Short Communication

Intake and major sources of dietary flavonoid in Korean adults: Korean National Health and Nutrition Examination Survey 2010-2012

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With an effort to investigate possible relationship between flavonoids and health, an accurate estimation of flavonoid intake is valuable. We estimated dietary flavonoid intake and identified the major food sources. Subjects were healthy adults aged ≥19 y (n=11,474) who completed the 24-h dietary recall of the Korean National Health and Nutritional Examination Survey (2010-2012). The US Department of Agriculture and newly estimated or published values for typical Korean foods were combined into a Korean-targeted flavonoid database. The mean intake of total flavonoid was 107±1.47 mg/d, with a higher intake in women than in men after energy-adjustment. Quercetin, cyanidin, genistein, daidzein, epigallocatechin 3-gallate, epicatechin, hesperetin, and luteolin were identified as major flavonoid compounds. Across the age range studied, flavonols and flavones showed a reversed U-shape curve; flavan-3-ol and flavanones showed a decreasing pattern; and anthocyanidins and isoflavones showed an increasing pattern. Forty-five food items were identified as contributing >2% of at least one flavonoid compound's intake. Kimchi was the major food source of total flavonoids, followed by green tea, persimmons, and soybeans. Single food items accounting for more than 50% of the intake of a specific flavonoid included persimmons (cyanidin), green tea (epigallocatechin, epicatechin-3-gallate, and epigallocatechin 3-gallate), black tea (thearubigin), tangerines (hesperetin and naringenin), and onions (isorhamnetin). This study provides information on Korean flavonoid intake to enable international comparisons, along with insight into how the sources and intake of various flavonoids vary according to age and gender. This work should facilitate future investigations of the association between flavonoid intake and health.

Key Words: flavonoid intake, major food source, adult, major food contributors, national survey

INTRODUCTION

Flavorous are not essential to life, but many studies have shown that flavonoids have a large variety of biological effects.[1] Hypotheses related to flavonoids' mechanisms of action have been tested by *in vitro* studies but still must be proven *in vivo*, specifically, in human studies. Thus, in recent years, a surge of small, short-term trials have presented the beneficial effects of specific flavonoid-rich foods, providing a basis for promoting the consumption of these foods. Considering the ubiquitous presence of flavonoids in plant-based foods, however, it should be noted that an accurate estimation of flavonoid intake in the context of total diet is valuable in confirming whether the required intakes of flavonoids for beneficial health outcomes are achievable through diet alone. The principal difficulty in estimating dietary flavonoid intake has been the incompleteness of the flavonoid food composition database.[2]

Since 2003, the US Department of Agriculture (USDA) began to develop and release a database by compiling the acceptable existing data for food flavonoids;[3] and investigators in western countries have expanded the USDA flavonoid database by adding previously published flavonoid values for foods typically consumed in those countries, allowing for inter-country comparisons of flavonoid intake. However, to the best of our knowledge, no database or descriptive study using a similar approach has been conducted in an Asian country. One study in China[4] used a database for flavonol and flavone contents that had been established by directly analyzing selected foods, and another study in Japan[5] evaluated the intake of 13 flavonoids using the Japan Functional Food Factor database.[6]

To provide a solid basis for future research on the role of flavonoids in promoting human health and quality of life in the Korean population, we previously created an integrated database by incorporating new values for foods typically consumed in Korea into the literature, recipes, calculations, and application of processing factors in the USDA database.[7] We found that this database included 95.6% of the plant-based foods widely consumed by Koreans, which were found to be in the 95th percentile of intake based on the data from the 24-h dietary recall (DR)

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in Korean National Health and Nutrition Examination Survey (KNHANES) 2008. This study aimed to estimate dietary flavonoid intake and to identify the main foods that contribute to flavonoid intake among Korean adults by matching the food intake data from the 24-h DR of KNHANES 2010-2012 with the flavonoid content database constructed for the Korean population.

