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COMPARISON OF PHYTOESTROGENS DIETARY INTAKE FROM VEGETABLES AND FRUIT IN SELECTED POPULATION IN SLOVAKIA

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ABSTRACT

Phytoestrogens are compounds that are naturally present in almost all plant foods to a varying degree. They include several different classes of chemical compounds known as isoflavones, coumestans and lignans. In our work we analyzed intake of phytoestrogens is based upon our answer questionaries' in different ages. Evaluating health effects of phytoestrogens is difficult and depends on numerous factors, including the kind and dose (amount) of phytoestrogens eaten and the age, gender, and health of the person. We are exposed daily to highly variable amounts of phytoestrogens. While adults are eating a vegetarian diet or those taking dietary supplements containing phytoestrogens have high levels of exposure, infants drinking soy-based formula have the highest exposure levels by far. Accurate information about dietary phytoestrogens is therefore important but there is very limited data concerning food contents. In this study, we analyzed the phytoestrogen content in fresh and processed fruits and vegetables. The comprehensive database of phytoestrogen content determined simultaneously in vegetables and fruits foods has been developed. The important source of phytoestrogens in Slovak men and women is garlic. Phytoestrogen intake of fruits in men as an in woman is very low. Slovak populations consume a lot of fruits but the total intake is low due to the lower content of phytoestrogens.

Keywords: phytoestrogens; daily intake; vegetables; fruits

INTRODUCTION

Phytoestrogens are classified into groups according to their chemical structure. The greatest estrogenic activity is found in flavones, flavonols, flavanones, lignans, chalcones and isoflavones. The most common of these are the isoflavones and lignans, which are found mainly in fruit, vegetables and whole grains **(Leathaby et al., 2007)**. The intake of 400 – 600 $g.d^{-1}$ of fruits and vegetables is associated with reduced incidence of many common forms of cancer, and diets rich in plant foods are also associated with a reduced risk of heart disease and many chronic diseases of ageing. These foods contain phytochemicals that have anti-cancer and anti-inflammatory properties which confer many health benefits. Many phytochemicals are colourful, and recommending a wide array of colourful fruits and vegetables is an easy way to communicate increased diversity of intake to the consumer **(Herber, 2004)**.

Estrogens play a major role in the control of energy homeostasis and glucose metabolism. They act on hypothalamic nuclei controlling food intake, energy expenditure, and body fat distribution **(Mauvais-Jarvis et al., 2013)**. Phytoestrogens are naturally occurring estrogen-like compounds commonly found in various foods, especially soybeans and soy products, flaxseed, and sesame seed **(Miller and Snyder, 2012)**. Phytoestrogens are probably the most bioactive components of soy and interest in these compounds stems from their structural similarity to 17-estradiol (the most abundant circulating estrogen). Consequently phytoestrogens can interact with estrogen receptors (ER) and mediate estrogenic responses. For example, where endogenous levels of circulating estrogen are high (e.g. during the ovulatory menstrual cycle phase in pre-menopausal women), phytoestrogens can act as ER antagonists by competing with activity of natural estrogens, but with a lower potency. When circulating estrogen is low (e.g. in men or post-menopausal women), phytoestrogens can operate as ER agonists **(Pilsáková et al. (2010)**.

Phytoestrogens are plant-derived compounds that, because of their structural similarity with mammalian estrogens, may display both estrogenic and anti-estrogenic effects. There are three major classes of phytoestrogens: the isoflavones, lignans and coumestans. Isoflavones are found in high concentration in soybean, soybean products (e.g. tofu) and red clover. Lignans are mainly found in flaxseed. The amount of phytoestrogen in any given plant varies considerably based on location of crop, time of harvest and crop conditions, processing, and preparation. The metabolism of phytoestrogens in humans is complex: once ingested, lignans are transformed by the intestinal microflora and converted to hormone-like compounds, while isoflavones (which are present in soy as glycosides) are initially hydrolyzed by glucosidases of the intestinal bacteria and then metabolized to glucuronide conjugates in the intestine and liver. Thus the bioavailability of phytoestrogens depends on the intestinal microflora **(Woodside et al., 2006)**.

According to a number of epidemiological and clinical studies in this area, phytoestrogens have been generally accepted to have a beneficial, rather than a deleterious effect in humans. Potential health benefits of

phytoestrogens may be attributable to metabolic properties that do not involve estrogen receptors, such as influence on enzymes, protein synthesis, cell proliferation, angiogenesis, calcium transport, Na+/K+ adenosine triphosphatase, growth factor action, vascular smooth muscle cells, lipid oxidation, and cell differentiation **(Adlercreutz and Mazur, 1997; Knight and Eden, 1996)**.

