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Estimated dietary isoflavone intake among Korean adults*

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Abstract

This study estimated the isoflavone intake level in Koreans using Food Frequency Questionnaire and analyzed related variables. The results showed that the average daily intake of isoflavone in adults was shown as 23.1 mg. The isoflavone intake level at 50 percentile was 16.9 mg (0~ 90 mg), and 10% of adults took almost 50 mg of isoflavone a day and 10% took about 5 mg a day. The major food sources for isoflavone in Koreans were in the order of soybean, soybean paste, soy milk, soybean curd (tofu), and bean sprouts; the intake was different depending on age, educational background, occupation, economic standard, and family type. The result showed higher isoflavone intake levels in the group over 30 years old and the highest isoflavone intake in subjects working in farming/fishery, followed by housemakers. According to the differences by families the families with elderly members showed 50% higher isoflavone intake than young families with friends or siblings. Depending on related ecological variables, therefore, various nutrition education programs should be developed for a variety of intakes of soybean foods, along with easy and simple cooking methods as parts of continuous research.

Key Words: Soy foods, isoflavone, daidzein, genistein, food frequency questionnaire

Introduction

Soy foods are Korean traditional foods and have been set as daily foods in the forms of not only fermentation products such as soybean sauces and pastes, but also soybean sprouts and processed foods such as soy milk and tofu, but the consumption has been gradually decreased compared to the past because of the influence of westernized dietary lives (Lee *et al.*, 1999, 2000, 2004). Recently, as a variety of functions of isoflavone contained in the soy have been uncovered, soy foods have been spotlighted in the aspects of not only chronic degenerative diseases but also the functions of soy proteins and physiologically active substances (Adlercreutz, 1997; Ho, 1999; Martin *et al.*, 1978; Messina *et al.*, 1991; Maskarinec *et al.*, 1998). An epidemiological study suggested that high intakes of soy foods in Asian people might be one of the reasons Asians had less chronic degenerative diseases and menopausal disorders than western people (Ho, 1999).

Isoflavone is a kind of phytoestrogens, also called a plant estrogen, that play roles similar to those of estrogen in mammals including humans. It has been reported that isoflavone could prevent various chronic diseases such as prostate cancer, breast cancer, cardiovascular diseases, and osteoporosis (Adlercreutz & Mazur, 1997; Sung, 1994). Isoflavones found in the soybean are mainly genistein and daidzein, which have been known to have various roles in disease prevention effects of the soybean, and there have been some trials for finding new isoflavone in soybean fermented food (Esaki *et al.*, 1998; Klaus & Brarz *et al.*, 1998). It has been reported that a Korean dietary life using lots of soybean products could reduce the incidence of prostate cancer or breast cancer, suggesting the cancer preventive possibilities of soybeans (Adlercreutz & Mazur, 1997; Harrison & Cho, 1999; Lee & Harrison, 1998; Lee *et al.*, 1999; Maskarinec *et al.*, 1998; Sung, 1994; Sung *et al.*, 2000).

To date, the database on isoflavone contents in Korean foods has been extremely lacking and thus an objective index for judging the intake level is necessary. Recently, there has been some research on the evaluation of isoflavone intakes in middle-aged women and adults in some regions, but research on soy foods and isoflavone intake levels on a national basis have not been reported yet, except for Korean adolescents in 2004 (Kim & Kwon, 2001; Lee *et al.*, 2000; Lee *et al.*, 2002; Lee *et al.*, 2004; Park *et al.*, 2002; Sung *et al.*, 2000). The isoflavone intake levels in Koreans based on the 1995 National Nutrition Survey data was estimated as 14.9 mg (Kim & Kwon, 2001) and the average daily intakes of isoflavone of adults in the Seoul region, using 6-day dietary records, were 14.4 mg in males and 21.0 mg in females (Lee *et al.*, 2002), The average isoflavone intake levels in middle-aged females, using the food frequency method, was 24.4 mg per day (Lee *et al.*, 2000). Also, the isoflavone

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intake level of adults in the Daejeon region, using the semi-quantitative food frequency method, was 39.03 mg (Park *et al.*, 2002) and the result in menopausal women in the rural area, using the 24-hour recall method, was 27.27 mg (Sung *et al.*, 2000). While in the study of isoflavone intakes in Hawaiian residents (Maskarinec, 1998), the intakes were in the order of 38.2 mg in Chinese origin, 31.3 mg in Japanese origin, 22.2 mg in native Hawaiians, 6.9 mg in Caucasians, and 5.0 mg in Philippino origin. Harrison & Cho (1999) studied the isoflavone intakes using the food frequency questionnaire in the Los Angeles region and reported that the intake was 29.33 mg in Korean- American women, 14.46 mg in Japanese-American women, and 0.419 mg in Caucasian American women.

