Original Article

Establishment of an isoflavone database for usual Korean foods and evaluation of isoflavone intake among Korean children

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Asian populations including Koreans are assumed to have a higher isoflavone intake due to the higher consumption of soybean. However, it is difficult to estimate isoflavone intake because there is no isoflavone database in Korea. In this study, an isoflavone database was established with systematic review. Literature with analytical values of Korean soybeans and its products were collected and evaluated to establish an isoflavone database. A total of 142 food items containing isoflavones were selected among 2,932 food items in the Korean Nutrient Database. Among these, only 25 food items were evaluated with analytical values and the remaining 98 items were replaced with adaptations or calculations from similar items. Dietary intake of isoflavones was assessed for 426 boys and 365 girls aged 8 to 11 years with 3-day food records. The daily mean isoflavone intake was 8.3 mg among boys and 7.2 mg among girls. More than 70% of subjects had a daily isoflavone intake below 10 mg. The most contributory food item to the isoflavone intake among adolescents was tofu in quantity and soybean sauce in frequency. This database could be used to estimate isoflavone intakes from dietary data among various populations and to evaluate the relationships between isoflavone intake and chronic disease.

Key Words: isoflavone database, isoflavone intake, evaluation, children, Korea

Introduction

Recently more attention has been paid to isoflavones in epidemiological and clinical studies.[1] Isoflavones, a type of flavonoids, are found mostly in soybeans. Clinical studies found that a high intake of isoflavones increase bone mineral content among middle-aged women,[2] and protect against a decline in bone density.[3] Recent studies showed that soybean products with high contents of isoflavones decrease LDL oxidation in hyperlipidemic population,[4,5] and that Asian women who have a high intake of soybeans foods had a lower risk of breast cancer,[6] indicating that isoflavone intake might have positive effects on health.

A nutrient database containing isoflavones was developed in the USA.[7] This isoflavone database was developed with careful evaluation of items and using a confidence code, which enables researchers to better understand the database and which improves its validity. Continuous updates of isoflavone databases are necessary to keep them reliable, due to the interest in new components, new skills of plant breeding, and the rapid increase of processed foods with added isoflavones.[8]

Koreans have traditionally consumed significant quantity of soybeans and their products. However, the consumption of soybean products among adolescents has decreased. According to the 1998 National Health and Nutrition Survey,[9] the average daily intake of soybeans and their products among 7-12 year old children was 23.7 g. However, a survey conducted in 2001[10] showed a decrease to 18.8 g, which would indicate a rapid decrease in isoflavone intake and concerns about the possible consequences on health.

To date there is no isoflavone database in Korea. A few studies about isoflavones have been conducted to analyze isoflavone content for a limited number of food items[11-13] and to evaluate their clinical effects. Because there is no standard database to estimate isoflavone intakes, there have been problems regarding study comparisons. In addition, most studies have been conducted among adults and only a few have been conducted among children, especially around puberty.

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The purpose of this study was to establish an isoflavone database for usual Korean foods based on a systematic review of published data and to evaluate the intake of isoflavones among Korean children.

Materials and methods

Preparation of a Korean Isoflavone Database

A total of 142 food items were selected among 2,932 food items in the Korean Nutrient Database,[14] because only those items were assumed to contain isoflavones. Since vegetables contain only small amounts of isoflavones, their isoflavone contents were assumed to be zero. The major food sources of isoflavones are soybeans and their products.[7]

The isoflavone database was jointly developed by USDA and Iowa State University in the U.S. with systematic evaluation.[7] However, there were only a few Asian food items. We reviewed all national and international articles published between January 1990 and March 2004, which analyzed the isoflavone contents of Korean foods, especially soybeans and their products. Among them 22 articles were selected which included analytical values of isoflavone contents. Although we tried to contact authors with queries, 6 articles were excluded because of insufficient information or inappropriate sampling.

Data for only the most common isoflavones, daidzein, genistein, and glycitein were evaluated using the expert systematic evaluation system that USDA also used for the establishment of the isoflavone database.[7] This evaluation system includes five general categories, namely analytical methods, analytical quality control, number of samples, sample handling, and sampling plan. Each analytical value of isoflavones in a food item from each reference was rated from 0 to 3 with specific criteria for each category. Specific details of the evaluation system were described by Mangeles et al.[15] Each analytical value of isoflavone in certain food items receives a score between 0 to 3 points for the five categories and the average points result in a 'Quality Index'. The sum of these 'Quality Indexes' of a food item, which excludes points below 1, is called the 'Quality Sum' based on which the food item is assigned a letter between A (considerable confidence) and C (less confidence) as a 'Confidence Code'. Table 1 provides an example of ratings assigned to various references for isoflavone in a Korean soymilk.

Regarding Korean soymilk we found 6 published articles and reviewed their analytical values of isoflavones with 5 categories of the expert evaluation system. The average score with 5 categories from 6 reference articles resulted in the quality index. Among the 6 references, analytic values from 3 references were below 1.0 point so they were excluded from further evaluation. Quality indexes, 1, 1.2 and 2.4 from 3 reference articles amounted to the quality sum of 4.6. If the quality sum is more than 3.4 and less than 6.0 point, the confidence code is "B". In addition, median values were selected in this study because the distribution of analytical values of isoflavone was not normal and the variance was too high. Therefore, the isoflavone content for Korean soymilk was 9.02 mg /100g with a confidence code B.

The analytical values of only 25 food items from the total of 142 food items were evaluated with confidence codes. The analytical values of isoflavones in 98 food items were unreliable or not available from reviewed literatures even though the food is assumed to contain isoflavones. The values of isoflavones in these food items were assigned either by calculation or adaptation from isoflavone values of similar food items. For 19 food items, USDA database were used.

