Original Article

Intake of soy foods and soy isoflavones by rural adult women in China

Zhaoping Liu MD[1], Wenxian Li BSc[1], Jing Sun BSc[1], Chenghong Liu BSc[2], Qiang Zeng BSc[3], Jian Huang BSc[1], Bo Yu, MSc[1], Junsheng Huo PhD[1]

[1] *Institute of Nutrition and Food Safety, Chinese Center for Disease Control and Prevention, Beijing, 100050, China*
[2] *Lanzhou Center for Disease Control and Prevention, Gansu Province, 730000, China*
[3] *Chengde Center for Disease Control and Prevention, Hebei Province, 067000, China*

This study evaluated the intake of soy foods and soy isoflavones by rural adult women and potential determinant factors. Soy food consumption and information on age, education and medical history were collected on 1,188 subjects in Gansu Province and Hebei Province, China using a food frequency questionnaire to gather data on food intake over the past year. Weight and height were simultaneously measured. The results showed that 1139 (95.9%) rural women consumed soy foods in the past year. The average intake of soy foods and isoflavones was 38.7 ± 58.2 (median = 23.5) g/d and 17.7 ± 26.6 (median=8.9) mg/d, respectively. Tofu accounted for the most contribution to their intake. The soy isoflavone intake ranged between 0-35 mg/day in 89.2% of subjects. Gansu women had higher intakes of soy foods and isoflavones than Henbei women (P<0.05). Women aged 41-50 years consumed less soy foods and isoflavones than the 20-30-year olds and 31-40 year olds (P <0.05). The intake of soy foods (P<0.01) and isoflavones (P<0.01) by women who experienced secondary education or above was significantly higher than illiterate women. Women without a medical history had a higher soy isoflavone intake than women with a medical history, but the difference was not statistically significant. These results suggest that the intake of soy isoflavones by Chinese rural adult women was much higher than women in Western countries. The distribution of intake was skewed to the right and varied among women in regard to region, age group and education level.

Key Words: Chinese women, food consumption, rural, soy foods, soy isoflavones, food frequency questionnaire

Introduction

Isoflavones, including daidzein, genistein and glycitein, are a group of phytooestrogens that are oestrogen-like plant chemicals and commonly found in soybeans.[1] Soy isoflavones account for most of dietary intake of phyto-oestrogens than other groups of phytooestrogens, i.e. lignans and coumestans.[2] According to earlier studies, they were best known for the reproductive disturbances they caused in livestock.[3] However, the discovery of these substances in human urine has raised intense interest and particular focus on their potential effects on human health over the past two decades.[4] In many *in vitro* and animal studies, isoflavones have been shown to exhibit a variety of biological effects such as regulation of cell growth and inhibition of tumour development.[5-7] Epidemiological studies suggest that soy consumption is associated with a low risk of chronic diseases such as coronary heart disease,[8,9] osteoporosis,[10,11] menopausal symptoms[11] and certain hormone-dependent cancers.[12, 13]

It is generally deemed that soybeans and their products are eaten more by people of Asian descent, such as the Chinese and Japanese poulations, than by Western populations. In China, some soy foods such as tofu are frequently consumed. A study conducted in Shanghai suggested that substantially lower incidence rates of breast cancer among Shanghai women may be partly attributed to a high level of soy foods present in diets.[14] There has been an increasing trend in the incidence of many chronic diseases, including breast cancer in China.[15] This has occurred in parallel to declining intakes of soy foods, according to data from the 1998 Chinese Food and Nutrition Surveillance System.[16] Studies are currently looking at whether there is a link between the above opposite trends. Evaluation of the usual intake of soy foods and isoflavones is at the root of this research. However, data on the dietary intake and sources of isoflavones among Chinese women are still scarce. In the present study, average intake of soy foods and isoflavones by rural adult women in China was estimated using a food frequency questionnaire (FFQ). In addition, the sources and distribution of soy isoflavones were discussed and comparison of intake by different population was also conducted.

