Soy product consumption and association with health characteristics and dietary quality indices in Isfahan, Iran

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Original Article

Abstract

BACKGROUND: To determine the average intake of soy products and its association with socio-demographic, general and health characteristics, and dietary quality indices among the population of Isfahan, Iran.

METHODS: In this descriptive cross-sectional study conducted on 491 subjects in 2013-2014, grocery stores, nuts stores, chain stores, and supermarkets from different areas of Isfahan Municipality were visited. Shop owners were asked to report the amounts of soy products sales (soy nut, processed soy protein, soy milk and soy yogurt). Furthermore, a food frequency questionnaire was completed from 496 customers by an experienced nutritionist. Mean sales and intake of soy products and dietary intakes including dietary quality indices and mean adequacy ratio (MAR) as well as anthropometric and socio-demographic variables were assessed.

RESULTS: Soy protein and soy yogurt are the highest [673 ± 81 (g/month)] and lowest [420 ± 148 (g/month)] purchased soy products, respectively. While soy nut [63 ± 10 (g/month)] was consumed to the lowest amount, soy protein [236 ± 39 (g/month)] was the most consumed soy product. Subjects with higher consumption of soy products were older and had higher intake of protein, vitamin C, zinc and iron, and lower intake of whole grains, legumes, and vegetables as well as greater values of MAR and dietary diversity score as well as nutrient adequacy ratio for vitamin C.

CONCLUSION: Soy protein is the most purchased and consumed soy product among people living in Isfahan. More intakes of whole grains and vegetables among those with higher consumption of soy foods could define greater quantities of zinc, iron and vitamin C in the diet. Soy consumption had a reverse correlation with body mass index.

Keywords: Soy Products, Isoflavones, Food Frequency Questionnaire, Iran

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Introduction

Soy products are considered as a functional food having beneficial effects on the heath as they are rich in phytoestrogens, notably isoflavones.[1,2] Besides phytoestrogens, other contents of soy foods including fiber, lipid and peptides are also responsible for these healthy benefits.[3] Epidemiologic studies suggest that soy foods are reverse contributors to many diseases including Type 2 diabetes,[4,5] blood pressure,[6] chronic diseases,[3,7,8] certain cancers,[9-11] and menopausal flushes.[12]

Several reports based on the average intake of soy products and phytoestrogens are available worldwide. Higher intake of phytoestrogens were observed in northern European countries (non-Mediterranean countries) than southern countries (Mediterranean countries), with a maximum intake in UK.[13] A cohort of patients participated in European prospective investigation into cancer and nutrition study found that consumption of soy foods is low in Western European countries and only 1.5% of males and 2.1% of females reported soy consumption.[14] Moreover, reports from Asian

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population showed a much more amounts of intake compared with western population. Japanese adults consume approximately 6-11 g of soy protein and 25-50 mg of isoflavones per day[15] and daily intake of total isoflavones was 7.8 ± 5.6 mg among midlife Chinese women in Hong Kong.[16] Besides the average intake of soy products, the sources of soy foods are also different worldwide. Dairy products are the most used soy substitutes among European subjects,[14] while it is traditional soy products for Asian individuals.[17,18]

Earlier studies revealed that higher dietary diversity score (DDS) were associated with healthier dietary intake in Iran.[19] High intake of soy products among western individuals may be a marker of healthier habitual lifestyle.[14] However, it is not determined whether it is true in Iran or not. Moreover, there was a reverse association between DDS and obesity.[20] Furthermore, it was always believed that soy foods are more consumed among low-income adults, and that is not related to healthy eating.

Although the average intake of soy products has been estimated in Asian population, few reports have been published from the Middle-East countries. Considering the fact that beneficial effects of these products on risk factors of chronic diseases have been proved by many clinical trials in Iran,[3,8,21,22] it is not yet determined how many percent of Iranian population are soy consumers.

Therefore, we conducted this study to determine the average consumption of soy products in Esfahan city of Iran and to evaluate its association with general and health characteristics and dietary quality indices.