This study was performed to evaluate the isoflavone intake levels in Korean adults and to analyze variables related to isoflavone intakes, and thus to provide useful information in preparing measures for the promotion of isoflavone intakes.

Subjects and Methods

Subjects

The study was performed with Korean adults over 20 years old and residing in a non-institutional environment. The selection of target subjects was done so as to include big city, medium-sized city, and eup/myeon area by region, and the samples were assigned by gender and age, and the sampling was done using convenience/purposive sampling.

The preliminary survey was done in 50 adults residing in Seoul during November ~ December of 2002; then the questionnaire was modified and complemented, and the main survey was performed during March ~ May of 2003. A total of 5000 survey questionnaires were distributed and 4025 (80.5%) questionnaires, excluding uncollected questionnaires and incomplete response questionnaires were used in the statistical analysis.

Questionnaires

The survey tool was a self-administered questionnaire and made of socio-demographic characteristics and soy food frequency, etc. The survey tool was developed for the soy food frequency questionnaire suggested in a previous study (Lee *et al.*, 2002) and then modified and complemented after the preliminary study.

1) Socio-demographic characteristics: Socio-demographic characteristics such as gender, age, residence, birthplace, and economic standard of the collected target subjects were investigated.

2) Soy food frequency questionnaire: The food frequency questionnaire developed by Lee *et al.* (2003) was used to rapidly evaluate the intake levels of isoflavone through the daily meal of Koreans. This survey tool was made of 14 food sources of isoflavone and constructed for answering the average intake frequency and 3 levels of one serving size, and the average intake frequency of each food was divided into 10 categories such as 'seldom eat', 'once a month', '2~3 times a month', 'once a week', 'twice a week', '3~4 times a week', '5~6 times a week', 'once a day', 'twice a day', and 'more than 3 times a day', and one serving size was divided into 3 categories referring one serving size as standard, and adding more than usual intake and less than usual intake.

Table 1. Isoflavone contents[1] in soybeans and soybean products

Food item	Isoflavone content (mg/100g)		
	Daidzein	Genistein	Isoflavone[2]
Soybean curd	3.93	5.77	9.70
Uncurdled soybean curd	3.57	3.22	6.79
Soybean curd residue	11.24	13.93	25.18
Fried soybean curd	17.83	28.00	45.83
Bean sprouts	3.81	8.42	12.23
Soybean paste	39.43	42.54	81.97
Dambuk	28.40	27.97	56.37
Miso	16.13	24.56	40.69
Seasoned soybean paste	5.47	6.14	11.61
Soybean	56.22	69.66	125.88
Soy milk	4.51	7.84	12.35
Soybean broth	4.51	7.84	12.35
Red bean	0.00	0.31	0.31
Peanut	0.03	0.24	0.27

[1] Source : Lee *et al.* (2000) and USDA-Iowa University isoflavones database (1999)
[2] Isoflavone=daidzein+genistein

Data analysis

1) Estimation of isoflavone intake

The intake of isoflavone was decided through the estimation of daily isoflavone intake by multiplying the amount of one serving size of each food and the frequency and the isoflavone content in each food from the food frequency questionnaire.

The isoflavone database used in this study is presented in Table 1.

2) Statistical analysis

The statistical analysis of data was performed using the SPSS statistical analysis program to obtain descriptive statistics for each type of data. The differences in isoflavone intake levels by socio-demographic variables were verified using t-test and one-way ANOVA, and Scheffé multiple comparison analysis was used for post hoc test. The significance level was set at $p<0.05$ for statistical significance.