Evaluation of Isoflavone Intake

A total of 791 subjects (426 boys and 365 girls), aged between 8 and 11 years, were recruited from two elementary schools in Seoul, Korea for this study. The 3-day food record method was used to assess the dietary intake with one day on the weekend and two weekdays. Trained staff taught subjects how to keep food records at the first visit. When dietary data were collected on the second visit after 1 week, trained staff reviewed incomplete food records. The study protocol was reviewed and approved by the Institutional Review Board of Seoul National University.

The nutrient intake was calculated based on the Korean Nutrient Database[14] and isoflavone intake was calculated with the database established in this study. The correlation between isoflavone and other nutrient intakes were analyzed. Adjusted for energy intake, isoflavone density (isoflavone intake per 1,000kcal) was calculated and correlated with other nutrients. Food items, which contribute to the isoflavone intakes, were ranked according to amount and frequency of intake.

Statistical Analysis

Statistical analysis was performed using the Statistical Analysis System (SAS version 8.01, SAS Institute, Cary, NC).

Results

Structure of the isoflavone database for usual Korean foods

The isoflavone database was established for usual Korean foods. Among 2,932 food items in Korean Nutrient Database,[14] 2,790 food items were assumed to have no isoflavone, which were assigned the estimated value of 0. Among the remaining 142 food items, only 25 food items had been evaluated with analytical values using the systematic evaluation system with which USDA has also used. The isoflavone contents of 19 food items were used from the USDA isoflavone database[7] and the isoflavone contents of 98 food items were calculated or adapted from similar food items (Table 2).

Evaluation of analytical values of isoflavone

Table 3 shows the isoflavone contents of 25 food items with confidence code from the expert evaluation system and total isoflavone contents. Only yellow soybean (dried, domestic) was assigned an 'A' confidence code, 8 food items were assigned a 'B' code and the remaining 16 fooditems were assigned a 'C'.

Table 4 shows the isoflavone contents for usual Korea foods with the moisture content and most common

Table 1. Worksheet of isoflavone contents for Soymilk with evaluation system

Description	Reference[d]	Data quality criteria ratings						Quality Index[a]	Isoflavone Value(mg/100g)			
		No. of samples		Analytic method	Sample handling	Sampling plan	Quality control		Daidzein	Genistein	Glycitein	Total Isofl.
		Actual no.	Rating									
Commercial soymilk	A[16]	2	2	0	2	2	0	0	3.65	4.33		7.98
Commercial soymilk	B[17]	2	2	0	2	2	0	0	4.16	4.31	0.36	8.83
soymilk	C[18]	1	1	1	1	0	0	0.6	3.41	5.90	0.15	9.46
Commercial soymilk	D[19]	2	2	1	1	2	0	1.2	0.65	0.47		1.12
Commercial soymilk	E[20]	3	3	2	2	3	2	2.4	42.1	45.5	3.30	87.6
soymilk	F[21]	2	2	1	1	0	1	1	4.51	7.84		12.4
Median[b]									3.91	5.12	0.36	9.02
Summary: Quality Sum=4.6 ; confidence code[c]= B ; median= 9.02												

[a]A Quality Index ≧1.0 is required for a datum to be considered acceptable; [b]The median is calculated from all values owing to lack of analytical data; [c]The Confidence Code is derived from the sum of Quality Indexes of acceptable studies; [d]References: A. Choi YB, Sohn HS; B. Kim SR, Hong HD, Kim SS; C. Kim CH, Park JS, Sohn HS, Chung CW; E. Moon BK, Jeon KS, Hwang IK; F. Kim MJ; G. Lee SK, Lee MJ, Yoon S, Kwon DJ

Table 2. Composition of Isoflavone Contents for Korean Nutrient Database

Categories		No. of food Items	Percentage (%)
Analytical values		25	0.9
Adapted values	USDA database	19	0.6
	Calculated or Adapted from similar foods	98	3.3
Assumed to have no isoflavone		2790	95.2
Total Number		2932	100

Table 3. Isoflavone contents of 25 food items from analytic data with evaluation system

Food code[a]	Food Items	Confidence code[b]	Total isoflavone content (mg/100g)
2043	Arrowroot, raw	B	220
3009	Honey, acacia	B	48.1
4002	Kidney beans, dried	C	2.5
4004	Mungbeans, dried, domestic	C	1.1
4007	Mungbean powder	C	0.1
4012	Soybeans, black soybeans	C	70.7
4013	Soybeans, SoRiTae	C	102
4014	Soybeans, yellow soybeans, dried, domestic	A	98.6
4020	Soybean curd, pressed	B	15.2
4023	Soybean curd, not pressed	B	11.5
4024	Soybean curd, soft	C	12.4
4027	Soybean milk	B	9.0
4028	Soybean milk, apple flavored	C	2.8
4029	Soybean drink (Vegemeal)	C	10.8
4034	Cowpeas, dried	C	2.4
4040	Green peas, raw	C	0.3
4048	Small red beans, gray	C	4.5
4049	Small red bean, dried	C	3.0
5015	Peanuts, roasted	C	6.4
6189	Mungbean sprout, raw	C	4.6
6292	Soybean sprout, raw	B	12.1
16002	Soy sauce, Kan Jang (Korean style)	B	0.3
16010	Ko Ch'u Jang (Korean red pepper paste)	C	7.6
16018	Soybean paste (Korean style)	B	39.2
16066	Chong Kuk Jang (Fermented soybean paste)	C	60.8

[a] Food code in the Korean Nutrient Database (Korean Nutrition Society, 2000); [b] Confidence code (A-considerable confidence, B-fairly, C-less)

isoflavones established in this study. The total isoflavone contents are the sum of daidzein, genistein and glycitein. If the food items did not contain glycitein, only daidzein and genistein contributed to the total isoflavone contents. The moisture contents of food items were obtained from the Korean Nutrient Database[14] and used when calculated to convert from dry-weight value to wet-weight value of isoflavone for food items. The type of source was classified with "A" for analytical values, "U" for adaptation from USDA database,[7] and "S" for adaptation from similar foods.