METHODS

Survey design and participants

KNHANES is a series of cross-sectional and nationally representative surveys that study the health and nutritional status of the non-institutionalized Korean population, aged more than 1 y old. The sampling frame was based on the Korean Census, and household units were selected using a stratified, multistage probability sampling design. Taking into account seasonal variation, this annual survey has been conducted year-round since 2007. A single 24-h DR was collected from each participant by trained dietary interviewers of Korea Center for Disease Control and Prevention (KCDC). For the purpose of this study, we used the data from individual ages ≥19 y from KNHANES 2010-2012.[8] Among 25,534 (n=8,958 in 2010; n=8,518 in 2011; n=8,058 in 2012) individuals of all ages, we excluded 2,579 participants with extremely low (<500 kcal) or high (>4,500 kcal) energy intake; 5,935 participants <19 y according to the legal definition of adults in Korea; 247 pregnant or lactating women; 5,299 participants diagnosed as hypertension, dyslipidemia, stroke, CVD, diabetes, or cancer. Thus, the data of 11,474 participants were included in the final data set. The Research Ethics Board of the KCDC approved the use of the KNHANES data in this study.

Flavonoid database

Since a comprehensive composition dataset for flavonoid contents was not available for usual Korean foods, our research group constructed the flavonoid database mainly derived from the USDA flavonoid database. The current flavonoid content database of selected foods for the Korean population contains values for thirty individual flavonoids in six subclasses of flavonoids expressed as aglycone forms in milligrams per 100 grams of the edible portions of foods. To expand the coverage, local composition data was added following the steps reported in detail in the previous publication.[7] Briefly, 1) by using the 2008 KNHANES dataset of 8,631 subjects, 1,549 plant-based food items were selected stemming from a total of 5,015 foods; 2) to these, the respective flavonoid values were assigned from USDA flavonoid; 3) local composition data from Functional Food Factor database[6] and published literature were incorporated into the USDA flavonoid database after evaluating data quality; 4) flavonoid contents were adapted from similar food items based on species, genus, nutrients, shape, and colour; 5) flavonoid contents were calculated on dry weight basis if the moisture contents data were available from the Korean Nutrient Database; and 6) flavonoid contents for combination foods were calculated using standard recipes and a zero value was marked if appropriate. This expanded USDA flavonoid database covered 85% of the plant-based food items commonly consumed by Korean population.

Estimation of dietary flavonoid intake

Individuals' dietary flavonoid intake was estimated by matching the food consumption data from the 24-h DR portions with the aforementioned flavonoid content database.[7] Total and subclass flavonoid intakes were determined by summing individual flavonoid intake in total and by subclass, respectively. The contributions of individual intake and subclasses to the total flavonoid intake were also determined.

Determination of major dietary sources

Dietary flavonoid intakes were determined from each of the food items; then, the contributions of the top twenty food items to flavonoid intake by all of the participants were calculated by taking the ratio of the daily total and subclasses of flavonoids provided by the specific food over the intakes of total and subclass flavonoids from all foods.

Statistical analyses

All of the analyses were conducted using Statistical Analysis System software (version 9.3; SAS Institute, Cary, NC, USA) using SURVEY PROCEDURES that included STRATA, CLUSTER, and WEIGHT statements. Individual and total flavonoid intakes were calculated as both energy-unadjusted and energy-adjusted values. Energy-adjusted values were calculated by the residual method to represent the quality of diet.[9] Distributions were determined and expressed as means, medians, and 10^{th} and 90^{th} percentiles. Differences in intakes by gender were tested by Student's *t*-tests, and differences among age subgroups were tested by ANOVA. Linear regression analysis was used to determine the *p*-trends of subclass and individual flavonoid intake across age groups in each gender. Values were expressed as means±SE, and $p<0.05$ was considered significant.