Results

Socio-demographic characteristics of subjects

The gender distribution of the subjects was similar with 48% of males and 52% of females, but the age distribution showed

Table 2. Socio-demographic characteristics of the subjects

Characteristics	n (%)	Characteristics	n (%)
Gender		***Education***	
Male	1962 (48.4)	~ Middle school	175 (7.6)
Female	2093 (51.6)	High school	730 (31.6)
		College ~	1404 (60.8)
Age group		***Economic level (self-reported)***	
20-29	2225 (55.9)	Lower	84 (2.1)
30-39	729 (18.3)	Middle-lower	414 (10.3)
40-49	644 (16.2)	Middle	2869 (71.2)
≥ 50	383 (9.6)	Upper-middle	628 (15.6)
		Upper	36 (0.9)
Present residential district		***Occupation***	
Seoul	972 (24.4)	Professional worker	649 (16.5)
Kyung Gi Do	1006 (25.2)	Office worker	537 (13.6)
Kang Won Do	150 (3.8)	Service	392 (9.9)
Chung Cheung Do	182 (4.6)	Farming-Fishery	73 (1.9)
Kyung Sang Do	1393 (34.9)	Others	160 (4.1)
Jeolla Do	288 (7.2)	Student	1747 (44.3)
		Homemaker	384 (9.7)
Area of present residence		***Family type***	
Urban	3351 (85.2)	Married couple	143 (3.9)
Rural	583 (14.8)	Parents + Children	2972 (80.7)
		W/Grandparents	507 (13.8)
		Young people	61 (1.7)
Growing up area		***Birth area***	
Big city	1676 (41.7)	Urban	2501 (66.6)
Small city	1381 (34.4)	Rural	1254 (33.4)
Rural area	963 (24.0)		

55.9% of under 30 y. The residences of the subjects was in the order of 34.9% in the Yeongnam area, including Busan, Ulsan, and Daegu metropolitan cities, 25.2% in the Gyeonggi area including the metropolitan city of Incheon, 24.4% in Seoul, and other regions, including the Honam area (including Gwangju metropolitan city), the Chungcheong area (including Daejeon metropolitan city), and the Gangwon area, for a nationwide survey. Twenty four percent of the subjects were raised in the eup/myeon areas and 33.4% of subjects were born in the eup/myeon areas. The self-estimated economic standard showed 71.2% as middle class. The occupation of subjects were shown in the order of 44.3% in college or graduate students, 16.5% in professional jobs, 13.6% in administrative, managerial and office work 9.9% in sales or service areas, and 9.7% as housewives. The distribution of final academic background, except students, showed 60.8% as college graduates, suggesting that the overall educational background of the subjects were higher than the Korean average. The family type of subjects was mostly a nuclear family consisting of parents and children showing 80.7%, and the extended family type with elderly was 13.8% (Table 2).

Intake frequency for isoflavone food sources

The intake frequency for 14 isoflavone sources and foods was investigated (Table 3). Over 50% of the subjects had more than

Table 3. Frequencies of source foods of isoflavone intake in adults (%)

	Never	1/mo	2-3/mo	1/wk	2/wk	3-4/wk	5-6/wk	1/d	2/d	3/d
Soybean curd	2.6	6.9	17.5	22.0	24.1	18.0	4.3	3.4	0.9	0.2
Uncurdled soybean curd	18.7	29.0	25.2	16.8	6.8	2.3	0.6	0.4	0.1	0.1
Soybean curd residue	59.3	23.6	8.8	4.9	2.0	0.9	0.3	0.1	0.0	0.1
Fried soybean curd	28.1	33.5	21.8	9.8	4.2	1.8	0.5	0.2	0.0	0.1
Bean sprouts	2.6	9.4	22.7	25.4	22.1	13.0	3.2	1.0	0.4	0.2
Soybean paste	1.9	4.8	13.9	20.8	25.2	22.0	5.7	4.4	0.9	0.3
Dambuk	51.4	21.6	11.8	7.9	4.1	1.9	0.7	0.4	0.1	0.1
Miso	74.2	12.6	7.0	3.3	1.5	1.0	0.2	0.1	0.1	0.0
Seasoned soybean paste	11.4	20.2	27.4	18.9	11.7	7.1	2.0	1.0	0.3	0.1
Soybean	17.2	16.6	15.9	13.0	10.8	9.5	4.0	7.1	3.4	2.6
Soy milk	44.5	16.0	13.7	9.4	6.5	4.2	1.8	3.3	0.3	0.2
Soybean broth	65.0	20.7	7.2	3.7	1.7	0.9	0.4	0.3	0.0	0.1
Red bean	51.3	26.4	10.7	5.0	2.6	1.3	0.7	1.0	0.5	0.4
Peanut	33.5	31.8	16.4	8.6	4.5	2.8	1.0	1.2	0.1	0.1