Evaluation of isoflavone intake and nutrient intake

Dietary intake of isoflavones was calculated with data from 791 elementary school students (54% boys and 46% girls). The mean age of students was 9.8 years, and did not differ significantly between genders. The average daily isoflavone intake was 8.3 mg among boys and 7.2 mg among girls in this study. Eighty-three percent of girls and 71% of boys had an isoflavone intake between 0mg to 10mg (Fig 1). More than half of all girls had an isoflavone intake between 2.5mg and 7.5mg. The intake range was 0.002-43.14 mg among girls and 1.8-40.6 mg among boys and the distribution of isoflavone intake was skewed to the left.

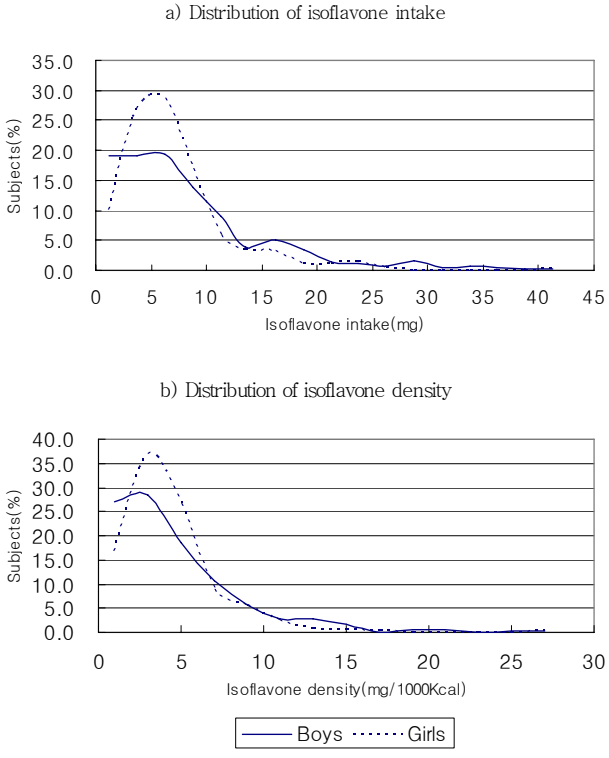

Figure 1. Distribution of isoflavone intake among Korean boys and girls aged 8 to 11

Table 4. Isoflavone contents for Korean Nutrient Database (142 food items except foods assumed no isoflavone)

Food code	Food Name	Source type	Moisture content (%)	Isoflavone content (mg/100g)			
				Daidzein	Gen-istein	Gly-citein	Total Isofl.
1063	Doughnuts, with small red bean	S	31.5	0.05	0.03	0.07	0.16
1070	Monaka	S	17.5	0.12	0.08	0.16	0.36
1139	Cracker, sandwich with peanut butter filling	S	3.1	0	0.01	0	0.02
1148	Small red bean-jam bread	S	33	0.13	0.08	0.17	0.37
1169	Chinese-style manju with small red bean	S	40.7	0.09	0.06	0.12	0.26
1228	Song Pyon (pine flavored rice cake with black soybean)	S	52.1	0.66	0.28	0	0.95
1230	Song Pyon (pine flavored rice cake with small red bean)	S	45.7	0.03	0.02	0.04	0.09
1241	In Jol Mi (rice cake with soybean flour)	S	47.4	4.86	4.84	0.8	10.5
1242	In Jol Mi (rice cake with small red bean flour)	S	49.1	0.16	0.06	0.16	0.38
1243	Shi Ru Ddok (steamed glutinous rice bread)	S	39.9	0.11	0.1	0.12	0.33
1244	Glutinous rice cake, mochi	S	42.6	0.11	0.07	0.15	0.34
1245	Kangjung with peanuts	S	3.1	0.01	0.04	0	0.05
1251	Kangjung with soybean	S	3.1	8.25	3.55	0	11.8
1257	Yookwa, Soybean	S	11.1	10.9	10.9	1.8	23.6
2043	Arrowroot, raw	A	60.3	185	34.8	0	220
3005	Honey, honey	S	20	6.1	0	42	48.1
3006	Honey, perilla	S	20.6	6.1	0	42	48.1
3007	Honey, chestnut	S	19.4	6.1	0	42	48.1
3008	Honey, bushclover	S	14.3	6.1	0	42	48.1
3009	Honey, acacia	A	19.4	6.1	0	42	48.1
3010	Honey, miscellaneous sources	S	19.3	6.1	0	42	48.1
3011	Honey, Korean honey	S	17.9	6.1	0	42	48.1
3012	Royal jelly	S	62.2	6.1	0	42	48.1
3033	Yang Gaeng (Gelatin glu with red bean)	S	28.6	0.11	0.07	0.15	0.33
4001	Kidney beans, raw	S	57.7	0.14	0.42	0.61	1.18
4002	Kidney beans, dried	A	10.3	0.3	0.9	1.3	2.5
4003	Kidney beans, boiled	S	60.9	0.12	0.35	0.5	0.97
4004	Mungbeans, dried, domestic	A	10.9	0.5	0.97	0	1.12
4005	Mungbeans, dried, China	S	67.9	0.5	0.97	0	1.12
4006	Mungbeans, boiled	S	64.3	0.19	0.37	0	0.57
4007	Mungbean powder	A	9.9	0	0.1	0	0.1
4008	Mungbean dough	S	75.6	0	0.03	0	0.03
4009	Mungbean starch noodle	S	14.6	0.15	0.29	0	0.44
4010	Mungbean starch jelly	S	90.8	0.05	0.09	0	0.14
4011	Soybean, Black soybean, Raw, dried	S	12.9	45.7	19.7	NA	65.4
4012	Soybeans, black soybeans,	A	5.9	49.4	21.3	NA	70.7
4013	Soybeans, SoRiTae	A	11.7	33	66.4	2.5	102
4014	Soybeans, yellow soybeans, dried, domestic	A	9.7	35.5	46.6	16.5	98.6
4015	Soybeans, yellow soybeans, dried, U.S.A.	U	9.5	19.9	33.4	4.63	56.8
4016	Soybeans, yellow soybeans, dried, Chinese	S	10.3	35.5	46.6	16.5	98.6
4017	Soybeans, yellow soybeans, boiled	S	61.7	13.7	18.0	6.35	38.1
4018	Soybean, Yellow soybean	S	86.3	6.61	6.55	0.87	14.0
4019	Soybeans, brown soybeans, dried	S	11.2	35.5	46.6	16.5	98.6
4020	Soybean curd, pressed	A	84.1	5.87	7.77	1.55	15.2
4021	Soybean curd, freezed	S	8.1	0.57	0.75	0.15	1.46
4022	Soybean curd, frozen, dried	S	8.1	0.57	0.75	0.15	1.46
4023	Soybean curd, not pressed	A	90.4	5.71	4.98	0.8	11.5
4024	Soybean curd, soft	A	91	5.15	6.76	0.5	12.4
4025	Soybean curd, fried	S	42.9	21.1	27.9	5.57	54.6
4026	Soybean curd, curd residue	S	82.7	8.89	11.7	4.12	24.7