Correspondence address: Dr Zhaoping Liu, Institute of Nutrition & Food Safety,29 Nanwei Road, Beijing,100050, China
Tel: 8610-83132553;; Fax: 8610-83132021
Email: zhpliu@yahoo.com

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Subjects and methods

Subjects

Adult women included in this study were aged 20-65 years and came from Hebei Province and Gansu Province, China, respectively. In each selected regions, four rural communities were randomly sampled according to average income, lifestyle and health care system. Women residing permanently in these four communities were recruited voluntarily to form the target population. Of the 1,188 subjects recruited (609 from Hebei Province and 579 from Gansu Province), 90.8% were engaged in housework or farming. The study was approved by the Ethic Review Board of the Institute of Nutrition and Food Safety, Chinese Centre for Disease Control and Prevention.

Interview using FFQ

The dietary questionnaire developed for the study included 47 food items and was based on the 2002 Chinese Nutritional Survey. The eight types of soy foods commonly consumed by the four communities were included in the 'soy foods' group and were as follows: tofu; tofu cooked with pickled vegetables (tofu-CPV); soymilk; tofu sheet/rolled sheet/soybean slab (sheet/slab); fried tofu; fermented tofu; soymilk skim; and whole soybean. Before interview, all investigators involved were trained on how to perform the dietary interview. Subjects were asked to sign an informed consent. Data were collected by face-to-face interview using the FFQ. During each interview, general information on demographic characteristics, lifestyle factors and medical history were sought. Consumption frequency and portion size of each food consumed during the past year were obtained. Portion size estimation was based on the Chinese standard measure *liang*, which is equivalent to 50 grams. In addition, body composition, haemoglobin level and some anthropometric measurements were taken and a blood sample was collected for other analyses.

Data management and analysis

All data were inputted into Epi Info 2002 and each food was subsequently converted into the amount of foods consumed in grams/day (g/d) using the following equation: daily intake (g/d) = (times/year × size/ time× 50)/365. Total soy food intake (in g/d) was calculated as the sum of the daily intake of all eight soy foods included in the questionnaire. The intake of total soy isoflavones was evaluated using data on isoflavone contents in Chinese Tables of Food Components 2002.[17] The isoflavone content of tofu-CPV was not available in the Chinese Tables of Food Components 2002 and was therefore cited from another report.[18] For the purpose of comparison with other reports, mean values (M ± SD) and medians were simultaneously reported in the present study. The *t*-test or ANOVA was used to compare the difference between regions, age groups and education groups. $P<0.05$ was taken as significant. All statistical analyses were performed using SPSS for windows version 10.

Results

Demographic profiles

Among the 1,188 targeted population, 609 (51.3%) subjects were from Hebei Province and 579 (48.7%) from Gansu Province. Their average age was 37.8 years. The age distribution, anthropometric and demographic characteristics of the subjects are shown in Table 1.

Food consumption

The average food consumption by women in this study, together with gender-mixed data from 1998 Chinese Food and Nutrition Surveillance System[16] and Chinese Dietary Guidelines developed in 1998[19] are shown in Table 2. The average consumption of cereals, fruits, meat and eggs was similar to the recommendations in the Chinese Dietary Guidelines. In contrast, vegetable, fish and milk intakes were lower than recommendations in the Dietary Guidelines. In comparison with data from 1998 Chinese Food and Nutrition Surveillance System (rural, gender-mixed), consumption of cereals, vegetables and fish was lower, but consumption of fruits, tubers, eggs, milk and soy foods was higher.

Intake of soy foods and soy isoflavones

Among the targeted rural women, 1,139 (95.9%) subjects reported that they consumed soy foods frequently. Tofu was the most commonly consumed soy food. The average intakes of soy foods and isoflavones were 38.7 (median=23.5) g/d and 17.7 (median=8.9) mg/d, respectively. In 8 selected soy foods, tofu accounted for the most contribution to intake of total soy foods and isoflavones, with values of 70.3% and 46.3%,respectively (Table 3).

Distribution of soy isoflavone intake

Figure 1 depicts the distribution of soy isoflavone intake by the targeted population. This abnormal distribution was skewed to the right. About 29% of the rural adult women had isoflavone intakes within 0-5 mg/d (excluding 0) and 89.2% had intakes in the range of 0-35 mg/d.

