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Using an FFQ to assess intakes of dietary flavonols and flavones among female adolescents in the Suihua area of northern China

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Abstract

Objective: The present study aimed to (i) evaluate the reproducibility and validity of a designed FFQ, (ii) apply the FFQ for estimating the dietary intakes of four flavonols and two flavones in female adolescents and (iii) explain their major dietary sources.

Design: The reproducibility between the first and second FFQ administrations (1 year interval) was estimated using the intra-class correlation coefficient. The validity of the first FFQ relative to the average of four three-day 24 h dietary recalls (24-HR) from four seasons was assessed using the Spearman correlation coefficient. Using a flavonoid content database, the individual flavonol and flavone intakes were calculated and the major food sources were estimated.

Setting: Middle school in Suihua area of Heilongjiang Province, northern China.

Subjects: Female adolescents (*n* 887) aged 12–18 years.

Results: Better reproducibility and validity were obtained in the present study. The flavonol and flavone intakes were 16·29 and 4·31 mg/d, respectively. Quercetin and kaempferol were the major contributors (26·8 % and 23·7 %, respectively) to the total intake of flavonols and flavones. The main food sources of flavonols and flavones were apples (14·1 %), followed by potatoes (7·5 %), lettuce (7·3 %) and oranges (7·3 %).

Conclusions: The dietary flavonol and flavone intakes among female adolescents in northern China were similar to those reported in several countries, but significant differences were observed in the food sources ascribed to the geographical location and dietary characteristics.

Keywords
FFQ
Flavonol
Flavone
Female adolescents

Foods have many components other than the commonly known nutrients such as proteins, fats, carbohydrates, vitamins and minerals, many of which are associated with biological activities related to the reduced risk of several chronic diseases and cancer[(1–3)]. Flavonoids possess a wide range of biochemical and pharmacological effects, including anti-inflammatory and antioxidant effects[(4–7)]. In addition, recent studies have suggested that flavonoid intake may contribute to body weight maintenance in the general female population[(8)]. Flavonol and flavone contents are the highest in plant-based foods, and are concentrated mainly in leafy vegetables and some fruits.

Although flavonoids have various biological activities, their biological function depends mainly on their intakes and bioavailabilities. Databases of flavonoids in Chinese plant foods are currently limited and few data on the estimated flavonoid intake of the Chinese population have been published. Cao *et al.*[(9)] reported the major flavonols (quercetin, kaempferol, myricetin and isorhamntin) and flavones (apigenin and luteolin) found in 100 types of vegetables and fruits consumed by the Chinese population. Based on their findings, a preliminary database of flavonols and flavones was built.

Several international studies have reported flavonoid intakes of adults and a few studies have focused on the intake of minor populations, e.g. among the elderly and women[(10–12)], but few have focused on adolescent girls. Adolescence is an important period of growth and development. Given the special physiological and psychological factors that define adolescence among girls, as well as the phenomenon of blind weight loss, their health has received increasing attention among researchers in recent years[(13)]. Suihua is located in northern China, where the economic condition is not as prosperous as in

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the southern parts of the country. Seasonal vegetables and fruits are still much less eaten, especially during winter. The flavonol and flavone intakes of female adolescents in this area remain unclear. Based on available data on flavonol and flavone contents, the present study was performed to estimate the intakes of two subgroups of flavonoids (flavonols and flavones) and to explain their major dietary sources among female adolescents in the Suihua area in northern China using an FFQ. To demonstrate the feasibility of the FFQ on the target population, the reproducibility and validity of the FFQ were also evaluated. This study would facilitate further investigation on the relationship between flavonoids and chronic diseases.

Methods

Ethics statement

The study was approved by the Research Ethics Committee of Harbin Medical University. Written informed consent was obtained from either the participants or their parents (for participants below 18 years old) before the participants were enrolled in the study.

Study population

Female adolescents aged 12–18 years were enrolled in the study using a stratified multistage cluster sampling method. The participants were randomly recruited from three middle schools in the Suihua area of Heilongjiang Province, China. Each school had six grades. A total of twenty-five resident (living in the countryside) and twenty-five non-resident (living in the city) female students were selected from each grade. A total of 887 adolescents from the 900 potential participants joined in the study, excluding those who did not satisfactorily complete the FFQ (n 13). Among the qualified participants, 120 girls were expected to participate in the 24 h dietary recalls (24-HR) and answer the FFQ again after one year.