Source type (A from analytic value; U from USDA database; S from adaptation of similar foods)

Table 4. Isoflavone contents for Korean Nutrient Database (continued)

Food code	Food Name	Source type	Moisture content (%)	Isoflavone content (mg/100g)			
				Daidzein	Gen-istein	Gly-citein	Total Isofl.
4027	Soybean milk	A	88.2	3.91	5.12	0.36	9.02
4028	Soy milk, Apple	A	89	2	0.62	0.7	2.78
4029	Soybean milk, drink(Vegemeal)	A	89	4.48	5.9	0.39	10.8
4030	Soybean powder, parched	U	7	99.3	98.8	16.4	199
4031	Soybean powder, defatted	U	8	57.5	71.2	7.55	131
4032	Soybean, boiled with soya sauce	S	47.1	27.2	11.7	0	39.0
4033	Cowpeas, raw	S	58.5	0.7	0	0.42	1.13
4034	Cowpeas, dried	A	11.5	1.5	0	0.9	2.4
4035	Cowpeas, boiled	S	64.8	0.58	0	0.35	0.93
4036	Lima beans, raw, immature	U	67.5	0.02	0.01	0.03	0.06
4037	Lima beans, dried, mature	S	11.9	0.05	0.03	0.08	0.16
4038	Lima beans, boiled, drained	U	71.1	0	0	0	0
4039	Green peas, raw	S	78.7	0.02	0.05	0	0.07
4040	Green peas, dried	A	13.4	0.1	0.2	0	0.3
4041	Green peas, boiled	S	79.9	0.02	0.04	0	0.06
4042	Broad beans, raw	U	68.1	0.02	0	0.03	0.05
4043	Broad beans, dried	U	13.3	0.05	0	0.08	0.14
4044	Broad beans, boiled	U	71.5	0.02	0	0.03	0.05
4045	Blank	U	70.4	0	0	0	0
4046	Soybean, immatured	U	71.5	9.27	9.84	4.29	20.5
4047	Small red beans, dark gray or black	S	14.5	0.67	0.43	0.9	3
4048	Small red beans, gray	A	10.6	2.7	1.8	0	4.5
4049	Small red bean, dried	A	13.4	0.67	0.43	0.9	3
4050	Small red beans, red, dried, Chinese	S	10.4	0.67	0.43	0.9	3
4051	Small red beans, red, boiled	S	49.5	0.26	0.17	0.35	0.77
4052	Baked beans, Canned, with pork and tomato sauce	S	72.7	0	0.46	NA	0.46
5009	Peanuts, raw	U	6.5	0.03	0.24	NA	0.26
5010	Peanuts, dried	S	7.7	0.03	0.24	NA	0.26
5011	Peanuts, dried, large size grain	S	3.9	0.03	0.24	NA	0.26
5012	Peanuts, dried, medium size grain	S	5.3	0.03	0.24	NA	0.26
5013	Peanuts, dried, small size grain	S	5.1	0.03	0.24	NA	0.26
5014	Peanut, Powder	S	2.3	2	3	1.4	6.4
5015	Peanuts, roasted	A	2.3	2	3	1.4	6.4
5016	Peanuts, boiled	S	41.9	0.02	0.14	NA	0.16
5017	Peanuts, fried and salted	U	2.4	2	3	1.4	6.4
5018	Peanut, Coating with coffee-flavor syrup	S	1.8	1.04	1.56	0.73	3.33
6069	Green peas, immature, raw	S	76.5	0.02	0.05	0	0.07
6070	Green peas, immature, boiled	S	75.7	0.02	0.04	0	0.06
6071	Green peas, immature, canned	S	78.5	0.01	0.02	0	0.03
6189	Mungbean sprout, raw	A	95.7	4.4	0.2	0	4.6
6190	Mungbean sprout , boiled	S	95.9	4.25	0.19	0	4.44
6292	Soybean sprout, Raw	A	90.7	2.49	3.36	6.23	12.1
6293	Soybean sprout , boiled	S	90.5	2.41	3.24	6.02	11.7
14008	Peanut butter	S	1.5	1.8	2.7	1.26	5.76
14009	Peanut butter, chunk style	S	1.1	1.8	2.7	1.26	5.76
14010	Peanut butter, smooth style	S	1.4	1.8	2.7	1.26	5.76
15073	Green tea, Leaves, Dried	U	7.7	0.65	5.48	NA	6.12
15074	Green tea, leaves, dried , powder	U	4.8	0.67	5.65	NA	6.32
15075	Green tea, leaves, dried , infusion	U	98.6	0.01	0.04	NA	0.05
16001	Soy sauce, shoyu (Japanese style)	U	71.6	0.93	0.82	0.45	1.64
16002	Soy sauce, Kan Jang (Korean style)	A	70.4	0.05	0.25	0	0.3
16003	Soy sauce, chukyum soy sauce	S	74.4	0.05	0.25	0	0.3
16010	Ko Ch'u Jang (Fermented 5% red pepper soybean paste)	A	38.5	3.63	3.54	0.47	7.64
16011	Ko Ch'u Jang, modified soybean paste powder with red pepper	S	4.4	5.64	5.5	0.72	11.9
16013	Soybean products, Natto	U	55	21.9	29.0	8.17	58.9

