietary intake of biotin is not complete, and some optimized parameters to evaluate the state of biotin deficiency are not defined and established. As almost all foods analyzed in Himeji study are fresh and raw, the amount of cooking loss and the destroy of biotin by processing with a food processor remain unclear. More studies on the bioavailability of biotin in the gastrointestinal tract will be needed.

5. Conclusion

The "Biotin content table" covers most common foods served in Japanese meals. To summarize Himeji study and the previous studies the intake of biotin was estimated to be 50 µg/day for adults in Japan. This biotin content table might be useful as a database for the estimation of the dietary intake of biotin from meals.

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References

1. Zempleni J, Wijeratne SSK, Kuroishi T: Biotin, Present Knowledge in Nutrition, 10th ed. 359-374, International Life Sciences Institute, Washington DC, USA, (2012)
2. Mock DM: Biotin. Edited by Rucker RB: Handbook of Vitamins, 397-426, Marcel Dekker, New York, NY, USA, (2001)
3. Watanabe T: Teratogenic effects of biotin deficiency in mice. J Nutr, 113: 574-581, 1983.
4. Watanabe T: Dietary biotin deficiency affects reproductive function and prenatal development in hamsters. J Nutr, 123: 2101-2108, 1993.
5. Watanabe T, Oguchi M, Ebara S, Fukui T: Measurement of 3-hydroxyisovaleric acid in urine of biotin-deficient infants and mice by HPLC. J Nutr, 135: 615-618, 2005.
6. Mock DM, Quirk JG, Mock NI: Marginal biotin deficiency during normal pregnancy. Am J Clin Nutr, 75: 295-299, 2002.
7. Sawamura H, Fukuwatari T, Shibata K: Effects of excess biotin administration on the growth and urinary excretion of water-soluble vitamins in young rats. Biosci Biotechnol Biochem, 71: 2977-2984, 2007.
8. Sawamura H, Ikeda C, Shimada R, Yoshii Y, Watanabe T: Dietary intake of high-dose biotin inhibits spermatogenesis in young rats. Cogenit Anom (Kyoto), 54: 2014.
9. Watanabe T, Masaki T, Yuasa M, Morimoto M,