Study design

The study began in March 2011 and continued into the following year. Four three-day 24-HR were quarterly collected from 120 participants, who also completed the second FFQ (FFQ2). The first FFQ (FFQ1, n 887) was administered during the first three-day 24-HR, whereas the FFQ2 (n 120) was administered in February 2012. The reproducibility of the FFQ was estimated using intra-class correlation coefficient (ICC) analysis between FFQ1 and FFQ2, whereas its validity was assessed by comparing FFQ1 with the average of the four three-day 24-HR using Spearman's correlation coefficient.

FFQ and 24 h dietary recalls

The FFQ was developed according to the methodology proposed by Willett[14]. Revisions were made to ensure that the list of foods reflected the Chinese diet, according to the 2002 National Health and Dietary Survey[15]. Further revisions were made to improve the estimates of flavonoid-rich food intakes. The FFQ collected consumption information across eight food groups and eighty-six food items (Table 1). Respondents were requested to recall the average consumption of a given amount of each food item during the previous 1-year period using a graded scale with seven levels, ranging from never to ≥ 3 times per day. The portion size was also considered for the survey. For the 24-HR, each participant was asked to choose from a set of colour photographs showing different-sized portions of twenty-three specific food items, whereas photographs of dishes, bowls and cups were used to represent the average portion size for the other sixty-three food items. Participants had to describe qualitatively and quantitatively all food consumed during the previous day using the correct

Table 1 Food grouping used in the present study

Food group	Food items (n 86)	Portion size*
Cereals	Steamed bun, bread, corn steamed bun	Number
	Baked cake, biscuit	Piece
	Wheat noodle, fast-food noodle, rice, panicum, purple rice, corn	Bowl
Vegetables	Carrot, white radish, soyabean sprouts, aubergine, cucumber, pumpkin, hot pepper, Chinese cabbage, spinach, cabbage, celery, *Cucurbita pepo*, tomato, potato, sweet potato, onion, parsley, spring onion, cauliflower, garlic sprouts, garden pea, lettuce, *Foeniculum vulgare*, potherb mustard, leek, mushrooms	Plate
Fruits	Apple, orange, pear, banana, grape, watermelon, peach, muskmelon, Chinese pearleaf crabapple, apricot, hawthorn, plum	Number
	Date, strawberry, cherry	Bowl
Meat	Pork, beef, mutton, chicken, duck, goose meat, cyprinoid fish, morrhua, shrimp, crab, shellfish	Plate
Eggs	Chicken egg, duck egg, goose egg, quail egg, pidan, salty egg	Number
Milk	Milk, yoghurt	Cup
Beans	Soyabean, small red bean, green gram, black bean	Bowl
	Soyabean curd, dried bean curd, bean products	Plate
	Bean paste, Chinese cheese	Tablespoon
	Soyabean milk	Cup
Drinks	Scented tea, green tea, Coca-Cola, coffee, fruit juice	Cup

*Assigned portion sizes for all eighty-six food items used in the FFQ.

pictures to allow the dietitian to estimate their food intakes. All FFQ data were double entered into a computer and any discrepancies were resolved by referring to the original forms. Two dietitians visited each participant four times to complete the three-day 24-HR and these data were used as a standard to measure the relative validity of the FFQ. The dietitians were instructed to ask the participants key questions for a better qualitative description of food items (e.g. green leafy vegetables and fruits).

Intakes of dietary nutrients, flavonols and flavones

The nutrient calculator software Fei Hua V2·3 (Institute for Nutrition and Food Security, Chinese Center for Disease Control and Prevention, Beijing, China) was used to calculate the daily intakes of energy and nutrients. The database of flavonols and flavones established by our laboratory was used to calculate the daily flavonol and flavone intakes in our study.

Statistical analysis

Means and standard deviations of daily energy, flavonol and flavone intakes were calculated for the two FFQ and the average of the four three-day 24-HR, and analysed using the Wilcoxon signed-rank test. The residual method was used to help exclude the possibility of variations caused by energy intake[14]. Reproducibility between the two FFQ administrations was estimated using ICC[14]. The validity of the FFQ relative to the 24-HR was assessed using Spearman's correlation coefficient. Considering within-person variations caused by day-to-day fluctuations and seasonal variations, Spearman's correlation coefficients were 'de-attenuated' using the within- and between-person components of variation from the 24-HR[16]. All statistical analyses were performed using the SPSS statistical software package version 13·0 and Microsoft® Excel 2003. Unless stated otherwise, $P < 0.05$ was considered significant.