Source type (A from analytic value; U from USDA database; S from adaptation of similar foods)

Table 4. Isoflavone contents for Korean Nutrient Database (continued)

Food code	Food Name	Source type	Moisture content(%)	Isoflavone content (mg/100g)			
				Daidzein	Genistein	Glycitein	Total Isofl.
16017	Soybean paste, powdered, soybean paste, with salt 23%	S	8.2	27.8	36.1	8.44	72.31
16018	Soybean paste, soybean paste	A	50.2	15.1	19.6	4.58	39.2
16019	Soybean paste, soybean paste with barley	S	54.5	13.8	17.9	4.18	35.8
16020	Soybean paste, seasoned	S	51.5	6.57	8.31	2.05	16.9
16021	Soybean paste, miso (Japanese style soybean paste)	U	44.9	16.1	24.6	2.87	42.6
16022	Soybean paste, Korean style	S	54	13.9	18.1	4.23	36.2
16064	Tcha Jang, Black noodle sauce paste type	S	47.6	14.7	18.6	4.58	37.9
16065	Black noodle sauce paste type (chun jang)	S	53.6	14.7	18.6	4.58	37.9
16066	Chong Kuk Jang (Fermented soybean)	A	56	25.6	30.1	5.1	60.8
16067	Fermented soybean powder	S	7.7	52.8	62.0	10.5	125
16068	Pepper paste with vinegar	S	0	2.1	2.04	0.27	4.41
16073	Soybean products, tempeh	U	55	17.6	24.9	2.1	43.5
16079	Mixed soybean paste with red pepper paste	S	45.6	6.74	8.76	2.05	17.6
17002	Soy sauce, Yangjo soy sauce 701, Saempyo	S	71.6	0.05	0.25	0	0.3
17003	Soysauce, Jinsoysauce GeumF3, Saempyo	S	71.6	0.05	0.25	0	0.3
17004	Soysauce, Jinsoysauce S, Saempyo	S	71.6	0.05	0.25	0	0.3
17005	Soysauce, Jinsoysauce S, Saempyo	S	71.6	0.05	0.25	0	0.3
17034	Pan-fried mungbean, frozen	S	0	0	0.02	0	0.02
17044	Soybean paste, Soybea paste, Daerim	S	50.2	15.1	19.6	4.58	39.2
17045	Soybean paste, Jjigae Soybea paste, Daerim	S	50.2	15.1	19.6	4.58	39.2
17046	Soybean curd, Uncur soybean curd, Pulmuwon	S	90.6	5.71	4.98	0.8	11.6
17047	Soybean curd, Soft soybean curd, Pulmuwon	S	90.5	5.15	6.76	0.5	12.4
17048	Soybean milk, Vegemil adult, Vegemil	S	89	6.09	8.94	NA	15.0
17049	Soybean milk, Vegemil Infant, Vegemil	S	89	4.92	7.7	NA	12.6
17051	Peanut, Honeypeanut, Woosung food	S	7.6	1.49	2.23	1.04	4.76
17052	Peanut, Nutplaza, Woosung food	S	5.6	0.9	1.35	0.63	2.88
17053	Peanut, Matpeanut, Woosung food	S	7.7	2	3	1.4	6.4
17055	Peanut, Mixnut, Woosung food	S	6.3	1.2	1.8	0.84	3.84
17055	Peanut, Mixnut, Woosung food	S	6.3	1.2	1.8	0.84	3.84
17056	Peanut, Al peanut, Woosung food	S	7.7	1.97	2.95	1.38	6.3
17058	Peanut, Coffee peanut, Woosung food	S	4.6	1.04	1.56	0.73	3.33
17170	Snack, Prawn peanut ball, Orion	S	1.5	0.6	0.9	0.42	1.92
17315	Chajang, Deluxe chajang, Daesang	S	78	1.62	2.04	0.5	4.16
17316	Chajang, Letto beef chajang, Cheiljedang	S	76.2	1.62	2.04	0.5	4.16
17317	Chajang, Letto uni chajang, Cheiljedang	S	39.5	1.62	2.04	0.5	4.16
17318	Tcha Jang, retort pouched	S	76.2	1.62	2.04	0.5	4.16
17319	Black bean paste noodle	S	54.4	0.9	1.14	0.28	2.31
17359	Caramel(peanut), Orion	S	6.8	0.27	0.41	0.19	0.86

Source type (A from analytic value; U from USDA database; S from adaptation of similar foods)

Figure 1(b) shows that the isoflavone density is below 6mg/1000kcal among 74% of girls and among 81% of boys. Boys had a higher isoflavone intake, but the isoflavone density was higher among girls. The distribution of isoflavone density was also skewed to the left.