Comparison of intake of soy foods and isoflavones in different populations

The intake of soy foods and isoflavones by 41-50 year old women was significantly lower than the intake by other age groups ($P<0.05$). Gansu subjects had statistically higher intakes of soy foods and isoflavones than Hebei subjects ($P<0.05$). Women with secondary or tertiary education consumed more soy foods and isoflavones than illiterate women ($P<0.01$, $P<0.05$, respectively). But there was no significant difference between the intakes of soy foods and isoflavones by the Han women and the minority women. Women with BMIs between 18-24 had similar intakes of soy foods and isoflavones to women with BMIs >24 ($P>0.05$). Women without a medical history , consumed more soy foods and isoflavones than women with a medical history (especially women with cardiovascular/cerebrovascular diseases or digestive tract diseases) ($P<0.05$) (see Table 4).

Table 1. Anthropometric and lifestyle characteristics of subjects

N	1,188
Age in years (M ± SD)	37.8 ± 7.5
Height in cm (M ± SD)	156.6 ± 4.9
Weight in kg (M ± SD)	57.3 ± 7.9
BMI (kg/m^2)	23.6 ± 2.8
Marital and delivery status	
Marital age in years (M ± SD)	22.7 ± 2.4
Married (%)	99.7
Ever delivery (%)	96.6
Ever smoking (%)	2.0
Ever drinking tea (%)	61.9

BMI, Body Mass Index, is referred as weight (kg) divided by height (m^2).

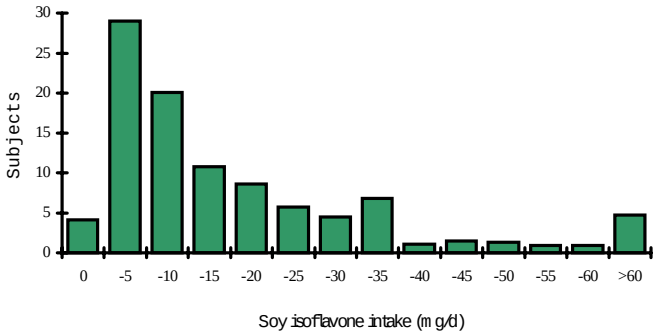

Figure 1. Distribution of soy isoflavone intake by rural adult women in China

Discussion

In several studies, food frequency questionnaires (FFQ) have been used to study the relationship between isoflavone intakes and chronic diseases.[2,20-22] Horn-Ross *et al.*, suggested that the FFQ would be appropriate and superior to other survey methods (such as dietary records and dietary recalls) for use in epidemiological studies.[22] In the present study, the dietary survey was conducted by face-to-face interviews using a FFQ which gathered food intake data over the past year. Detailed information on usual food and soy food consumption was collected. Thus, the estimated intake of soy foods and isoflavones in this study would represent the long-term consumption levels in the targeted population. The results in Table 2 showed that, although vegetables, fish and milk did not meet the requirements of the Chinese Dietary Guidelines, an overall improvement in food consumption, especially in fruits, eggs and milk, was found in rural adult women when compared with the previous national survey.[16] This study specifically targeted the intake of soy foods and isoflavones by Chinese rural adult women aged 20-65 years. Our results demonstrated that over 95% of subjects in this study reported consuming soy foods and the average consumption frequency of tofu was 98.5 times/year

The amount and frequency of soy foods consumed was much higher in rural Chinese women than in Iowa women or Chinese women living in America.[13,23] The mean soy food intake was 38.7 (median=23.5) g/d, which was much higher than data from the 1998 Chinese Food and Nutrition Surveillance System. However, the mean intake was significantly lower than that reported in the late 1990s by Chen *et al.*,[21] who found that 100.6 g/d (median) soy foods were consumed by Shanghai women aged 37-61 years. When compared with recent data, however, soy food consumption estimated in this study was similar. For example, Zhao and her colleagues reported in 2002 that mean soy food intake by urban residents living in eight Chinese Provinces was 43.7g/d.[24] These figures approached the recommendations in the Chinese Dietary Guidelines. To date, there has been a paucity of information (especially in China) in the literature regarding the contribution of each soy food to total intake of soy foods and soy isoflavones. We found in the present study that tofu provided the greatest contribution to total consumption of soy foods and was followed in turn, by whole soybean and sheet/slab.