Table 4. Daily intake level of isoflavone in adults (mg/day)

	Daidzein	Genistein	Isoflavone (Daidzein+Genistein)
Mean ± SE	9.9 ± 0.16	13.2 ± 0.21	23.1 ± 0.37
Minimum	0.0	0.0	0.0
5 percentile	1.4	1.9	3.3
10 percentile	2.1	2.8	4.8
25 percentile	3.9	5.3	9.2
50 percentile	7.2	9.7	16.9
75 percentile	13.1	17.5	30.5
90 percentile	20.5	27.8	48.2
95 percentile	27.1	36.6	64.5
Maximum	74.0	116.3	190.3

double of soybean paste soup/stew and soybean curd (tofu) per week, and 13.1% of subjects had more than one serving of soybeans per day.

On the other hand, isoflavone food sources not preferred were miso soup, a Japanese soybean paste soup, in 74.2% of subjects and then soybean broth (65.0%), soybean curd residue (59.3%), Dambuk (51.4%), and red bean (51.3%) of which over 50% of the subjects rarely had. Also, in the case of soy milk, 44.5% of the subjects responded as 'not preferred'.

Isoflavone intake level

1) Isoflavone intake distribution

The results showed that subjects took an average of 23.1 mg of isoflavone a day, among which the average intake of genistein was 13.2 mg and that of daidzein was 9.9 mg (Table 4). The intake of isoflavone at 50 percentile was 16.9 mg, ranging 0~190 mg, showing that the distribution of isoflavone intake in these