The correlation between isoflavone density and other nutrients are presented in Table 5. Among boys, calcium, phosphorous, sodium, folate and vitamin E had a significantly positive correlation with isoflavone density, and fat, vitamin B_1, vitamin B_2 and retinol had a significantly negative correlation. Among girls, protein, calcium, phosphorous, iron, sodium, vitamin C and folate had positive correlation and fat had significantly negative correlations with isoflavone density.

Table 6 presents the 10 major food items that contributed to the isoflavone intake by amount and frequency of consumption. Tofu (soybean curd) was the main food item, which contributed to the isoflavone intake in amount among girls and boys. Soybean sauce and red pepper paste were the highest in frequency, and are also two of the most frequently used seasonings by Koreans. There was no difference in food sources for isoflavone intake between boys and girls.

Discussion

The isoflavone database for usual Korean foods was established and used to estimate isoflavone intake for Korean adolescents. Because Korean Nutrient Database does not contain isoflavone contents, previous studies among Koreans were not able to assess isoflavone intakes.

In this study the isoflavone database was established using the critical evaluation system, which was also used to establish the USDA-isoflavone database[7]. From available published articles the analytical values of isoflavone

Table 5. Correlation coefficients between isoflavone density and the density of other nutrients

Nutrients (/1000Kcal)	Boys (n=426)	Girls (n=365)	Total (n=791)
Protein (g)	0.05	0.14 **	0.07 *
Fat (g)	-0.10 *	-0.14 **	-0.12 ***
Carbohydrate (g)	0.02	0.06	0.04
Calcium (mg)	0.15 **	0.23 ***	0.18 ***
Phosphorus (mg)	0.18 ***	0.20 ***	0.19 ***
Iron (mg)	-0.01	0.12 *	0.02
Potassium (mg)	0.12	0.29 ***	0.19 ***
Vitamin A (R.E.)	-0.05	0.06	0.00
Sodium (mg)	0.14 **	0.21 ***	0.17 ***
Vitamin B_1 (mg)	-0.10 *	0.00	-0.06
Vitamin B_2 (mg)	-0.15 **	-0.02	-0.10 **
Niacin (mg)	-0.03	0.06	0.01
Vitamin C (mg)	0.07	0.22 ***	0.13 ***
Zinc (ug)	0.01	0.08	0.04
Folate (ug)	0.10 *	0.19 ***	0.14 ***
Cholesterol(mg)	-0.04	-0.12 *	-0.08 *

The correlation coefficient was significant ($^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$).

Table 6. Contribution of food items to the isoflavone intake by quantity and frequency

Rank	Boys		Girls	
	In quantity	In rank	In quantity	In rank
1	Soybean curd	Soy sauce	Soybean curd	Soy sauce
2	Black soybean	Red pepper paste	Soybean paste	Red pepper paste
3	Soybean paste	Soybean curd	Black soybeans	Soybean paste
4	Soybean sprout	Soybean paste	Soybean sprout	Soybean curd
5	Black noodle sauce	Black soybeans	Soybean milk	Mungbean sprout
6	Soybean milk	Soybean sprout	Red pepper paste	Black soybeans
7	Red pepper paste	Mungbean sprout	Black noodle sauce	Soybean sprout
8	Fermented soybean	Peanuts	Mungbean sprout	Peanuts
9	Mungbean sprout	Green peas	Rice cake with soybean flour	Green peas
10	Rice cake with soybean flour	Kidney beans	Honey	Kidney beans

from 25 Korean food items were reviewed. Even though isoflavone contents for each food item presented in this study are the best estimates, there are limitation and considerations. Only one item among the 25 food items (4%) had an "A" confidence code and it was quite low compared to 9% of foods in carotenoids[15] and 25% in selenium[16] and 9% in copper[17] database that had confidence codes of "A" with same evaluation system. One reason that this study had a low percent of foods with "A" confidence code was the difficulty to evaluate one of the five categories of the evaluation system, namely analytical method. Isoflavone exists in glucoside forms in food and is converted to the free form (aglycone) for absorption by the body.[24] To analyze isoflavone contents, isoflavone glycoside in foods are broken down to aglycone by acidic hydrolysis, and loss occurs. Few articles were found to suggest an explanation for how to correct the loss due to breakdown, or how to assess the recovery rate. TheUSDA[7] faced similar difficulties, while reviewing and evaluating articles when they established the isoflavone database. As a result, many food items received 0 points for the evaluation category 'analytical method', so that these food items were assigned a confidence code 'C'.

In addition, several calculations were performed with published data to establish the isoflavone database in this study. If analytical values of isoflavone were presented as glycoside forms in published articles, we converted the values for glycoside forms into aglycone forms by using appropriate ratios of molecular weights regarding respective common isoflavones. If analytical values of isoflavone were presented on a dry weight basis, we converted the values to wet weight basis either by using given moisture contents or by obtaining the moisture contents from the Korean Nutrition Database.[14]

Another consideration was that the variety, the crop year, and the location affect the isoflavone contents of the soybeans[25] and these factors contribute to the large vari ability in the isoflavone contents of soybeans and their

products. Choi and colleagues[26] reported that the total isoflavone contents varied greatly in the range of 45-230mg/100g for Korean soybeans with different type of seeds. Various soybeans come out throughout the market in Korea. In this study, four varieties of soybeans were collected that contributed 97% of total soybeans supplied in Korea during the year of 2001-2003.[27] The type of soybean as well as the product amounts was considered when calculating the isoflavone contents in this study. This resulted in the isoflavone content for yellow soybean of, 98.6mg/100g, which is different from the amount for Korean soybean in USDA database (144.99mg/100g), because the USDA reviewed only one reference article.[7]

When starting to review the analytical values for foods, we did not aggregate similar foods because we wanted to insert the isoflavone contents into the Korean Nutrient Database,[14] and thus we used the food item from the Korean Nutrient Database. Although an isoflavone database has been completed with a small data set, this is the first isoflavone database for usual Korean food items. It provides an important data to study isoflavone and its health effects.