Materials and Methods

In this descriptive cross-sectional study conducted on 491 subjects in March 2013 to September 2014, grocery stores, nuts stores, chain stores, and supermarkets from different areas of Isfahan, Iran, Municipality were visited. Isfahan Municipality was divided into five areas considering people's socio-economic status. Considering the population of Isfahan city, five grocery stores, nuts stores, chain stores (including Refah, Kowsar, and Etka shops or any available hypermarket in that area) or supermarkets were randomly selected from each area using a computer based program. When the stores' locations were reconciled with all areas of Isfahan Municipality, at least two stores accepted to cooperate in every municipality area, and they reached to three in some areas. Some areas included all grocery stores, nuts stores, chain stores or supermarkets but some others included only one grocery store or one of the three nuts store, chain store or supermarket. Eventually, 39 grocery stores, nuts stores, chain stores, and supermarkets agreed to report their sales statistics. Every available soy product in Iran (soy nut, processed soy protein, soy milk, and soy yogurt) were listed in a questionnaire so that the amounts of monthly soy products sales were asked after interviewing shop owner or supervisor.

We included all customers aged 20-60 years who agreed to participate in this study. Finally, 496 subjects agreed to complete a food frequency questionnaire (FFQ). Under reporters (< 800 kcal/day) and over reporters (> 4200 kcal/day) of energy intake or those not reported more than 40 items of FFQ were excluded from the study and the analysis were performed on 491 subjects. A paper containing nutritional recommendations was given to the individuals accepted to participate in this study to thank their cooperation. This study was approved by the Isfahan University of Medical Sciences, and it was ethically confirmed.

To assess the usual daily intake, a semi-quantitative FFQ with 168 items was used. The reliability and validity of this questionnaire has been approved previously.[23] The four mentioned soy products were added specifically into this FFQ. Therefore, the final items were 172 items in the FFQ. The frequency of consumption was reported according to a given serving of each food item during the previous year on a daily (e.g., bread), weekly (e.g., rice, meat), or monthly (e.g., fish) basis. Daily intake of all food items from FFQ was computed. Then we used household measures to convert consumed foods to grams. A registered dietitian was responsible for fulfilling the questionnaires. We analyzed the data obtained from FFQ using Nutritionist III 7.0 (N-Squared Computing, Salem, OR, USA) refined for Iranian foods.

To calculate nutrient adequacy ratio (NAR), we used the ratio of daily individual intakes to standard recommended amounts for each group of the subject's sex and age.[24] Since the recommended dietary allowances (RDA) revises every 10 years and the new form of RDA is dietary reference intake (DRI) and RDA includes DRI, we used RDA and DRI and daily individual intakes to collect the standard recommended amounts using FFQ. The NAR for nine nutrients important to us including vitamin E, vitamin B6, vitamin A, vitamin B2, vitamin C, calcium, iron, zinc, selenium, the most deficient micronutrients previously mentioned,[19] was estimated. Mean adequacy ratio (MAR) was

calculated as the sum of NARs divided by the number of nutrients (n = 9).[19]

The method described by Kant et al. was used to score dietary diversity.[25,26] According to the food guide pyramid of the U.S. Department of Agriculture (USDA), we propounded five groups including bread grains, vegetables, fruits, meats, and dairy.[27] The main groups were divided into 23 subgroups. The maximum and minimum scores of diversity for each five main food groups were 2 and 0. The sum of these five scores showed the total score which means the total DDS varies from 0 to 10.