RESULTS

Estimated dietary flavonoid intake

We calculated unadjusted and energy-adjusted daily intake of total flavonoid using the average intake: 107±1.47 mg/d (unadjusted) and 96.6±1.3 mg/d (energy-adjusted). The mean values were 1.5 to 20 times the median value, representing a skewed distribution with a high number of low consumers. Eighteen flavonoids (quercetin, pelargonidin, genistein, cyanidin, daidzein, kaempferol, epigallocatechin 3-gallate (EGCG), epicatechin, hesperetin, catechin, naringenin, glycitein, epigallocatechin, isorhamnetin, thearubigin, epicatechin 3-gallate, delphinidin, and luteolin) were identified as consumed at the level of more than 1% of overall intake, whereas thirteen flavonoids (myricetin, gallocatechin, malvidin, apigenin, eriodictyol, petunidin, peonidin, theaflavin, theaflavin-3-3'-digallate, theaflavin-3'-gallate, theaflavin-3-gallate, and catechin 3-gallate) were rarely consumed (Table 1). The changes of the energy-adjusted intakes of each flavonoid subclass are visualized by gender and age group (Figure 1). Overall, women had a significantly higher intake of flavonoids than did men. Total flavonoids, flavonols, and flavones showed a reversed U-shape curve; flavan-3-ols and flavanones showed a decreasing pattern; and anthocyanidins and isoflavones showed an increasing pattern across the

Table 1. Daily flavonoid intake from the Korean diet: data from 11,474 adults aged ≥19 y (KNHANES 2010-2012)

Flavonoids	Unadjusted intake				Energy-adjusted intake†			
	Mean±SE	Median	P_{10}	P_{90}	Mean±SE	Median	P_{10}	P_{90}
Total flavonoids	107±1.47	78.3	22.0	221	96.6±1.34	70.4	22.8	192
Anthocyanidins	24.3±0.76	9.95	0.00	62.4	26.4±0.90	6.36	0.00	68.1
Cyanidin	9.51±0.64	0.00	0.00	18.2	9.68±0.69	0.00	0.00	12.5
Delphinidin	0.92±0.05	0.00	0.00	2.09	0.89±0.05	0.00	0.00	1.68
Malvidin	0.20±0.03	0.00	0.00	0.00	0.20±0.03	0.00	0.00	0.00
Pelargonidin	13.5±0.32	5.98	0.00	35.9	15.4±0.49	2.98	0.00	42.2
Peonidin	0.08±0.01	0.00	0.00	0.00	0.08±0.01	0.00	0.00	0.00
Petunidin	0.08±0.01	0.00	0.00	0.00	0.08±0.01	0.00	0.00	0.00
Flavan-3-ols	21.8±0.87	1.33	0.00	49.1	25.5±1.80	1.08	0.00	43.2
(+)-Catechin	4.53±0.19	0.34	0.00	12.9	4.64±0.24	0.18	0.00	10.6
(-)-Epigallocatechin	2.31±0.11	0.13	0.00	3.91	2.59±0.19	0.12	0.00	3.50
(-)-Epicatechin	4.73±0.18	0.26	0.00	13.3	4.84±0.20	0.27	0.00	13.1
(-)-Epicatechin-3-gallate	1.56±0.09	0.00	0.00	1.49	1.59±0.11	0.00	0.00	1.17
(-)-Epigallocatechin-3-gallate	5.82±0.37	0.00	0.00	4.03	6.50±0.55	0.00	0.00	4.06
Theaflavin	0.04±0.01	0.00	0.00	0.00	0.04±0.01	0.00	0.00	0.00
Thearubigin	2.39±0.36	0.00	0.00	0.00	2.27±0.35	0.00	0.00	0.00
Theaflavin-3,3'-digallate	0.04±0.01	0.00	0.00	0.00	0.04±0.01	0.00	0.00	0.00
Theaflavin-3'-gallate	0.03±0.01	0.00	0.00	0.00	0.03±0.01	0.00	0.00	0.00
Theaflavin-3-gallate	0.03±0.01	0.00	0.00	0.00	0.03±0.01	0.00	0.00	0.00
(+)-Gallocatechin	0.29±0.01	0.00	0.00	0.67	0.34±0.03	0.00	0.00	0.41
(+)-Catechin 3-gallate	0.00±0.00	0.00	0.00	0.00	0.00±0.00	0.00	0.00	0.00
Flavanones	8.81±0.43	0.00	0.00	28.3	8.15±0.39	0.00	0.00	25.1
Eriodictyol	0.12±0.03	0.00	0.00	0.00	0.12±0.03	0.00	0.00	0.00
Hesperetin	4.84±0.25	0.00	0.00	14.5	4.40±0.21	0.00	0.00	13.6
Naringenin	3.85±0.21	0.00	0.00	11.4	3.62±0.19	0.00	0.00	10.4
Flavones	0.97±0.03	0.50	0.13	2.05	0.87±0.03	0.45	0.13	1.86
Apigenin	0.12±0.02	0.02	0.00	0.15	0.11±0.02	0.02	0.00	0.13
Luteolin	0.85±0.02	0.45	0.11	1.86	0.77±0.02	0.41	0.12	1.72
Flavonols	27.8±0.45	18.8	4.66	60.1	24.6±0.42	16.8	4.88	50.2
Isorhamnetin	1.97±0.06	0.94	0.00	4.66	2.03±0.07	0.59	0.00	4.72
Kaempferol	9.95±0.15	6.75	1.40	21.6	8.44±0.13	6.19	1.47	17.3
Myricetin	0.48±0.02	0.21	0.03	1.06	0.46±0.03	0.18	0.03	0.96
Quercetin	15.4±0.36	8.30	0.96	36.4	13.9±0.36	7.37	0.96	30.5
Isoflavones	24.3±0.43	14.1	0.26	58.6	21.9±0.39	12.1	0.27	53.9
Daidzein	9.84±0.17	5.73	0.16	23.5	8.84±0.16	4.94	0.15	21.4
Genistein	11.9±0.22	6.76	0.10	29.3	10.7±0.19	5.77	0.10	26.6
Glycitein	2.56±0.04	1.53	0.00	6.19	2.37±0.05	1.24	0.00	6.01