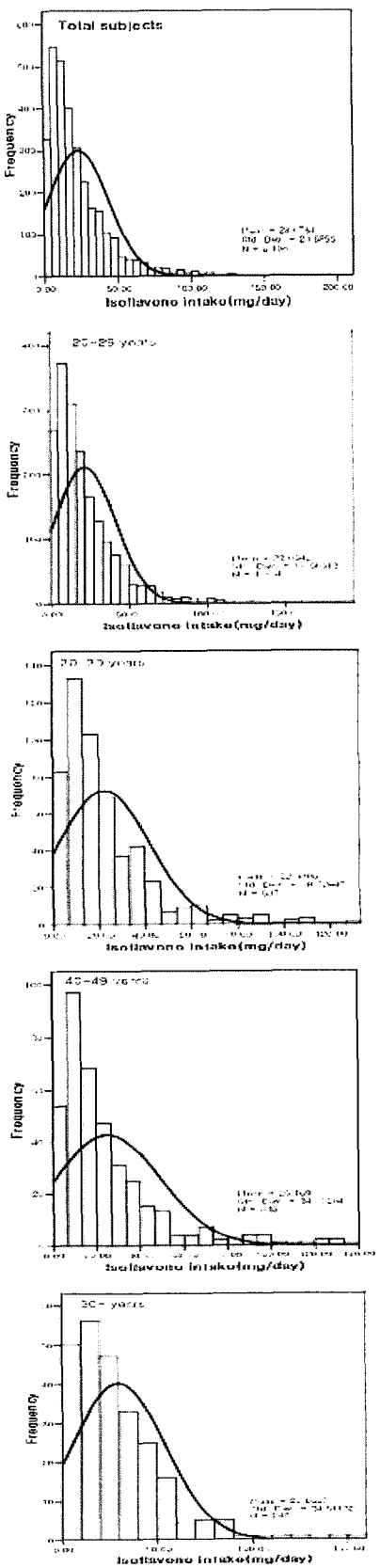

Fig. 1. The distribution of isoflavone intake by age groups

Table 5. The food sources of isoflavone intake in adults

	Daidzein		Genistein		Total	
	Mean daily intake (mg/day)	% of daidzein intake	Mean daily intake (mg/day)	% of genistein intake	Mean Daily intake (mg/day)	% of total intake
Soybean curd	0.93	9.41	1.36	10.31	2.29	9.93
Uncurdled soybean curd	0.33	3.34	0.29	2.20	0.62	2.69
Soybean curd residue	0.34	3.44	0.42	3.18	0.76	3.29
Fried soybean curd	0.34	3.44	0.54	4.09	0.88	3.81
Bean sprouts	0.65	6.58	1.43	10.84	2.08	9.02
Soybean paste	2.87	29.10	3.10	23.50	5.96	25.83
Dambuk	0.29	2.94	0.28	2.12	0.57	2.47
Miso	0.07	0.71	0.10	0.76	0.17	0.74
Seasoned soybean paste	0.07	0.71	0.07	0.53	0.14	0.61
Soybean	2.68	27.13	3.32	25.17	5.99	25.96
Soy milk	1.05	10.63	1.83	13.87	2.89	12.53
Soybean broth	0.26	2.63	0.45	3.41	0.72	3.12
Red bean	0.00	0.00	0.00	0.00	0.00	0.00
Peanut	0.00	0.00	0.00	0.00	0.00	0.00

subjects had a positive skew due to a few extremely high value: (Fig. 1). On the other hand, 10% of subjects took almost 5(mg of isoflavone a day and 10% took about 5 mg a day. Thus it is considered that using the median rather than the mean i: reasonable to estimate the isoflavone intake levels in Koreans

2) Isoflavone intake level by food sources

The intake of daidzein per day was 2.87 mg (29.10%), mainl from soybean paste, which contributed the most, and followe by soybean, soy milk, soybean curd (tofu), and bean sprouts and in case of genistein, it was in the order of soybean, soybea paste, soy milk, bean sprouts, and soybean curd (tofu). Also subjects in this study took 83% of daily isoflavone intakes fro soybean (5.99 mg), soybean paste (5.96 mg), soy milk (2.8 mg), soybean curd (tofu) (2.29 mg), and bean sprouts (2.08 mg (Table 5).

3) Differences in average isoflavone intake depending on socio-demographic variables

The intake was different depending on age, educationa background, occupation, economic standard, and family typ among socio-demographic characteristics. The age was divide into 20 s, 30 s, 40 s, and over 50 s for the analysis of difference of the average, and the result showed higher isoflavone intak levels in the group of over 30 s. The difference by occupation of subjects showed the highest average isoflavone intakes o

Table 6. Average isoflavone intake according to socio-demographic variables

Characteristics		Mean isoflavone intake (mg/day)	t-value / F-value	Prob.
Gender	Male	23.50	1.10	0.273
	Female	22.69		
Age Group	~29	22.05[a]	11.44	0.000
	30-39	22.34[a]		
	40-49	25.17[b]		
	50~	29.67[c]		
	~29	22.05	-3.47	0.001
	30~	24.82		
Present residential area	Urban	22.99	-1.56	0.119
	Rural	24.71		
Present residential District	Seoul	24.22	1.28	0.271
	Kyung gi do	23.55		
	Kang won do	20.50		
	Chung cheung do	22.55		
	Kyung sang do	22.35		
	Jealla do	24.27		
Birth area	Urban	23.02	-0.75	0.451
	Rural	23.66		
Growing up area	Big city	20.80	1.36	0.258
	Small city	19.79		
	Rural area	22.12		
Education	Middle school	28.32[b]	7.26	0.001
	High school	26.15[ab]		
	College	22.40[a]		
Occupation	Professional worker	22.75[a]	9.59	0.000
	Office worker	21.52[a]		
	Service	21.13[a]		
	Farming/Fishery	39.30[c]		
	Others	24.89[ab]		
	Student	22.22[a]		
	Homemaker	30.27[ab]		
Economic level	Lower	25.95[ab]	3.17	0.013
	Middle-lower	20.88[a]		
	Middle	22.67[ab]		
	Upper-middle	25.43[ab]		
	Upper	26.76[b]		
Family type	Married couple	23.52[b]	7.45	0.000
	Parents + Children	22.56[ab]		
	W/Grandparents	27.66[b]		
	Young people	18.43[a]		

[abc] : Different superscript letters mean significant difference among groups by Scheffé test at α=0.05.

39.30 mg/day in subjects working in the agriculture/livestock/fishery and 30.27 mg/day in housewives. According to the differences by family type, the family with elderly members showed 50% higher isoflavone intakes than the young family type with friends or siblings (Table 6). Therefore, it was analyzed that the isoflavone intake levels of Koreans were different depending on various ecological variables.