The average intake of total soy isoflavones by Chinese rural adult women was 17.7 (median=8.9) mg/d. This intake was much higher than that by western populations. It was reported that the intake of soy isoflavones by women in the Netherlands, England and Unites States of America was estimated to be less than 1 mg/d.[2, 25, 26]

Tofu, whole soybean and sheet/slab contributed equally to isoflavone intake and to total soy food intake. Soymilk film had the lowest contribution to soy food consumption, but its contribution to isoflavone intake was higher than tofu-CPV, soymilk, fermented tofu and fried

Table 2. Food consumption by Chinese rural adult women and comparison with other nutrition data (g/d)

Items	Average consumption (M±SD)	National Survey [16]	Dietary Guidelines [19]
Cereals	379.3 ± 158.5	731.5	300-500
Vegetables	172.2 ± 116.7	355.9	400-500
Fruits	120.6 ± 122.1	56.9	100-200
Tubers	101.1 ± 81.4	21.4	----
Meat	46.2 ± 52.6	42.7	50-100
Eggs	43.4 ± 40.8	14.5	25-50
Fish	4.8 ± 11.5	9.3	50
Milk	14.9 ± 32.8	2.2	100
Soy foods	38.7 ± 58.2	17.8	50
Edible oil	40.8 ± 33.9	----	25
Animal-derived	7.3 ± 11.6	3.0	----
Vegetable-derived	33.5 ± 26.4	17.3	----

Table 3. Consumption of soy foods and intake of isoflavones by targeted population

	Consumption population	Soy foods		Soy isoflavones	
		Consumption	Contribution	Intake	Contribution
	(%)	(g/d, M±SD)	(%)	(mg/d, M±SD)	(%)
Tofu	93.7	27.2 ± 40.3	70.3	8.2 ± 12.5	46.3
Tofu-CPV	16.2	1.2 ± 7.6	3.1	0.5 ± 2.9	2.8
Soymilk	12.5	1.1 ± 10.3	2.8	0.1 ± 0.7	0.6
Sheet/slab	30.3	2.7 ± 10.1	7.0	1.8 ± 5.9	10.2
Fried tofu	18.8	1.2 ± 9.7	3.1	0.4 ± 3.0	2.3
Fermented tofu	22.0	1.1 ± 6.4	2.8	0.3 ± 2.7	1.7
Soymilk film	10.9	0.4 ± 5.2	1.0	0.9 ± 5.8	5.1
Whole soybean	37.8	3.8 ± 10.7	9.8	5.5 ± 17.2	31.1
Total	95.9	38.7 ± 58.2	99.9	17.7 ± 26.6	100.1
Median	-	23.5	-	8.9	-