Values are expressed as means±SE, median, and percentile scores (unit: mg/d per capita).
†Energy adjusted values were calculated using the residual method.

age range.

Major food sources and their contribution to flavonoid intake

Of the most commonly consumed plant-based foods (353 food items) in KNHANES 2010-2012, the majority (95%) was included in the flavonoid content database. Table 2 shows the major food sources and their contribution by total, subclass, and individual flavonoids. Kimchi (traditional fermented vegetable product) was the most important food source for total flavonoid intake, followed by green tea, persimmons, soybeans, onion, tofu, radish, and tangerine. Forty-five food items were identified as contributing more than 2% of at least one flavonoid compound's intake. Single food items that accounted for more than 50% of the intake of a specific flavonoid included persimmons for cyanidin; green tea for epigallocatechin, epicatechin-3-gallate, and EGCG; black tea for thearubigin; tangerines for hesperetin and naringenin; and onions for isorhamnetin. Apples, kimchi, and pears were identified as contributors to more than three subclasses of flavonoid intake. Bananas, blueberries, grapes, hot peppers, kimchi, oranges, persimmons, radishes, spinach, and strawberries were identified as contributors to two subclasses of flavonoid intake. Within each subclass of flavonoid, every compound of the anthocyanidins, flavanones, and isoflavones had certain specific contributors of its own; however, the prominent sources of each compound in flavan-3-ols, flavonols, and isoflavones were all similar.

DISCUSSION

To the best of our knowledge, this is the only study to estimate dietary flavonoid intake and to determine the dominant food sources in Korean healthy adults ≥19 y at the levels of total, subclass, and individual compounds using an expanded flavonoid database for the Korean population and food intake data from the 24-h DR of KNHANES 2010-2012. Our results also have provided insight into how intakes of dietary flavonoids vary by age and gender. When stratified by gender after energy adjustment, flavonoid intake was significantly higher in women (109 mg/d) than in men (84.1 mg/d). A significant gender difference was also found in US[10] and Finnish adults.[11] Total flavonoids increased with ages of up to 64 years before falling noticeably. However, flavan-3-ol and