Results

The mean age and BMI of the participants (n 887) were 16·1 (SD 1·3) years and 23·9 (SD 3·5) kg/m^2, respectively. The mean intakes of energy, protein, fat, carbohydrate, eight food groups, four flavonols and two flavones of 120 adolescent girls, who completed FFQ1 and four three-day 24-HR from four seasons and FFQ2 for over 1 year, were calculated using the questionnaires as bases, with the aid of the nutrient calculator software and flavonoid database. The aforementioned data are shown in Table 2. The intake of beans from FFQ2 and the intake of drinks from FFQ1 were significantly higher than those from the 24-HR ($P < 0.05$), and the intake of drinks from FFQ2 was lower than that from FFQ1 ($P < 0.05$). No differences were observed for the intakes of energy, protein, fat,

Table 2 Daily mean intakes of energy, macronutrients, food groups, flavonols and flavones of female adolescents aged 12–18 years from the Suihua area of northern China (n 120), estimated using two FFQ and the average of four three-day 24 h dietary recalls (24-HR), March 2011–February 2012

	24-HR		FFQ1		FFQ2	
	Mean	SD	Mean	SD	Mean	SD
Macronutrients						
Energy (kJ)	8246	1965·1	9582	2710·8	9730	3132·6
Protein (g)	71·56	26·32	76·02	30·72	79·26	31·54
Fat (g)	48·67	21·06	65·69	26·45	64·23	23·52
Carbohydrate (g)	312·14	114·01	349·26	124·28	358·15	133·13
Food groups						
Cereals (g)	433·07	110·45	462·22	121·34	476·49	148·76
Vegetables (g)	366·34	176·57	398·97	185·90	419·55	204·45
Fruits (g)	259·95	126·12	276·82	153·73	295·38	140·67
Meat (g)	57·58	16·75	63·56	27·67	59·44	27·13
Eggs (g)	29·94	19·22	36·54	21·43	31·59	21·94
Milk (g)	56·43	18·63	72·21	17·35	60·85	19·29
Beans (g)	25·20	9·47	29·42	10·15	33·42*	16·12
Drinks (ml)	86·21	30·32	140·53*	93·10	93·35†	31·53
Flavonols						
Quercetin (mg)	5·17	3·01	5·48	2·81	5·65	3·23
Kaempferol (mg)	4·77	1·49	5·07	2·06	5·19	2·09
Myricetin (mg)	2·21	1·52	2·33	1·60	2·35	1·99
Isorhamntin (mg)	2·88	1·44	3·10	1·22	2·94	1·93
Sum of flavonols	15·03	7·48	15·98	7·71	16·13	9·26
Flavones						
Luteolin (mg)	2·52	1·78	3·17	1·80	3·02	1·22
Apigenin (mg)	0·96	0·68	1·05	0·51	1·09	0·65
Sum of flavones	3·48	2·47	4·22	2·32	4·11	1·88
Total flavonoids (flavonols + flavones)	18·51	9·98	20·21	10·12	20·24	11·18

*Significantly different from 24-HR, Wilcoxon signed-rank test, $P < 0.05$.
†Significantly different from FFQ1, Wilcoxon signed-rank test, $P < 0.05$.

Table 3 Reproducibility and validity of the FFQ designed for evaluation of the daily flavonol and flavone intakes of female adolescents aged 12–18 years from the Suihua area of northern China, March 2011–February 2012

	ICC* (FFQ1 *v.* FFQ2)		Spearman's correlation coefficient† (FFQ1 *v.* 24-HR)		
	Crude‡	Energy-adjusted‡	Crude§	Energy-adjusted§	De-attenuated
Energy (kJ)	0·64	–	0·65	–	0·63
Quercetin (mg)	0·65	0·50	0·77	0·58	0·78
Kaempferol (mg)	0·50	0·44	0·56	0·41	0·59
Myricetin (mg)	0·47	0·38	0·63	0·43	0·65
Isorhamntin (mg)	0·45	0·35	0·56	0·47	0·57
Luteolin (mg)	0·59	0·47	0·67	0·59	0·68
Apigenin (mg)	0·46	0·36	0·53	0·40	0·55
Mean value	0·52	0·42	0·62	0·48	0·64

*Intra-class correlation coefficient (ICC) was used to assess the reproducibility between FFQ1 and FFQ2 administrations (*n* 120).
†Spearman's correlation analysis was used to assess the validity of FFQ1 relative to the average of four three-day 24 h dietary recalls (24-HR; *n* 120).
‡All ICC values were significant ($P < 0·05$).
§All Spearman's correlation coefficients were significant ($P < 0·05$).