We evaluated the isoflavone intake among Korean children and it was lower than that of Korean middle-aged women (24mg) and menopausal women (27mg).[11,28] Other studies conducted among Asian populations with a high intake of soybeans, such as Chinese or Japanese women reported between 15 to 40 mg of isoflavone intake, which is higher than the results of this study.[29-31] However, studies conducted among Caucasian middle-aged women showed an isoflavone intake of 0.2-5mg, which is lower than results of this study.[32-35] African American women aged 42 to 52 had lower isoflavone intakes than Caucasians, Chinese and Japanese.[36] These data show that the isoflavone intake differs by ethnicity, and most isoflavone studies were conducted for adults, especially women around menopause.

According to the 2001 Korean National Health and Nutrition Survey,[10] intake from soy and its products was 19g/day for 7-12 year old adolescents compared to about 35g for adults above 30. Among studies conducted for Koreans, isoflavone intakes were 17mg/day for college women, compared to 24mg for middle-aged women.[28,37] There were no available data for children and adolescents except our data (7-8mg for 8-11 years old). These data support that isoflavone intake is different between age groups, and that children have lower isoflavone intake than adults.

In this study, 71% of boys and 83% of girls had an isoflavone intake below 10mg. More than half of all girls had isoflavone intakes between 2.5 and 7.5mg. The range of intake was 0.002mg to 43mg among girls and 1.8 to 41mg among boys, which is narrower than a study among Korean middle-aged women with a range of 0 to 144mg,[11] and is similar to Chinese women (aged 19 to 86) with a range between 5 to 33mg.[31] In this study, distribution of isoflavone intake was skewed to the left with a similar shape than other studies.[11, 31]

In summary, 142 food items containing isoflavone were selected from the Korean Nutrient Database.[14] Only 25 food items were evaluated with the analytical values using the critical evaluation process. The isoflavone intake for Korean children aged 8 to 11 was lower than that of Asian adults and higher than that of Caucasian adults. Isoflavone intakes differ between age groups and ethnicity. This study provides the baseline data to estimate isoflavone intake and make further studies possible to estimate isoflavone intake and its health benefits.

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References

1. Messina M. Brief historical overview of isoflavone research. In: Gilani GS, Anderson JJB, eds. Phytoestrogen and health. Illinois: AOCS Press, 2002; 8-43.
2. Potter SM, Baum JM, Teng H, Stillman RJ, Shay NF, Erdman JW. Soy protein and isoflavones: Their effects on blood lipids and bone density in postmenopausal women. Am J Clin Nutr 1998; 68: 1375S-9S.
3. Alekel L, St. Germain A, Peterson CT, Hanson K, Stewart JW, Toda T. Isoflavone-rich soy protein isolate attenuates bone loss in lumbar spine of perimenopausal women. Am J Clin Nutr 2000; 729: 844-52.
4. Jenkins DJA, Kendall CWC, Vidgen E, Mehling CC. The effect on serum lipids and oxidized low-density lipoprotein of supplementing self-selected low-fat diets with soluble-fiber, soy, and vegetable protein foods. Metabolism 2000; 49: 67-72.
5. Jenkins DJA, Kendall CWC, Vidgen E, Vuksan V. Effect of soy-based breakfast cereal on blood lipids and oxidized low-density lipoprotein. Metabolism 2000; 49: 1496-1500.
6. Ferlay J, Bray F, Pisani P, Parkin DM. GLOBOCAN 2000, Cancer incidence, mortality and prevalence worldwide, Version 1.0, IARC Cancer Base No. 5. Lyon, IARC Press, 2001.
7. USDA/ISU. Documentation for the USDA-IOWA State University Isoflavone database. (Accessed at http://www.nal.usda.gov/fnic/foodcomp/Data/isoflav/isoflav.html, Oct. 2004.)
8. Paik HY, Kim KJ, Kim YO, Kim JS, Moon HK, Oh SY, Lee SY, Lee SY, Jung HJ, Dwyer J. Nutrition and health survey of Koreans. Seoul: Seoul National University Press, 1997.
9. Ministry of Health & Welfare. 1998 National Health and Nutrition Survey [in Korean], 1999.
10. Ministry of Health & Welfare. 2001 National Health & Nutrition Survey [in Korean], 2002.
11. Lee SK, Lee MJ, Yoon S, Kwon DJ. Estimated isoflavone intake from soy products in Korean middle-aged women. J Korean Soc Food Sci Nutr 2000; 29: 948 -56 [in Korean].
12. Baek SK, Sung CJ. A study of soy isoflavone supplementation effect on bone mineral density and bone metabolism markers in female college students with low bone mass. Korean J Nutr 2003; 36: 154-66 [in Korean].
13. Sung CJ, Yun ME, Lee JK, Kim MH, Lee HS. Effect of soy isoflavone supplementation and exercise on bone mineral density and urinary deoxypyridinoline in postmenopausal women. Korean J Nutr 2004; 37: 291 -301 [in Korean].
14. KNS, The Korean Nutrition Society. Recommended dietary allowances, 7th revision. Seoul: Joung-ang Press [in Korean], 2000.