A phytoestrogen-rich diet is known to increase urinary excretion and circulating plasma levels of phytoestrogen metabolites. However, it is not known how a phytoestrogen rich diet may affect intake of other nutrients. Phytoestrogens are found in soy products, legumes, fruit and vegetables, foods that have been proposed to have health-promoting effects. It is important, however, that the effect of inclusion of phytoestrogen-rich foods in the diet on the intake of other micro- and macronutrients is determined to assess the impact that public health nutrition messages to encourage an increase in soy consumption may have on the nutritional balance of the diet **(Borelli and Enrst, 2010)**.

The objective of our study was to estimate daily intake of the phytoestrogens from selected vegetables and fruit sources in selected Slovak population.

MATERIAL AND METHODOLOGY

A package of 60 questions has been carefully prepared and developed on the basis of literature previously published in scientific journal. The major questions covers: age; sex; dietary habits (focused to selected foods which are marked as the most common phytoestrogens sources) With the help of several options, respondents reported total intake of phytoestrogens from 13 kinds of vegetables including: broccoli, cabbage, carrots, corn, potatoes, garlic, salad, olives, onion, pumpkin, spinach, tomatoes and zucchini and 12 kinds of fruits as: apples, bananas, currants, blackberries, blueberries, dried apricots, dried dates, dried pears, dried grapes, grapefruit, grapes, orange, and peach.

We analyzed dietary intake of 9 phytoestrogens: formononetin (FOR), daidzein (DAI), gensteín (GEN), glycitein (GLY), matairesinol (MAT), larinesinol (LAR), pinolaricinesinol (PINO), secoiresinol (SECO) and coumestrol (COU). From total collected answers we subsequently recalculated number of each of the nine received phytoestrogens, depending on the specified frequency, portion or unit dose to each respondent separately. These data were calculated to determine accurately the individual phytoestrogens in vegetables, fruits (which was presented by **Thompson et al., (2006)**. After a recount of 293 respondents (217 women and 76 men) individually, we counted the total number of nine phytoestrogens, and we received a total amount of phytoestrogens for each respondent. This content was analyzed and recalculated to a daily intake of mg.100g^{-1}, depending on the gender and age of respondents. The number of men from 21 to 26 is shown separately because the number of these respondents was less than 10; the resulting average could thus adversely affect the correct information when comparing the intake of phytoestrogens. Men aged from 30 to 39 was recorded in our survey as one single respondent, while for women aged from 30 to 39 is not recorded any respondent. Statistics were calculated to summarize the eating occasions by kind of fruit and vegetables and age of respondents. For the calculation we used Microsoft Excel.

RESULTS AND DISCUSSION

Daily intake of phytoestrogen had been calculated according to data collected from dietary questionnaire, realized on 293 (divided into Males – covered by 76 individuals and Females – 217 individuals) respondents coming from Slovakia. Questionnaire was designed to determine intake frequency as well as amount of selected food fruits and vegetables. Respondents reported a total intake of 13 kinds of vegetables (Table 1 – Table 4) As is evident from the results of an important source of phytoestrogens in Slovak men and women is a garlic. Resulting values were compared with a study **Kuhnle et al., (2009**), which reported a single daily intake of phytoestrogens for the English population living in the UK. **Kuhnle et al., (2009)** reported a study of the data for the daily intake of broccoli: 0.07 mg.100 g^{-1}, cabbage 0.06 mg.100 g^{-1}, carrots 1.25 mg. 100 g^{-1}, garlic 0.09 mg.100 g^{-1}, 0.33 mg.100g^{-1}, olives 0.33 mg.100g^{-1}, onion 0.31 mg.100 g^{-1}, pumpkin 0.72 mg.100g^{-1} potatoes 0.40 mg.100 g^{-1}, corn 0.09 mg.100 g^{-1} tomatoes 0.07 mg.100 g^{-1}, due to the higher levels of phytoestrogens.

Table 1 Daily intake of phytoestrogens for men in selected vegetables mg.100 g^{-1}.

Age	Broccoli	Cabbage	Carrots	Corn	Potatoes	Garlic	Salad
21	0.009	0.008	0.000	0.000	0.022	0.147	0.000
22	0.010	0.015	0.000	0.001	0.032	0.252	0.003
23	0.011	0.008	0.000	0.000	0.023	0.067	0.002
24	0.003	0.016	0.002	0.002	0.022	0.294	0.006
25	0.004	0.003	0.001	0.000	0.022	0.012	0.000
26	0.003	0.008	0.000	0.000	0.005	0.012	0.000
30 – 39	0.057	0.016	0.002	0.001	0.000	0.098	0.011
40 – 49	0.003	0.008	0.001	0.000	0.020	0.148	0.004
50 – 59	0.006	0.024	0.001	0.000	0.053	0.234	0.001
60 – 69	0.006	0.011	0.000	0.000	0.027	0.141	0.001
70 – 79	0.004	0.018	0.000	0.000	0.016	0.151	0.001
80 – 89	0.015	0.012	0.000	0.000	0.025	0.116	0.000

Table 2 Daily intake of phytoestrogens for men in selected vegetables mg.100 g^{-1}.