- Sawamura H: Estimate of the dietary intake of biotin in infants prescribed special therapeutic infant formulas in Japan. *Int J Anal Bio-Sci*, 1: 60-70, 2013.
10. Watanabe T, Yonekubo A, Kuwata T, Yamaguchi S, Kobayashi A, Yoshida I, Okano Y, Ohura T, Ohwada M, Matsuda I, Tada K, Oura T, Aoki K, Kitagawa T, Fukui T: Nutritional state of biotin in infants fed formulas and maternal milk[Jnp]. *Vitamins (Japan) (Bitamin)*, 79: 445-452, 2005.
 11. Watanabe T, Fukui T: Low biotin content of infant formulas made in Japan. *Food Add Contam*, 15: 619-625, 1998.
 12. Ministry of Health, Labour, and Welfare, Japan: Recommended Dietary Allowances for Japanese 6th Revision -2000-[Jpn]. Tokyo, Japan, (1999)
 13. Ministry of Health, Labour, and Welfare, Japan: Dietary Reference Intakes for Japanese -2010-[Jpn]. Tokyo, Japan, (2009)
 14. Ministry of Education, Culture, Sports, Science and Technology, Japan: Standard Tables of Food Composition in Japan, Fifth Revised and Enlarged Edition. Reports of the Subdivision on Resources, The Council for Science and Technology. Tokyo, Japan, (2005)
 15. Taniguchi A, Oogushi M, Takechi R, Watanebe T: Biotin content of foods in Japan[Jpn]. *J Jpn Soc Nutr Food Sci (Nihon Eiyo Shokuryo Gakkaishi)*, 58: 185-198, 2005.
 16. Taniguchi A, Takechi R, Fukushima A, Watanabe T: Biotin content of typical foods in Japan[Jpn]. *J Jpn Soc Nutr Food Sci (Nihon Eiyo Shokuryo Gakkaishi)*, 61: 27-37, 2008.
 17. Kioka M, Watanabe T: Nutritional characteristics of biotin collected in the Standard Tables of Food Composition in Japan in 2010[Jpn]. *Vitamins (Japan) (Bitamin)*, 86: 562-568, 2012.
 18. Ministry of Education, Culture, Sports, Science and Technology: Food Composition Database. <http://fooddb.mext.go.jp/>
 19. Fukui T, Inuma K, Oizumi J, Izumi Y: Agar plate method using *Lactobacillus plantarum* for biotin determination in serum and urine. *J Nutr Sci Vitaminol* 40: 491-498, 1994.
 20. The Danish Food Composition Data Book is on the Web. Revision 6.0, URL: <http://www.dfvf.dk/> [February 23, 2007].
 21. Scherz H, Senser F: Souci · Fachmann · Kraut Food Composition and Nutrition Tables, 6th revised and completed edition, CRC Press Book, Boca Raton, FL, USA (2000)
 22. Kirchhoff E: Souci Fachmann · Kraut Food Composition and Nutrition Tables, 7th revised and completed edition, CRC Press Book, Taylor and Francis Group, Boca Raton, FL, USA, (2008)
 23. Hoppner K, Lampi B, Smith DC: An appraisal of the daily intakes of vitamin B₁₂, pantothenic acid and biotin from a composite Canadian diet. *Can Inst Food Sci Technol J*, 11: 71-74, 1978.
 24. Hoppner K, Lampi B: The biotin content of breakfast cereals. *Nut Rep Internat*, 28: 793- 797, 1983.
 25. Hoppner K, Lampi B: Total folate, pantothenic acid and biotin in some fish products. *Can Inst Food Sci Technol J*, 22: 170-172, 1989.
 26. Hoppner K, Lampi B: Biotin content of cheese products. *Food Res Internat*, 25: 41-43, 1992.
 27. Hoppner K, Lampi B, O'Grady E: Biotin content in vegetables and nuts available on the Canadian market. *Food Res Internat*, 27: 495-497, 1994.
 28. Hardinge MG, Crooks H: Lesser known vitamins in foods. *J Am Diet Assoc*, 38: 240-245, 1961.
 29. Staggs CG, Sealey WM, McCabe BJ, Teague AM, Mock DM: Determination of the biotin content of select foods using accurate and sensitive HPLC/avidin binding. *J Food Compos Anal*, 17: 767-776, 2004.
 30. Watanabe T, Taniguchi A: Estimation of dietary intake of biotin from the Japanese diet[Jpn]. *Vitamins (Japan) (Bitamin)*, 83: 461-468, 2009.
 31. Watanabe T, Fukushima A, Matsumoto K, Sawamura H, Mizohata H: Estimated daily intake of biotin in hospital meals in Japan through dietary surveillance. *Trace Nutr Res*, 30: 64-73, 2013.
 32. Ministry of Health, Labour, and Welfare, Japan: The National Health and Nutrition Survey in Japan, 2012 [Jpn]. Tokyo, Japan, (2014).
 33. Watanabe T, Taniguchi A: Study on the estimate of dietary intake of biotin by total diet study[Jpn]. *J Jpn Soc Clin Nutr (Nippon Rinsho Eiyo Gakkaishi)*, 27: 304-312, 2006.
 34. Murphy SP, Calloway DH: Nutrient intakes of women in NHANES II , emphasizing trace minerals, fiber, and phytate. *J Am Diet Assoc*, 86: 1366-1372, 1986.
 35. Institute of Medicine: Biotin. In. Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B₆, Folate, Vitamin B₁₂, Pantothenic Acid, Biotin, and Choline. 374-389. National Academy Press, Washington, DC, USA, (1998)