Healthy eating index (HEI) was calculated according to Kennedy et al. method,[28] based on 9 components indicating different aspects of a healthy diet. Grains, vegetables, fruits, milk and meat groups were considered as the first five components of the HEI. Components number 6, 7, and 8 represent the total percent of fat, saturated fatty acids, and cholesterol intake, respectively. Component number 9 was used to calculate the dietary variety score. Diets with < 30% energy from fat, < 10% energy from saturated fat and < 300 mg cholesterol received a full score of 10 points. To determine the dietary variety, total number of different foods and food groups consumed over 2 days was counted to calculate HEI score. Of all food groups, foods were counted only if they contributed at least one-half of a serving. The frequency of the number of food items eaten was calculated over the FFQ. We contributed 18 and 8 to the most and least frequent value of variety, respectively. Therefore, the score of 10 was considered for the value of 18 and more, and the score of 0 was considered for the value of 8 and fewer. The total score of HEI was 90. Higher score indicates better compliance of subjects to recommendations of the food guide pyramid and dietary guidelines. The calculation method of HEI score was modified according to the USDA procedures.[29] Considering the numbers of foods consumed by the population of this study, we assessed the variety score.[30]

Digital scales were used to measure weight while subjects were clothed minimally. A tape measure was used to measure height while subjects were standing in a position which their heels, but, shoulders and head backed against the wall. Weight (in kg) divided by height (in m^2) to calculate body mass index (BMI).

Some individuals did not cooperate even though our dietitian was equipped with the scale and meter. Hence, we used the self-administered method to ask the anthropometric characteristics of all the subjects. Of 496 invited customers, 412 individuals accepted to be measured by the dietitian and the rest of them did not. Hence, we gathered the self-administered method for the remained subjects. By the way, a favorable correlation was observed between statements and measures, therefore, the same statements were considered for the rest.

Subjects were asked for the socio-economic situation by a pre-tested question including the number of family members, education, being a homeowner or tenant, kind of job and having a car. Subjects were scored according to the mentioned variables. Good socio-economic were used for subjects in the third tertile of the score. Those in the first and second tertiles were categorized as poor and moderate socio-economic status, respectively.

To ensure the normal distribution of variables, we used histogram and Kolmogorov–Smirnov tests. We first categorized soy products according to the tertiles of consumption. Then we used analysis of variance for comparing different groups. Analysis of covariance was used for those adjusted for energy intake and other confounders. All the individual intakes of soy products and tertiles of soy products intake among subgroups of general and health characteristics, DDS and HEI were adjusted for energy intake We described continuous variables as means and standard deviations and categorical variables as numbers or percent's. $P < 0.05$ was considered as significant. Using the χ^2 test, distribution of participants in terms of categorical variables was examined. Statistical analyses were carried out by the use of Stata, (version 11.2, Stata Corp, College Station, TX).

Results

Table 1 exhibits the amount of purchased soy products according to the seller's report as well as the quantities of soy food intakes based on the reports of the individuals in response to FFQ. Accordingly, soy protein (g/month) and soy yogurt (g/month) are the highest (673 ± 81), and lowest (420 ± 148) purchased soy products, respectively. While soy nut (63 ± 10) was consumed to the lowest amount, soy protein (236 ± 39) was the most consumed soy product.

Table 2 includes information about socio-demographic characteristics of subjects according to the tertiles of soy products. The findings show that older persons consume higher amounts of soy products. However, there was no significant difference for sex, socio-economic status, and number of children among tertile of soy consumption.

General and health characteristics of participants are reported in table 3. While there was no significant difference for family history of the

subjects, mean BMI was lower among those subjects in the highest tertiles of soy products.

We explained the dietary intakes of subjects in table 4 according to the tertiles of soy products. Those subjects in the higher tertile of soy products intake had higher protein consumption (P = 0.03). The results demonstrated that the intakes of vitamin C, zinc, and iron were higher in the third tertile of soy consumption compared with the first tertile. Subjects in the lowest tertile of soy products intake consumed less whole grains, legumes, and vegetables.

Table 5 describes the dietary quality indices for participants' diet according to the tertiles of soy product consumption. Those with higher amounts of soy products intake had greater values of MAR as well as NAR for vitamin C. Although there was no significant association between other indices of dietary quality, the findings for DDS are marginally significant.