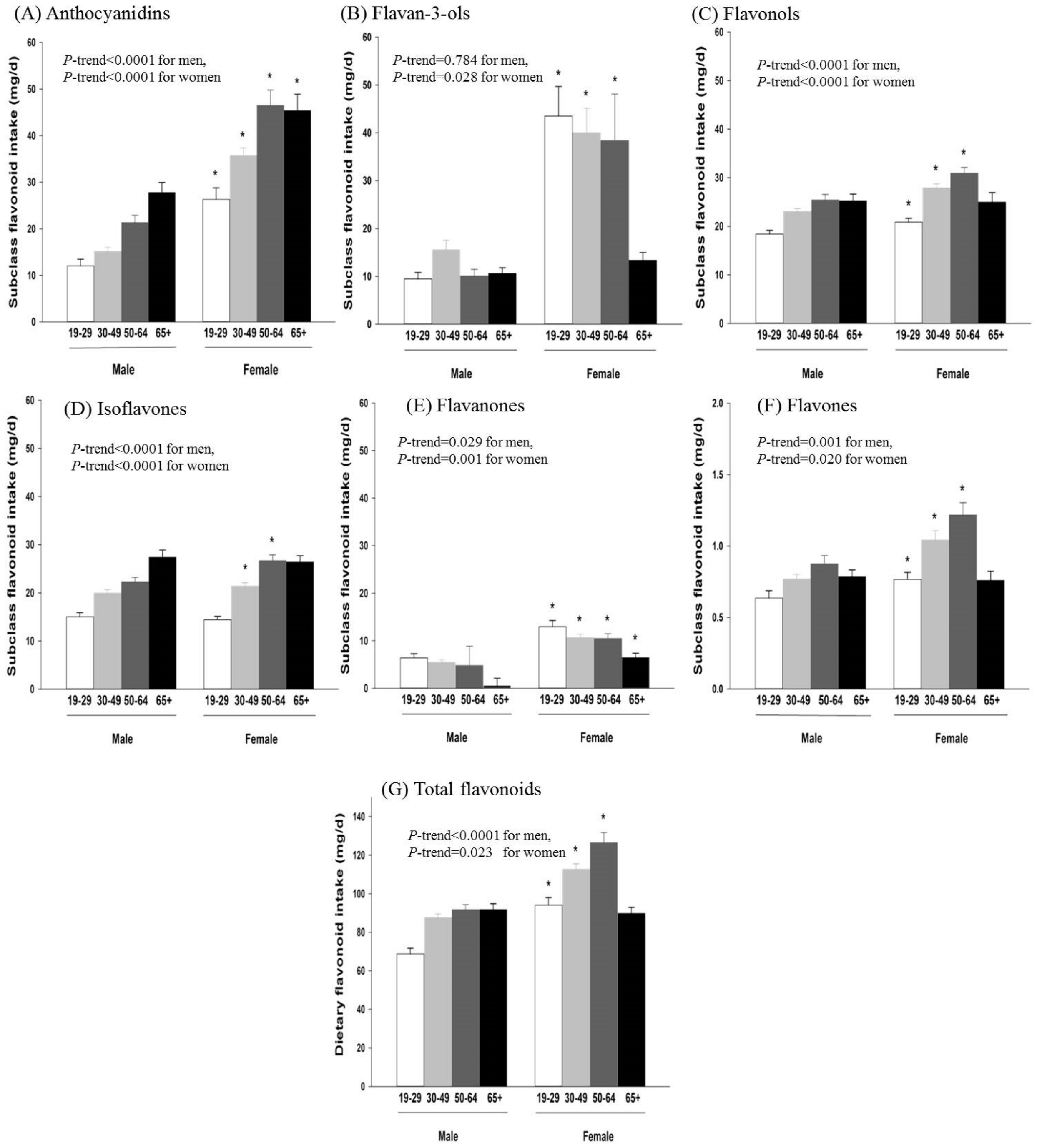

Figure 1. Daily intakes of flavonoid subclass and total flavonoids from the Korean diet by gender and age groups: data from 11,474 adults aged ≥19 y (KNHANES 2010-2012). Energy-adjusted values were calculated using the residual method. Trend in proportions (*p*-trend) was assessed with the flavonoid intakes modelled continuously across all age groups in each gender. Asterisks indicate a significant difference between men and women at each corresponding age group by Student's *t*-test ($p<0.05$).