Table 4 Daily flavone and flavonol intakes of female adolescents aged 12–18 years from the Suihua area of northern China, March 2011–February 2012

	Daily intake (mg)*		
	Mean	SD	Percentage of total flavonoids (%)
Flavonols			
Quercetin (mg)	5·51	4·00	26·8
Kaempferol (mg)	5·49	3·68	23·7
Myricetin (mg)	2·29	1·84	11·1
Isorhamntin (mg)	3·00	2·37	14·6
Sum of flavonols	16·29	11·91	79·1
Flavones			
Luteolin (mg)	3·27	1·63	15·9
Apigenin (mg)	1·03	0·58	5·0
Sum of flavones	4·31	2·21	20·9
Total flavonoids (flavonols + flavones)	20·60	14·12	100

*Data from FFQ1 (*n* 887).

carbohydrate and other food groups derived from the 24-HR, FFQ1 and FFQ2. The mean daily flavonoid intake derived from the 24-HR, FFQ1 and FFQ2 was 18·51 (SD 9·98) mg/d, 20·21 (SD 10·12) mg/d and 20·24 (SD 11·18) mg/d, respectively. No significant differences were detected for the mean total flavonoid intake (flavonols + flavones) and the individual flavonol and flavone intakes.

Reproducibility and relative validity of FFQ

The crude- and energy-adjusted ICC for FFQ1 *v.* FFQ2 were calculated to assess the reproducibility of the FFQ (Table 3). All flavonols and flavones were moderately correlated (ICC = 0·4–0·7). After adjusting for energy, all ICC decreased. The mean crude ICC was 0·52 from a range of 0·45 (isorhamntin) to 0·65 (quercetin), whereas the mean energy-adjusted ICC was 0·42 from a range of 0·35 (isorhamntin) to 0·50 (quercetin).

The crude, energy-adjusted and de-attenuated Spearman's correlation coefficients for FFQ1 *v.* the average resulting from the four three-day 24-HR are also presented in Table 3. These values were used to assess the relative validity of the FFQ. The crude Spearman's correlation coefficient between FFQ1 and 24-HR ranged from 0·53 (apigenin) to 0·77 (quercetin), with a mean value of 0·62. The energy-adjusted coefficient ranged from 0·40 (apigenin) to 0·59 (luteolin), with a mean of 0·48. The de-attenuated coefficients ranged from 0·55 (apigenin) to 0·78 (quercetin), with a mean of 0·64. All energy-adjusted Spearman's correlation coefficients were lower than the crude ICC in terms of FFQ1 and FFQ2. However, de-attenuation to correct for intra-individual variability improved the Spearman's correlation coefficients and led to an increase in the mean Spearman's correlation coefficient for FFQ1 *v.* 24-HR (from 0·62 to 0·64).

Estimated flavonol and flavone intakes and major food sources

The mean daily dietary flavonol and flavone intakes were estimated from the FFQ (FFQ1, *n* 887) completed by female adolescents in the Suihua area of northern China. The total flavonoid intake (flavonols + flavones) was 20·60 (SD 14·12) mg/d, mainly from quercetin and kaempferol (26·8 % and 23·7 %, respectively), followed by luteolin (15·9 %), isorhamntin (14·6 %) and myricetin (11·1 %). The contribution of apigenin was relatively minimal (5·0 %). The flavonol intake was 16·29 (SD 11·91) mg/d (79·1 %) and the flavone intake was 4·31 (SD 2·21) mg/d (20·9 %; Table 4).