Age	Olives	Onion	Pumpkin	Spinach	Tomatoes	Zucchini
21	0.004	0.003	0.000	0.000	0.003	0.001
22	0.008	0.014	5.388	0.000	0.003	0.000
23	0.001	0.004	0.000	0.000	0.003	0.000
24	0.001	0.077	0.000	0.000	0.011	0.000
25	0.000	0.005	0.000	0.000	0.000	0.000
26	0.000	0.001	0.000	0.000	0.000	0.000
30 – 39	0.006	0.019	0.000	0.004	0.011	0.009
40 – 49	0.000	0.019	0.000	2.084	0.015	0.003
50 – 59	0.000	0.024	0.000	0.000	0.006	0.000
60 – 69	0.000	0.017	0.000	0.000	0.004	0.000
70 – 79	0.000	0.010	0.000	0.000	0.002	3.820
80 – 89	0.000	0.017	0.000	0.000	0.002	0.000

Table 3 Daily intake of phytoestrogens for women in selected vegetables mg.100 g^{-1}.

Age	Broccoli	Cabbage	Carrots	Corn	Potatoes	Garlic	Salad
20 – 29	0.008	0.010	0.000	0.000	0.019	0.115	0.002
30 – 39	0.030	0.017	0.001	0.000	0.022	0.478	0.007
40 – 49	0.013	0.019	0.001	0.000	0.035	0.108	0.007
50 – 59	0.013	0.012	0.001	0.000	0.017	0.204	0.003
60 – 69	0.008	0.013	0.001	0.000	0.024	0.184	0.002
70 – 79	0.006	0.010	0.001	0.000	0.018	0.193	0.003
80 – 89	0.003	0.007	0.001	0.000	0.014	0.143	0.000

Table 4 Daily intake of phytoestrogens for women in selected vegetables mg.100 g^{-1}.

Age	Olives	Onion	Pumpkin	Spinach	Tomatoes	Zucchini
20 – 29	0.004	0.009	0.000	0.001	0.000	0.005
30 – 39	0.000	0.031	0.000	0.004	8.336	0.002
40 – 49	0.001	0.017	0.000	0.002	0.000	0.011
50 – 59	0.000	0.012	0.000	0.002	0.000	0.006
60 – 69	0.001	0.015	0.000	0.001	0.000	0.004
70 – 79	0.000	0.012	0.000	0.001	0.000	0.005
80 – 89	0.000	0.008	0.000	0.001	2.778	0.002

Table 5 Daily intake of phytoestrogens for men in selected fruits mg.100 g^{-1}.

Age	Apples	Bananas	Currants	Blueberries	Blackberries	Dried Apricots
21	0.001	0.000	0.006	0.000	0.002	0.000
22	0.001	0.000	0.000	0.001	0.000	0.004
23	0.002	0.000	0.000	0.000	8.946	0.002
24	0.012	0.001	0.002	0.000	0.001	0.000
25	0.001	0.000	0.000	0.000	0.000	0.000
26	0.004	0.000	0.000	0.000	0.000	0.000
30 – 39	0.000	0.000	0.000	0.000	0.000	0.000
40 – 49	0.001	0.000	0.001	0.000	0.000	0.216
50 – 59	0.003	0.000	0.005	0.013	0.002	0.000
60 – 69	0.003	0.000	0.000	0.000	0.000	0.006
70 – 79	0.002	0.000	0.001	0.003	0.000	0.004
80 – 89	0.007	0.001	0.000	0.000	0.000	0.000

In the next part of the questionnaire, respondents answer to the frequency of intakefor 12 kinds of fruits as: apples, bananas, currants, blackberries, blueberries, dried apricots, dried dates, dried raisins, grapes, grapefruit, orange and peach.

The result showed that Slovak populations consume a lot of fruits but the total intake is low due to the lower content

of phytoestrogens. That corresponding with study of free-living adults in the UK **(Day et al., 1999)**, such as bananas raw tomatoes apples and cucumbers also contained only small amounts of phytoestrogens. The results of men's daily intake (Table 5 and 6) were compared with a study **Curlej et al. (2015)** total phytoestrogens content of all fruits were for men aged 50 – 59 years 0.067 mg.100g^{-1} for men aged 60 – 69 years 0.017 mg.100g^{-1} and for men aged 70 – 79 years, the total sum received phytoestrogens 0.021 mg.100g^{-1}. When comparing our work with the presented study can be seen increases of phytoestrogens intake in men aged 51 – 59 years and another rise was recorded in the age group of men from 70 to 79 years. When men aged 60 – 69 years, were lower daily intake of phytoestrogens from fruits.