flavanone intakes were highest between the ages of 19 and 29 and showed a significant downward trend with age. This change is primarily attributable to lower intakes of EGCG and hesperetin, which are primarily derived from tea and citrus fruits, respectively. This pattern was different from that in western countries. There was a reverse U-shape curve for flavan-3-ol intake in Australia[12] and a constant flavanone intake in the United States.[10] In contrast, anthocyanidin and isoflavone intake increased with age, which was primarily attributable to elevated intake of cyanidin from persimmon and genistein from soybean, respectively. A similar pattern of isoflavone intake was observed in Chinese adults.[4]

The advantage of this study is that dietary flavonoid intake was estimated by matching a complied database based on USDA flavonoids to DRs from national representative food intake surveys, which enables comparisons across studies using the similar approach (Supplemental Table 1). It is also important to note that no such study has yet been performed in an Asian country, with the exception of the isoflavone intake estimation in China.[13] Total flavonoid intake was lower in Korea than in western countries: Mediterranean countries (151 mg/d),[14] the United States (189 mg/d),[10] non-Mediterranean countries (193 mg/d),[14] and Australia (454 mg/d).[12] A major difference was the mean flavonoid intake from tea consumption,

Table 2. Major food sources of total, subclass, and individual flavonoids in the Korean diet: data from 11,474 adults aged ≥19 y (KNHANES 2010-2012)

Flavonoids		Food items (% contribution)	Cumulative %†
Total flavonoids		Kimchi (12); green tea (9); persimmon (7); soybean (7); onion (7); tofu (6); radish (5); tangerine (5); apple (4); pear (3); welsh onion (3); bean sprout (3); grape (3); orange (3); strawberry (2); black tea (2); beer (2); doenjang (2); cabbage (2); cheonggukjang (2)	87
Anthocyanidins	Cyanidin	Persimmon (68); pear (18); tangerine (4); apple (2)	92
	Delphinidin	Banana (41); eggplant (34); blueberry (11); cowpeas (7); strawberry (2)	96
	Pelargonidin	Radish (49); kimchi (37); strawberry (13)	100
Flavan-3-ols	Catechin	Grape (30); beer (30); peach (10); banana (8); apple (6); strawberry (4); persimmon (2); blueberry (2)	92
	Epigallocatechin	Green tea (65); apple (15); black tea (6); pear (4); peach (4); coffee (4); strawberry (2)	99
	Epicatechin	Apple (36); grape (22); pear (13); green tea (12); peach (4); beer (4)	92
	ECG	Green tea (70); grape (22); black tea (7)	99
	EGCG	Green tea (86); apple (10); black tea (3)	99
	Thearubigin	Black tea (83); green tea (17)	100
Flavanones	Hesperetin	Tangerine (51); orange (38); fruit juice (9)	99
	Naringenin	Tangerine (64); orange (23); tomato (4); fruit juice (3); grapefruit (2); kumquat (2)	98
Flavones	Luteolin	Kimchi (25); hot pepper (18); watermelon (14); orange (8); oriental melon (7); spinach (4); kiwi (4); lettuce (3); angelica keiskei (3); pumpkin (2); sorghum (2); perilla leaf (2)	91
Flavonols	Isorhamnetin	Onion (69); water dropwort (22); kimchi (5); pear (3)	98
	Kaempferol	Welsh onion (36); kimchi (21); cabbage (16); garlic chives (6); beer (6); spinach (4); radish (2)	91
	Quercetin	Onion (36); Kimchi (33); pear (5); apple (4); radish (3); grape (2); hot pepper (2)	85
Isoflavones	Daidzein	Soybean (33); tofu (27); bean sprout (12); doenjang (10); cheonggukjang (6); soymilk (4)	93
	Genistein	Soybean (31); tofu (29); bean sprout (14); doenjang (9); cheonggukjang (7); soymilk (5)	94
	Glycitein	Soybean (30); tofu (22); doenjang (20); bean sprout (10); cheonggukjang (7); soymilk (3)	98