15. Mangels AR, Holden JM, Beecher GR, Forman MR, Lanza E. Carotenoid content of fruits and vegetables: An evaluation of analytic data. J Am Diet Assoc 1993; 93: 284-96.
16. Choi YB, Sohn HS. Isoflavone content in Korean fermented and unfermented soybean foods. Korean J Food Sci Technol 1998; 30: 745-50.
17. Kim SR, Hong HD, Kim SS. Some properties and contents of isoflavone in soybean and soybean foods. Korean Soybean Digest 1999; 16: 35-46.
18. Kim CH, Park JS, Sohn HS, Chung CW. Determination of isoflavone, total saponin, dietary fiber, soy oligosaccharides and lecithins from commercial soy products based on the one serving size – Some bioactive compounds from commercialized soy products-. Korean J Food Sci Technol 2002; 34: 96-102.
19. Moon BK, Jeon KS, Hwang IK. Isoflavone contents in some varieties of soybean and on processing conditions. Korean J Soc Food Sci 1996; 12: 527-34.
20. Kim MJ. Quantification of isoflavones and coumestrol in Korean soy foods and estimations of their intake. Master thesis, Seoul National University, 2001.
21. Lee SK, Lee MJ, Yoon S, Kwon DJ. Estimated isoflavone intake from soy products in Korean middle-aged women. J Korean Soc Food Sci Nutr 2000; 29: 948 -56.
22. Schubert A, Holden JM, Wolf WR. Selenium content of a core group of foods based on a critical evaluation of published analytical data. J Am Diet Assoc 1987; 87: 285-96.
23. Lurie DG, Holden JM, Schubert A, Wolf WR, Miller M. The copper content of foods based on a critical evaluation of published analytical data. J Food Comp Anal 1989; 2: 298-316.
24. Murphy PA, Song T, Buseman G, Barua K. Isoflavone in soy-based infant formulas. J Agric Food Chem 1997; 45: 4635-8.
25. Wang HJ, Murphy PA. Isoflavone composition of American and Japanese soybeans in Iowa: Effects of variety, crop year, and location. J Agric Food Chem 1994; 42: 1674-7.
26. Choi JS, Kwon TW, Kim JS. Isoflavone contents in some varieties of soybean. Food and biotechnology 1996; 5: 167-9.
27. National Seed Management Office, Government Seed Supply by Year, 1995~2003. (Accessed at http://www.seed.go.kr/, Oct. 2004.)
28. Sung CJ, Choi SH, Kim MH, Park MH, Ko BS, Kim HK. A study on dietary isoflavone intake from soy foods and urinary isoflavone excretion and, menopausal symptoms in Korean women in rural areas. Korean J Community Nutrition 2000; 5: 120-9 [in Korean].
29. Kimira M, Arai Y, Shimoi K, Watanabe S. Japanese intake of flavonoids and isoflavonoids from foods. J Epidemiol 1998; 8: 168-75.
30. Liu Z, Li W, Sun J, Liu C, Zeng Q, Huang J, Yu B, Huo J. Intake of soy foods and soy isoflavones by rural adult women in China. Asia Pac J Clin Nutr 2004; 13: 204-9.
31. Mei J, Young SSC, Kung AWC. High dietary phytoestrogen intake is associated with higher bone mineral density in postmenopausal but not premenopausal women. J Clin Endocrinol Metab 2001; 86: 5217-21.
32. Clarke DB, Lloyd AS. Dietary exposure estimates of isoflavones from the 1998 UK Total Diet Study. Food Addit Contam 2004; 21: 305-16.
33. Keinan-Boker L, van Der Schouw YT, Grobbee DE, Peeters PH. Dietary phytoestrogens and breast cancer risk. Am J Clin Nutr 2004; 79: 282-8.
34. Kreijkamp-Kaspers S, Kok L, Bots ML, Grobbee DE, van der Schouw YT. Dietary phytoestrogens and vascular function in postmenopausal women: a cross-sectional study. J Hypertens 2004; 22: 1381-8.
35. Maskarinec G, Franke AA, Williams AE, Hebshi S, Oshiro C, Murphy S, Stanczyk FZ. Effects of a 2-year randomized soy intervention on sex hormone levels in premenopausal women. Cancer Epidemiol Biomarkers Prev 2004; 13: 1736-44.
36. Greendale GA, FitzGerald G, Huang MH, Sternfeld B, Gold E, Seeman T, Sherman S, Sowers M. Dietary soy isoflavone and bone mineral density: Resulting from the study of women's health across the nation. Am J Epidemiol 2002; 155: 746-54.
37. Sung CJ, Kim SY, Kim MH, Kim EY. The effect of isoflavone supplementation by soymilk on bone mineral density in underweight college women. Korean J Nutr 2003; 36: 470-5 [in Korean].

Original Article

Establishment of an isoflavone database for usual Korean foods and evaluation of isoflavone intake among Korean children

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建立韓國常用食品異黃酮資料庫並評估韓國兒童異黃酮的攝取量

緣於黃豆攝取量較高，亞洲族群包含韓國被認為有較高的異黃酮攝取。然而，在韓國因為沒有異黃酮的資料庫，所以難以評估異黃酮攝取量。本研究以系統回顧的方式建立異黃酮資料庫。收集並評估文獻中韓國黃豆及其製品的分析數值，以建立異黃酮的資料庫。從韓國營養素資料庫的 2932 個食物項目中選出 142 個含異黃酮食物。其中，只有 25 個食物項目有分析數值，剩下的 98 個項目是採用適當的數值替代或是計算自相似的項目。評估年齡在 8 至 11 歲的 426 名男孩及 365 名女孩，其三天食物記錄的異黃酮飲食攝取量。男孩每日平均異黃酮攝取量為 8.3mg，女孩為 7.2mg。超過 70％的研究對象每日異黃酮攝取量低於 10mg。青少年大部分異黃酮攝取量的主要來源為豆腐，攝取頻率較多的則為醬油。此資料庫可以依據不同族群的飲食資料，評估異黃酮的攝取量及評估異黃酮攝取量與慢性疾病之間的相關性。

關鍵字：異黃酮資料庫、異黃酮攝取量、評估、小孩、韓國。