Discussion

Isoflavone intake levels of Koreans were estimated using FFQ and the average daily intakes of isoflavone in adults are shown as 23.1 mg. This was higher than 19.3 mg in Hong Kong (Mascarinec, 1998) but much lower than 150~200 mg in the Japanese traditional meal group (Cassidy, 1995). The isoflavone intake level at 50 percentile was 16.9 mg (0~190 mg), 10% of adults took almost 50 mg of isoflavone a day and 10% took about 5 mg a day. The results of the study showed that the distribution of isoflavone intakes in these subjects had positive skews due to a few extremely high values. Thus, it is considered that using the median rather than the mean is reasonable to estimate the isoflavone intake levels in Koreans.

The average daily intakes of isoflavone of adults in the Seoul region using the dietary record method were 14.4 mg in males and 21.0 mg in females, and the average isoflavone intake levels in middle-aged Korean females using the food frequency method were 24.4 mg per day (Lee *et al.*, 2000). Also, the isoflavone intake levels of adults in the Daejeon region using the semi-quantitative food frequency method were 39.03 mg (Park *et al.*, 2002). The result in menopausal women in the rural area using 24-hour recall method was 27.27 mg (Sung *et al.*, 2000) and the isoflavone intake levels in Koreans based on the 1995 National Nutrition Survey data was estimated as 14.9 mg (Kim & Kwon, 2001). Also, Ahn & Park (2003) reported that the average isoflavone intake in female college students was 33.46 mg/day. According to the survey on the estimated dietary isoflavone intake among Korean adolescents using the same FFQ by Lee, *et al.* (2004), the mean daily isoflavone intake of the subjects was 28.1 mg and the median value of isoflavone intake was 19.7 mg.

While in the study of isoflavone intake in Hawaiian residents (Maskarinec, 1998), the intakes were in the order of 38.2 mg in Chinese origin, 31.3 mg in Japanese origin, 22.2 mg in Hawaiian aborigines, 6.9 mg in Caucasians, and 5.0 mg in Philippino origin, and the isoflavone intakes in Asians of the soybean culture was about 20~100 mg.

The major food sources for isoflavone of Koreans were in the order of soybean, soybean paste, soy milk, soybean curd (tofu), and bean sprouts, and adult subjects took 83% from these. The intake was different depending on age, educational background, occupation, economic standard, and family type among socio-demographic characteristics. According to the study of Lee, *et al.* (2000), the intake frequencies of soybean foods in Korean middle-aged women showed that 81.2% of subjects ate soybean foods everyday in the order of soybean paste stew, soybean curd (tofu), and bean sprouts, and the intake distribution by soybean foods showed higher intakes for soybean paste stew as 3-4 times a week and for soybean curd (tofu) and bean sprouts as twice a week. The isoflavone intakes by frequently eating soybean foods in Korean Middle-aged women showed 10.68 mg from soybean paste stew, 3.34 mg from braised soybean, 2.44

mg from soybean curd residue, 2.42 mg from soybean curd (tofu), 2.42 mg from soy milk, 1.12 mg from Dambuk, 1.02 mg from bean sprouts, 0.29 mg from uncurdled soybean curd, and 0.33 mg from soybean broth (Lee *et al.*, 2000). Also, according to the study in adults in the Daejeon area, it was 13.01 mg from bean sprouts, 10.17 mg from soybean curd (tofu), 5.83 mg from soybean paste stew, 4.57 mg from uncurdled soybean curd, and 2.54 mg from braised soybean (Park *et al.*, 2002), showing slightly different aspects of major isoflavone food sources from those in this study.

The result showed higher isoflavone intake levels in the group over 30 s, and the differences by occupations of subjects showed the highest average isoflavone intakes in subjects working in agriculture/livestock/fishery, followed by housewives. According to the differences by family type, the family with elderly members showed 50% higher isoflavone intakes than the young family type with friends or siblings. Therefore, it was analyzed that the isoflavone intake levels of Koreans were different depending on various ecological variables and thus it is considered that educational materials for the promotion of isoflavone intake considering various ecological factors should be developed.

The results of the study are expected to be used as reference material in establishing the recommended intake level of isoflavone for Koreans, and the development of effective nutrition education programs and continuous education are required to recommend sufficient intakes of soybean foods on the basis of several physiologically active substances of soybeans, particularly preventive and treatment effects related to isoflavone, and to promote the recognition for the excellence of soybean foods as traditional foods. Also, continuous research is needed to develop simple and easy cooking methods for a variety of intakes of soybean foods, along with diversity and convenience.

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