ECG: epicatechin-3-gallate; EGCG: epigallocatechin-3-gallate.
†Cumulative contribution percentages are based on the sum of contributions from each food item providing at least 2.0% of a specific flavonoid.

which caused a remarkable increase in flavan-3-ol intake in western contries when compared with Korea. The flavan-3-ol intake accounted for only 25% of total flavonoid intake in Korea, whereas it dominated flavonoid intake in Australia (93%), the United States (83%), and non-Mediterranean countries (52%).[2,10,15] In addition, this phenomenon can be explained by the lower flavonoid density of major sources (kimchi, persimmon, tangerine, onion, radish, and *etc.*) in Korea than those (tea, citrus fruit, apples, pears, wine, *etc.*) in western countries. In contrast, the isoflavone intake was much higher in Korea than the estimates for western countries due to high intakes of legumes and legume products including soybeans, tofu, and fermented soy pastes. Furthermore, this approach enables to investigate the association between habitual intake of dietary flavonoid and the potential health benefits in Korean population and also to explore whether the required dose of flavonoids for beneficial health outcomes in clinical trials are achievable through diet alone.

This study has some limitations that can be equally applied to or found in intake estimations based on data from a composition table: incompleteness of the database used, lack of consideration of the bioavailability of flavonoid in foods, and omission of popular Korean dietary supplements. Thus, both over- and under-estimation of the flavonoid intake are possible. Flavonoid content in processed foods may have been overestimated, as the preparation techniques affect the structure and stability of flavonoids.[15] In contrast, the estimates may be increased if the flavonoid database is updated to cover more comprehensive food commodities. Another limitation of this study is that we used a 24-h DR. Many sources of flavonoids particularly fruits are not consumed every day, and thus tended to show greater individual variation in frequency of consumption than found for staple foods such as rice. Given the high day-to-day intra-individual variation, it is possible that a 24-h DR may not describe long-term flavonoid intakes. In particular, the elderly are known to exhibit wide intra-individual variation in fruit and vegetable consumption.[15] Furthermore, the distributions of most flavonoid intake in this study was skewed due to the large numbers of low- or non-consumers, most likely reflecting their occasional consumption of flavonoid-rich foods.[16] Food fermentation is also an issue to be addressed in further studies. We still do not know whether fermentation can affect the bioavailability and transformation of flavonoids, although many plant-based fermented foods such as kimchi and soybean paste have been listed as commonly consumed foods among Korean adults. Even in light of these limitations, however, the Korean flavonoid intake estimated in this study is important, both in terms of the amount of flavonoids ingested and the variety of the contributing food sources.

In summary, this is the first and the largest study to date to describe flavonoid intake and major dietary contributors in an Asian country. Combined with further elucidated information on the bioavailability of flavonoids, the data generated in this study should facilitate the investigation of the association between flavonoid intake and chronic disease risk on a population basis in Korea. At present, it is unclear whether the absolute intake of individual flavonoid compounds or ratios between the intakes of various individual compounds are more relevant to human health. For this reason, it is a strength of this study that all of the results were reported according to individuals, classes, and totals.[12] Furthermore, our findings may contribute to the establishment of accurate reference standards for national flavonoid intake in Korea.

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AUTHOR DISCLOSURES
None of the authors had a personal or financial conflict of interest.

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Supplemental table 1. Energy-unadjusted mean dietary flavonoid intake of adults in several countries using nationally representative samples and the modified USDA database