Table 4. Average intake of soy foods and isoflavones in different populations

		N (%)	Soy foods (g/d)		Soy isoflavones (mg/d)	
			M ± SD	Median	M ± SD	Median
Region	Hebei	609 (51.3)	37.2 ± 39.0	23.3	16.4 ± 20.3	8.9
	Gansu	579 (48.7)	41.1 ± 62.8 [b]	26.4	20.7 ± 33.2 [b]	9.7
Age in year	20-30	189 (15.9)	44.2 ± 58.4 [c]	26.3	21.1 ± 38.3 [c]	9.7
	31-40	566 (47.6)	40.4 ± 57.9 [c]	27.1	18.0 ± 25.6 [c]	9.6
	41-50	383 (32.2)	32.9 ± 34.5	21.4	15.2 ± 20.4	8.2
	51-65	50 (4.2)	42.4 ± 47.4	22.4	18.2 ± 20.0	12.9
Nationality	the Han	761 (64.1)	38.6 ± 57.0	22.7	17.5 ± 27.0	8.8
	Minority [a]	427 (35.9)	38.9 ± 39.0	27.3	17.7 ± 20.9	10.1
BMI (kg/m^2)	<18	15 (1.3)	42.7 ± 48.1	31.8	18.9 ± 18.1	14.0
	18-24	723 (60.9)	38.5 ± 45.5	21.8	17.9 ± 27.9	9.7
	>24	450 (37.9)	38.9 ± 59.5	24.7	17.1 ± 24.1	8.8
Education	Illiteracy	162 (13.6)	28.9 ± 37.6	15.2	13.8 ± 19.8	6.7
	Primary	419 (35.3)	37.4 ± 47.1	22.6	16.6 ± 21.1	8.9
	Secondary	478 (40.2)	41.1 ± 61.6 [d]	27.9	18.9 ± 32.7 [e]	9.8
	Tertiary	129 (10.9)	46.7 ± 47.2 [d]	31.3	20.8 ± 22.2 [e]	12.4
Medical history	Non-	923 (77.7)	43.2 ± 45.6	24.7	17.8 ± 22.8	9.5
	Cardiovascular / cerebrovascular diseases	35 (2.9)	27.4 ± 32.7[f]	23.7	12.1 ± 9.2 [f]	8.9
	Gynecopathy	34 (2.9)	33.1 ± 41.5	20.8	15.8 ± 19.7	7.0
	Digestive tract diseases	99 (8.3)	29.9 ± 40.0 [f]	21.4	13.9 ± 15.7 [f]	7.3
	Other diseases	97 (8.2)	29.3 ± 35.2 [f]	16.9	13.1 ± 17.9 [f]	6.2

a: only referred to Mongolia, Manchu and the Hui nationality; b: Compared with Hebei women, *P* value <0.05•; c: Compared with 41-50 year women, *P* value <0.05; Compared with illiteracy women, d: *P* value <0.05, e: *P* value <0.01; f: Compared with women with non-medical history, *P* value <0.05 BMI, Body Mass Index, was referred as weight (kg) divided by height (m^2).

tofu (Table 3). This different contribution to soy food consumption and isoflavone intake was resulted from the different isoflavone contents in various soy foods. Compared with other soy foods selected, soymilk film had higher contents of soy isoflavones.[17] The distribution of soy isoflavone intake was skewed to the right (Fig. 1). There were over 89.2% subjects whose isoflavone intake ranged within 0-35 mg/d. This abnormal distribution was also found in other studies conducted in China and Japan and has been regarded as an issue that must be taken into account in the evaluation of isoflavone intake.[20,21] In this situation, median values are more meaningful than mean values and should be presented to summarize the data.

It was found in the present study that rural adult women living in different regions had differing intakes of

soy foods and isoflavones. Gansu women had a greater intake than Hebei women due to, in part, the higher consumption of whole soybean, sheet/slab and fermented tofu (Table 3). Women aged 41-50 years had lower intakes of soy foods and isoflavones than younger and older women. There was no clear explanation for this observation. It was also shown (Table 4) that the intake of soy foods and isoflavones by Chinese rural women may be influenced by education level. The higher the education level the greater the intake of soy foods and isoflavones. This may be attributed to better understanding of soybean nutrition and its benefits. A few emerging studies suggested that soy proteins or isoflavones could have beneficial effects on many aspects of obesity. Body weight- or body fat-decreasing effects were observed in obese subjects and mouse models.[27,28] However, other reports have not found any effect on body weight[29] and, to date, epidemiological data has not shown a relationship between soybean consumption and body weight or BMI. In this incipient study, we did not find a clear association between the intake of soy isoflavones and BMI. There were a number of experimental studies and epidemiological data suggesting that soy foods and soy isoflavones might protect against human diseases.[30-32] In this study, we found that women without a medical history consumed more soy foods and isoflavones than women who had cardiovascular or cerebrovascular diseases, digestive tract disease or gynecopathy, suggesting certain potential beneficial effects of soy foods and isoflavones on health. Further studies, especially large-scale epidemiological study, are needed in this field to elucidate their conclusive relationship.

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