Results in the second gender determination, which women are (Table 7 and Table 8) were also compared with the study of **Curlej et al., (2015)** the total intake of phytoestrogens from fruits determined as follows: women aged 50 – 60 years are taken daily 0.033 mg.100 g^{-1}, aged 61 to 70 years was value 0.035 mg.100g^{-1}, women in the age group 71 – 80 years are taken daily 0.036 mg.100g^{-1}. Phytoestrogens from fruits in the age group 81– 90 years women take daily 0. 019 mg.100 g^{-1}. In our work we noted an increase in the daily intake of women aged 50 – 59 years (0.067 mg.100 g^{-1}) and a further increase in women aged 80 – 89 years (0.032 mg.100g^{-1}). For the remaining two age groups has been an increase in dietary intake of phytoestrogens on average 0.015 mg.100 g $^{-1}$. Average intake (summary for male and female) of isoflavones at retirees of selected Slovakia region is represented by following values: 0.0226 (50 – 60 age intervals); 0.1485 (61 – 70 age intervals); 0.2599 (71 – 80 age intervals) and 0.005 mg.day^{-1} (over 81).

Presented values are in accordance to conclusion identified in our work and apparently lower than those found in Japanese population (50 mg.day^{-1}) presented by **Messina (1995)**; or population of Asia (a range between 25 to 45 mg.day^{-1}) **(Coward et al., 1961)**.

Table 6 Daily intake of phytoestrogens for men in selected fruits mg.100 g^{-1}.

Age	Dried dates	Dried raisins	Grapefruit	Grapes	Orange	Peach
21	0.000	0.0000	0.000	0.000	0.000	0.003
22	0.000	0.000	0.000	0.000	0.004	0.002
23	0.002	0.001	0.000	0.000	0.004	0.002
24	0.009	0.004	0.002	0.011	0.037	0.020
25	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.000	0.000	0.000	0.005	0.001
30 – 39	0.000	0.000	0.000	0.000	0.001	0.003
40 – 49	0.216	0.014	6.303	0.000	0.001	0.002
50 – 59	0.021	0.001	0.000	0.004	0.017	0.004
60 – 69	0.000	0.000	0.000	0.001	0.006	0.004
70 – 79	0.007	0.000	0.000	0.001	0.002	0.001
80 – 89	0.000	0.001	0.000	0.012	0.011	0.000

Table 7 Daily intake of phytoestrogens for women in selected fruits mg.100 g^{-1}.

Age	Apples	Bananas	Currants	Blueberries	Blackberries	Dried Apricots
20 – 29	0.002	0.000	0.000	0.001	0.000	0.003
30 – 39	0.002	0.000	0.000	0.000	0.000	0.000
40 – 49	0.006	0.001	0.000	0.000	0.000	0.016
50 – 59	0.005	0.000	0.002	0.001	0.001	0.002
60 – 69	0.004	0.000	0.001	0.001	0.000	0.007
70 – 79	0.004	0.000	0.001	0.001	0.000	0.011
80 – 89	0.003	0.000	0.000	0.000	5.964	0.036

Table 8 Daily intake of phytoestrogens for women in selected fruits mg.100 g^{-1}.

Age	Dried dates	Dried raisins	Grapefruit	Grapes	Orange	Peach
20 – 29	0.002	0.000	0.000	0.001	0.004	0.007
30 – 39	0.000	0.000	0.000	0.000	0.000	0.000
40 – 49	0.003	0.000	0.000	0.001	0.002	0.008
50 – 59	0.015	0.000	0.000	0.003	0.005	0.007
60 – 69	0.001	0.000	0.000	0.001	0.005	0.004
70 – 79	0.002	0.000	0.000	0.001	0.003	0.003
80 – 89	0.000	0.000	0.000	0.000	0.002	0.002

CONCLUSION

Phytoestrogens are estrogen hormone-like chemicals found in plants. They include a group of chemicals such as isoflavones, flavones, coumestans and lignans. Phytoestrogens are available in medically formulated pills. However, dietary phytoestrogen can also be found naturally in wide variety of plant and fruit based foods, with the amount varying depending on the plant and fruit type. The study demonstrated that phytoestrogen sources are diverse. Food is also a part of traditions and culture. This can mean that eating has an emotional component as well. Sources of phytoestrogens from fruits and vegetables are different depending on dietary habits and traditions of the Slovak population.

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