Table 5 Main food sources and their contribution (%) to the flavone and flavonol intakes of female adolescents aged 12–18 years from the Suihua area of northern China, March 2011–February 2012

	Flavonols*				Flavonols*		
Food	Quercetin	Kaempferol	Myricetin	Isorhamntin	Luteolin	Apigenin	%†
Apple	30·4	15·0					11·7
Lettuce	27·3						7·3
Orange	16·8			17·1			7·0
Muskmelon	10·5						2·8
Potato		41·6					9·9
Soyabean sprouts		17·7					4·2
Leek		16·3					3·9
Hawthorn			26·0				3·2
Celery			24·3			30·5	4·2
Strawberry			14·7				1·8
Cherry			12·6				1·6
Chinese cabbage				32·3			4·7
Potherb mustard				10·4			1·6
Pumpkin				10·0			1·5
Tomato					26·2		4·2
Aubergine					24·4		3·9
White radish					19·2		3·3
Garlic sprouts					13·8		2·3
Sweet potato						16·2	1·3
Peach						10·9	0·9
Onion						8·8	0·7
Others	15·0	9·4	22·4	30·2	28·4	33·6	17·8

*Percentage of individual flavonols or flavones.
†Percentage of total flavonols and flavones.

The primary food items contributing to the individual flavonol and flavone intakes are shown in Table 5. After colligating the daily dietary intakes, the results show that apple was the primary food item contributing to the total flavonol and flavone intakes (11·7 %), followed by potatoes (9·9 %) and lettuce (7·3 %). Other main contributors included oranges (7·0 %), Chinese cabbage (4·7 %), tomatoes (4·2 %), celery (4·2 %), soyabean sprouts (4·2 %), leeks (3·9 %) and aubergine (3·9 %). The sources of the total flavonoid intakes (flavonols + flavones) were vegetables (55·6 %), fruits (26·6 %) and others (17·8 %; e.g. cereals, tea, fruit juice and coffee).

Discussion

Given that the FFQ method is inexpensive and reflects the long-term dietary conditions of participants, it is generally considered to be a good tool for conducting dietary nutritional epidemiological studies. The results from FFQ differ depending on cultural background, eating habits, food sources, season, climate, age, economy and other factors, even in the same country. Thus, a special FFQ should be designed for the target population while considering the differences in food items that contribute to the daily supply of nutrients or phytochemicals with biological activities[17]. Suihua is located in north-east China, where winter lasts for more than five months and the economic condition is not as prosperous as that of the southern part of the country. In the current study, a new FFQ was designed for adolescent girls from Suihua, with the specific aim of selecting food groups that contribute significantly to flavonol and flavone intakes.

The reproducibility and relative validity of the FFQ were evaluated. The crude and energy-adjusted ICC for the mean daily flavonol and flavone intakes from FFQ1 *v.* FFQ2 were 0·52 and 0·42, respectively, for reproducibility. The crude, energy-adjusted and de-attenuated Spearman's correlation coefficients for the mean daily flavonol and flavone intakes from FFQ1 *v.* 24-HR were 0·62, 0·48 and 0·64, respectively, for validity, indicating that better correlations were obtained. Our study population consisted of a group of female adolescents with similar lifestyles (i.e. students in three middle schools who frequently dine in the school canteen), which possibly contributed to the moderate correlations. The ability of an individual to deal with abstract concepts and form mental images of her dietary regimen that are as close as possible to the truth[18], was another crucial factor in producing reliable estimates of habitual intake using the FFQ. Thus, colour photographs of foods taken in classrooms were used to make the task less tedious and encourage the interviewees to provide more accurate dietary information[19]. When the 24-HR were used to estimate the individual dietary intakes, we used a method that provided better estimates of the intake of even episodically consumed foods by accounting for the correlation between the probability of consumption and the amount consumed, and incorporating covariate information[20,21]. Adjusting for energy decreased the correlation in almost all subclasses of flavonoids, as high-energy foods may contain little to no amounts of flavonols and flavones[22].

Despite numerous reports on the health-improving effects of flavonoids, a limited number of studies on flavonoid intake are available worldwide. The flavonol and flavone intakes from several countries are listed in Table 6, showing that the estimates varied widely among studies. In the current study, the mean flavonoid (four flavonols and two flavones) intake of 887 female adolescents was 20·6 mg/d. The total flavonol intake was 16·3 mg/d and the total flavone intake was 4·3 mg/d. These results are similar to those in studies conducted in Australia[23], the Netherlands[24], China[25] and the USA[26], and are even higher than those in other studies reported from the USA[27,28], Finland[11,29] and Japan[30,31]. However, our results are lower than those found in studies conducted in Belgium[22] and Spain[32].