Table 1. The amount of purchased and consumed soy products during a month*

Soy products**	Purchased (mean ± SD)***	Consumed (mean ± SD)§,€
Soy nut (g/month)	661 ± 52	63 ± 10
Soy protein (g/month)	673 ± 81	236 ± 39
Soy milk (cc/month)	480 ± 53	193 ± 69
Soy yogurt (g/month)	420 ± 148	105 ± 54

* ANCOVA test was used for analysis of the amount of soy product consumption while were adjusted for energy intake; ** As the amounts of different packages of soy nut, soy protein, and soy yogurt were not equal, we calculated the amount of packages and reported in grams; *** Values are based on the amount of purchased products obtained from sales statistics; § All intakes of subjects were adjusted for energy intake; € Values are based on individual intakes reported as FFQ; FFQ: Food frequency questionnaire; SD: Standard deviation

Table 2. Sociodemographic characteristics of subjects according to the tertiles of soy products*

Variables	Tertiles of soy products**			P
	1	2	3	
Age (year)	39.1 ± 3.8	45.3 ± 4.3	58.5 ± 4.9	0.01
Sex				
Male [n (%)]	51 (31.0)	60 (38.0)	51 (31.0)	0.21
Female [n (%)]	109 (33.0)	110 (33.5)	110 (33.5)	
Socioeconomic status [n (%)]				
Good	21 (12.9)	29 (16.9)	38 (23.6)	0.09
Moderate	111 (69.5)	124 (73.2)	113 (70.3)	
Poor	28 (17.6)	17 (9.9)	10 (6.1)	
Number of children [n (%)]				
≤ 2	64 (39.9)	77 (45.6)	81 (50.1)	0.23
3-4	88 (55.1)	93 (55.4)	75 (46.7)	
> 4	8 (5.0)	0 (0.0)	5 (3.2)	

* ANCOVA which was adjusted for energy intake was used for quantitative variables and χ^2 was used for qualitative variables; **All the tertiles of soy intakes were adjusted for energy intake by ANCOVA

Table 3. General and health characteristics of subjects according to the tertiles of soy products*

Variables	Tertiles of soy products**			P
	1	2	3	
BMI (kg/m^2)	26.1 ± 3.5	26.2 ± 3.7	25.1 ± 3.3	0.01
Weight (kg)	79.8 ± 16.3	74.6 ± 11.4	67.3 ± 10.1	0.01
Family history of diseases n (%)				
Diabetes	56 (35.2)	66 (38.7)	63 (39.3)	0.42
Obesity	58 (36.5)	61 (35.6)	61 (37.6)	0.38
High blood pressure	66 (41.1)	67 (39.5)	62 (38.7)	0.43
Osteoporosis	69 (43.3)		63 (38.9)	0.33

* ANCOVA test which was adjusted for energy intake was used for quantitative variables and χ^2 was used for qualitative variables; ** All the tertiles of soy intakes were adjusted for energy intake; BMI: Body mass index

Table 4. Dietary intakes of subjects according to the tertiles of soy products*

Dietary intakes	Tertiles of soy products**			P
	1	2	3	
Energy	2871.0 ± 131.0	2639.0 ± 142.0	2730.0 ± 170.0	0.11
Carbohydrate (% of calorie)	56.5 ± 16.7	58.5 ± 13.9	57.3 ± 15.1	0.16
Fat (% of calorie)	37.1 ± 901	34.2 ± 8.5	30.1 ± 79	0.05
Protein (% of calorie)	6.4 ± 2.0	7.3 ± 1.9	12.6 ± 2.3	0.03
Vitamin C (mg/d)	49.6 ± 19.2	40.3 ± 20.0	56.1 ± 17.0	0.01
Vitamin B2 (mg/d)	2.6 ± 1.1	2.3 ± 1.0	2.4 ± 1.2	0.21
Vitamin B6 (mg/d)	2.5 ± 1.2	2.4 ± 1.5	2.3 ± 1.1	0.23
Calcium (mg/d)	933.5 ± 129.2	896.1 ± 134.5	910.2 ± 156.3	0.16
Iron (mg/d)	9.0 ± 2.3	8.1 ± 2.0	11.9 ± 3.6	0.01
Zinc (mg/d)	256.6 ± 93.2	217.6 ± 80.6	299.3 ± 78.6	0.01
Food groups				
Whole grains (g/d)	33.6 ± 51.5	30.1 ± 34.3	61.1 ± 51.5	0.01
Refined grains (g/d)	399.1 ± 109.5	363.3 ± 98.5	370.1 ± 100.9	0.16
Fruits (g/d)	291.1 ± 80.5	393.2 ± 67.6	381.3 ± 59.3	0.31
Vegetables (g/d)	229.2 ± 31.3	301.2 ± 39.6	279.6 ± 29.7	0.03
Red meat (g/d)	84.3 ± 11.6	71.2 ± 9.3	70.3 ± 10.5	0.05
Fish and poultry (g/d)	44.3 ± 10.3	32.5 ± 9.3	38.7 ± 9.5	0.17
Dairy (g/d)	339.5 ± 101.3	306.2 ± 90.0	311.7 ± 96.5	0.27
Legumes	29.1 ± 6.1	39.2 ± 5.3	53.2 ± 7.9	0.01