(A) Anthocyanidins, flavan-3-ols, flavanones, flavones, and flavonols

Country†	No of compounds included	Total (mg/d)	Flavonols (mg/d, %)	Anthocyanidins (mg/d, %)	Flavan-3-ols (mg/d, %)	Flavanones (mg/d, %)	Flavones (mg/d, %)
Australia[12,17]	Flavonols (4); Anthocyanidins (6); Flavan-3-ols (11); Flavanones (3); Flavones (2)	454	21 (5)	3 (1)	423 (93)	7 (2)	1 (0.1)
Non-Mediterranean countries[1,18]	Flavonols (4); Anthocyanidins (6); Flavan-3-ols (11); Flavanones (3); Flavones (2)	193	30 (15)	27 (14)	100 (52)	32 (17)	4 (2)
Mediterranean countries[2,18]	Flavonols (4); Anthocyanidins (6); Flavan-3-ols (11); Flavanones (3); Flavones (2)	151	25 (16)	37 (25)	50 (33)	34 (22)	6 (4)
United Kingdom[19]	Flavonols (4); Anthocyanidins (6); Flavonols (11); Flavanones (3); Flavones (2)	182	30 (17)	69 (38)	52 (29)	26 (14)	4 (2)
United States[10]	Flavonols (4); Anthocyanidins (6); Flavan-3-ols (4); Flavanones (3); Flavones (2)	189	13 (7)	3 (2)	157 (83)	14 (8)	2 (1)
Republic of Korea (present study)	Flavonols (4); Anthocyanidins (6); Flavan-3-ols (12); Flavanones (3); Flavones (2)	84	28 (33)	24 (29)	2 (26)	9 (11)	1 (1)

†Non-Mediterranean countries: Northeast/Northwest France, Germany, the Netherlands, United Kingdom (general population), Denmark, Sweden, and Norway; Mediterranean countries: Greece, Spain, Italy, southern France.

(B) Isoflavones

Country	Number of compounds included	Total (mg/d)	Genistein (mg/d, %)	Daidzein (mg/d, %)	Glycitein (mg/d, %)
China[13]	3	31.2	20.6 (66.0)	15.1 (48.3)	1.2 (4.0)
Ireland[20]	2	0.7	0.4 (50.7)	0.4 (50.4)	
Italy[20]	2	0.6	0.3 (54.5)	0.3 (45.5)	
The Netherlands[20]	2	0.9	0.5 (56.5)	0.4 (43.5)	
United Kingdom[20]	2	0.7	0.4 (54.2)	0.3 (43.7)	
United States[21]	3	1.2	0.4 (33.3)	0.6 (50.0)	0.1 (8.3)
Republic of Korea (present study)	3	24.3	11.9 (49.1)	9.84 (40.4)	2.6 (10.5)

Short Communication

Intake and major sources of dietary flavonoid in Korean adults: Korean National Health and Nutrition Examination Survey 2010-2012

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韩国成年人膳食类黄酮摄入量和主要食物来源：韩国全国健康和营养检查调查 2010-2012

为了探讨类黄酮与健康的关系，对类黄酮的摄入量进行准确估计是有价值的。我们估计膳食类黄酮摄入量，识别主要的食物来源。11474 名年龄≥19 岁的健康成年人完成了国家健康和营养检查调查（2010-2012）的 24 小时膳食回顾调查。美国农业部及新近估计或公布的典型的韩国食品相关数据被整合进韩国有针对性的黄酮类化合物数据库。总黄酮平均摄入量为 107±1.47 mg/d，经能量调整后女性比男性的摄入量更高。经鉴定槲皮素、飞燕草素、染料木素、大豆黄素、表没食子儿茶素 3-酸酯、表儿茶素、橙皮素和木犀草素为主要的黄酮类化合物。在整个研究年龄范围内，黄酮醇和黄酮呈倒 U 型曲线关系、黄烷-3-醇和黄烷酮类呈下降模式、花青素和异黄酮呈升高模式。经检测有 45 种食品至少含 1 种黄酮类化合物占该食物重 2%以上。朝鲜泡菜是总类黄酮的主要食物来源，其次是绿茶、柿子和大豆。能解释 50%以上特定类黄酮摄入的单一食物包括柿子（花青素）、绿茶（表儿茶素、表儿茶素 3-酸酯、表没食子儿茶素 3-酸酯）、红茶（茶红素）、橘子（橙皮素和柚皮素）、洋葱（异鼠李素）。这项研究提供的韩国的类黄酮摄入量信息便于国际间的比较，同时还深入研究了食物来源和不同黄酮类化合物的摄入随年龄和性别的变化。这项工作对将来调查黄酮类化合物摄入量和健康之间的关系有一定促进作用。

关键词：类黄酮摄入、主要食物来源、成人、主要食物提供者、全国调查