The major dietary sources of flavonol and flavone intakes reported in some of the aforementioned countries are onions and tea, followed by apples, broccoli and lettuce[24,26,33]. In the present study, apples, potatoes, lettuce, oranges, soyabean sprouts and leeks were the main food sources of flavonols, whereas tomatoes, aubergine, white radishes, celery and sweet potatoes were the main sources of flavones, similar to the results of a study on the Australian population with a sample population aged 16–18 years[23]. The participants in our study were adolescent girls with special dietary characteristics and much lower intakes of tea and onions compared with the respective populations of Western countries, leading to differences in both intake amounts and major sources. The contributions of cereals and cereal-containing foods, which the girls consumed in large amounts, to the flavonol and flavone intakes were minimal (7·2 %) in the present study. The differences in results could also be explained by the potato consumption. Our participants living in the Suihua area partly ate potatoes instead of the staple food, e.g. rice, making potato the primary food item that subsequently contributed to the total flavonol and flavone intake.

The current study had several limitations. First, only two subgroups of flavonoids were studied. However, other subclasses of flavonoids, such as isoflavones and isoflavanones, are also consumed in high amounts in China. This limitation could be ascribed to the flavonoid database, which has a limited number of food items, although the database is constantly being updated. Therefore, broader evaluations on other subclasses of flavonoids must be conducted. The second limitation was the time for the FFQ to be completed. The flavonoid contents of foods are influenced by region, season, sunlight and other factors[24]. For instance, the quercetin content of onions measured in our laboratory was 1·23 mg/100 g (fresh weight), which was much lower than that in the US flavonoid database (7·29–33·43 mg/100 g, fresh weight) and the contents reported by Arabbi *et al.* (38·3–93·6 mg/100 g, fresh weight)[34]. Third, the content changes in the storage and processing of the foods were not considered. As previously mentioned, food storage

Table 6 Estimated flavonol and flavone intakes in several countries

Country	Population*	Subclass	Intake (mg/d)	Food sources	Reference
USA	12 736 M (40–59 years)	3 flavonols, 2 flavones	12·9	Tea, onions, apples, broccoli	Hertog *et al.*[27]
	37 886 M, 78 886 F (40–75 years)	3 flavonols, 2 flavones	20·0–22·0		Sampson *et al.*[26]
	8809 M & F (>19 years)	4 flavonols	12·9		Chun *et al.*[28]
		2 flavones	1·6		
Australia	13 858 M & F (>18 years)	4 flavonols	20·69	Black tea, oranges	Johannot and Somerset[23]
		2 flavones	0·53		
Netherlands	4112 M & F (>19 years)	3 flavonols, 2 flavones	23·0	Tea, onions, apples	Hertog *et al.*[24]
Spain	40 683 M & F (35–64 years)	4 flavonols	18·48	Apples, oranges, tea, onion, lettuce, red wine, cabbage	Zamora-Ros *et al.*[32]
		2 flavones	3·45		
Finland	738 M & F (65–84 years)	3 flavonols, 2 flavones	25·9	Oranges, apples, tea, onions, cabbage	Hertog *et al.*[33]
	10 054 M & F	3 flavonols	4·1		Knekt *et al.*[29]
	12 000 M & F (25–64 years)	4 flavonols	5·8		Ovaskainen *et al.*[11]
Japan	50 F (>18 years)	4 flavonols	14·01	Tea, onions, cabbage, lettuce, apples	Kimira *et al.*[30]
		1 flavone	0·01		
	115 F (29–78 years)	Flavonols	16·4		Arai *et al.*[31]
		Flavones	0·3		
Belgium	45 F (22–69 years)	Flavonols	20·7	Oranges, apples, onions	Mullie *et al.*[22]
		Flavones	6·5		
China	5046 M & F (30–70 years)	4 flavonols	14·25	Apples, potato, celery, *Actinidia*, aubergine	Zhang *et al.*[25]

*M, males; F, females.

temperature, processing and peeling can influence flavonoid content[35]. Thus, more in-depth studies must be performed.

Conclusion

In conclusion, based on the proven reproducibility and validity of the FFQ, the present study estimated the dietary intakes and sources of flavonols and flavones among female adolescents. The dietary flavonoid intakes among female adolescents in the Suihua area were similar to those reported in previous studies, even though winter is longer and the economy is relatively poor in this area. The food sources showed significant differences because of the geographical position and dietary characteristics. This work provides data for epidemiological studies on the proposed relationship between these flavonoids and human health.

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