* ANCOVA was used for energy adjustment in quantitative variables; ** All the tertiles of soy intakes were adjusted for energy intake except for reporting the amount of energy

Table 5. Dietary quality indices of subjects' diet according to the tertiles of soy products*

Dietary intakes	Tertiles of soy products**			P
	1	2	3	
Energy density (Kcal/g)	1.50 ± 0.40	1.30 ± 0.40	1.20 ± 0.30	0.06
DDS	5.90 ± 1.00	6.70 ± 1.20	6.80 ± 1.20	0.03
HEI	56.10 ± 7.90	61.20 ± 8.30	60.30 ± 8.60	0.16
MAR	10.00 ± 1.70	11.20 ± 2.10	12.60 ± 2.00	0.02
NAR of different nutrients				
Zinc	0.91 ± 0.23	0.87 ± 0.29	0.89 ± 0.31	0.24
Vitamin B6	0.89 ± 0.16	0.89 ± 0.19	0.87 ± 0.18	0.53
Iron	0.88 ± 0.17	0.85 ± 0.21	0.83 ± 0.19	0.41
Calcium	0.93 ± 0.26	0.91 ± 0.27	0.90 ± 0.25	0.32
Vitamin C	0.87 ± 0.19	0.90 ± 0.21	0.96 ± 0.21	0.03
Vitamin B2	1.11 ± 0.21	1.23 ± 0.26	1.24 ± 0.29	0.16
Vitamin E	1.59 ± 0.36	1.57 ± 0.33	1.61 ± 0.39	0.17
Vitamin A	1.59 ± 0.33	1.60 ± 0.30	1.61 ± 0.31	0.22
Selenium	1.23 ± 0.36	1.36 ± 0.37	1.32 ± 0.34	0.26

* ANCOVA test was used for energy adjustment in quantitative variables; ** All the tertiles of soy intakes were adjusted for energy intake except for reporting the amount of energy; DDS: Dietary diversity score; HEI: Healthy eating index; MAR: Mean adequacy ratio; NAR: Nutrient adequacy ratio

Discussion

The results show that soy protein is the most purchased and consumed soy products among people living in Isfahan. The same findings of both the most purchased and consumed soy product indicate the conformity of the reported information. The least purchased and consumed products are soy yogurt and soy nut, respectively. By the age raises, the consumption of soy products increases. There is an inverse association between BMI and soy intake. More intakes of soy products are related to higher consumption of protein, vitamin C, zinc and iron intake and increased NAR, MAR, and DDS. Low intake of soy products is associated with lower consumption of whole grains and vegetables.

Studies have shown that soy intake is based mostly on easily accessible and ready-to-eat products in Western Europe and thus different from traditional soy products consumed by Asian population.[14] Our results revealed that the most

purchased and consumed soy product was soy protein. This shows an increasing approach toward modern soy products among Isfahan's people. However, soy nut were consumed at the minimum level, probably due to being a new product among Iranians and the fact that soy nut is not a baking form of soy products and is mostly used as a snack.

A Chinese study revealed that women aged 41-50 years had lower consumption of soy products compared with both younger and older women. Education level had also a direct relationship with soybean intake due to better understanding of soybean benefits. Moreover, women without a medical history of chronic disease consumed more soy foods than those engaged in chronic or digestive diseases.[31] Another study on Korean housewives demonstrated that the degree of perception and accompanied intake frequency had meaningful differences by age, education level, and economic level. Furthermore, taste and flavor showed great influence on the intake frequency of certain foods.[32] In contrast to previous findings, in this study we revealed a positive association between age and the consumption of soy products. But there was no significant relationship for sex, health, and economic conditions as well as number of children. High intake of soy products among older patients could be due to age-related diseases or health concerns regarding the prevention of chronic diseases. In agreement with previous studies,[33,34] we found that women consuming more soy products have lower BMI.

Among macronutrients, protein intake was higher in the last tertiles of soy consumption, but there were no changes in fat and carbohydrate intake. Iron, zinc, calcium, riboflavin, pyridoxine, and vitamin C were measured in the diet. More consumption of soy products is associated with higher intake of vitamin C, iron, and zinc. Studies have shown that women with higher intakes of soy foods were more likely to consume fruits and vegetables. Furthermore, they had a higher intake of total calories, fat, protein, dietary fiber, calcium, and folic acid, but a lower intake of carbohydrates.[35,36] Outcomes from our data revealed that subjects in the higher tertiles of soy consumption were likely to have higher intake of zinc, iron, and vitamin C which is because of higher intake of whole grains, rich in zinc and iron, and vegetables, rich in vitamin C. Although the consumption of animal sources of protein is low in the third tertile of soy intake, legumes are significantly consumed more among subjects with higher intake of soy products. Therefore, the vegetable sources of proteins may define the greater share of proteins in their diets.

To assess the quality of diet based on nutrient intake, we measured 4 indices including energy density (kcal/g),[37] DDS for food security detection, HEI for food guide conformance assessment and MAR. There were higher values of DDS and NAR for vitamin C and MAR but not HEI for those in a higher amount of soy consumption. More consumption of vegetables and whole grains in the highest tertiles of soy intake indicates higher values of MAR. Since the HEI is based on food groups, and we could not bring out any significant results for most of the HEI components, no significant finding was obtained for HEI in higher amount of soy intake.

Higher intake of carbohydrates is significantly associated with many risk factors of cardiovascular diseases. The consumption of potato and other carbohydrates are considerably increased among Iranian population.[38] Therefore, adding healthy foods including soy products as a substitute can decrease the consumption of simple carbohydrates.

Some strength could be considered for the current study. First, this is the first study which reports the whole intake of soy products and their subgroups as well as socio-demographic characteristics and individual intakes among the Iranian population. Second, since current study covers all municipalities of Isfahan city, the results represent the average intake of Isfahan's people. Although there are no data from other cities of Iran, the same distribution of soy products can generalize our results to other states. Prior studies considered a substantial role for soya preventing multiple chronic diseases,[7] so the results are expected to be used in improvement of nutrition education programs in order to recommend a sufficient intake of soy products and this is another strength of our findings. Although we asked all the individuals to participate in the study, few people did not accept to cooperate. This will reduce the generalization of study to some extent. Low cooperation of the subjects and shop owners as well as the possible not considered confounders are other limitations of our study.

Conclusion

In conclusion, soy protein is the most purchased and consumed sot product among Isfahans' residents. Inverse association was seen between BMI and soy intake. Higher intake of soy products is associated with more consumption of whole

grains and vegetables defining the greater share of zinc, iron, and vitamin C in the diet. Future analysis of the phytoestrogen content of separate consumed foods needs to be performed on the Iranian population. Moreover, assessment of soy products consumption in the other cities of Iran can provide a comprehensive data.

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Conflict of Interests

Authors have no conflict of interests.

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