Intake of Dietary Phytoestrogens by Dutch Women

Lital Keinan Boker,*2 Yvonne T. Van der Schouw,* Miriam J. J. De Kleijn,* Paul F. Jacques,† Diederick E. Grobbee* and Petra H. M. Peeters*

*The Julius Center for General Practice and Patient Oriented Research, University Medical Center Utrecht, 3508 GA, Utrecht, The Netherlands and †Jean Mayer U.S. Department of Agriculture Human Nutrition Research Center on Aging at Tufts University, Boston, MA 02111

ABSTRACT Higher consumption of phytoestrogens might be protective against certain chronic diseases. Accurate quantification of habitual phytoestrogen intake is important for assessing associations between phytoestrogens and risk for certain diseases. The aim of this study was to estimate dietary intake of phytoestrogens in Dutch middle-aged and elderly women and to describe their main sources. Women were recruited between 1993 and 1997 and aged 50–69 y at enrollment (Prospect-EPIC; n = 17,357). A detailed food frequency questionnaire referring to the preceding year was filled in at recruitment. A literature search was conducted to obtain data regarding content of the isoflavones daidzein, genistein, formononetin, biochanin A, the coumesterol coumestrol and the lignans matairesinol and secoisolariciresinol in relevant food items. Concentrations of each phytoestrogen in each food item were subsequently grouped by seven categories; group scores were multiplied by daily intakes of food items and then summed across food items to produce for each participant a total daily intake score for each phytoestrogen. Approximately 75% of participants were postmenopausal at recruitment. The mean age was 57 y. Geometric means of daily intake of daidzein, genistein, formononetin, biochanin A, coumesterol, matairesinol and secoisolariciresinol were 0.15, 0.16, 0.08, 0.001, <0.001, 0.07 and 0.93 mg, respectively. The main sources for isoflavones were peas and beans, nuts, grain products, coffee, tea and soy products. The main sources for coumestans were peas, beans and other vegetables. The main sources of lignans were grain products, fruits and alcoholic beverages (red and white wines). We conclude that intake levels of phytoestrogen in our study population are low; however, they are comparable with intake levels previously reported for other Western cohorts. In this population, phytoestrogen intake consisted largely of lignans.


KEY WORDS: • phytoestrogens • isoflavones • coumestans • lignans • food frequency questionnaire

Phytoestrogens, natural plant substances, are subdivided into three main classes: isoflavones, lignans and coumestans (1). Isoflavones are predominantly found in soybeans and other legumes (1–5). Two of the major isoflavones are genistein and daidzein. They are both present in plants and may also be metabolized from other isoflavonoid plant precursors, biochanin A and formononetin, respectively (1–5). Gut bacterial flora may further metabolize daidzein into equol or O-demethylangolensin (O-Dma),3 and genistein into p-ethyl phenol. Daidzein, genistein, equol and O-Dma are the major phytoestrogens detected in blood and urine of humans and animals (1–5).

Lignans form the building blocks for lignin, which is a main component of the plant cell wall. They are found mostly in oil seeds (i.e., flaxseed), whole grains, legumes, vegetables, berries and other fruits (1–5). Enterolacton and enterodiol, the main mammalian lignans, are formed from the plant lignans matairesinol and secoisolariciresinol, respectively, and possibly from other yet unknown plant precursors, by gut micro-flora. The chemical structure of the mammalian lignans differs somewhat from that of their plant precursors (1–6). Coumestans occur predominantly during germination, for example, in bean sprouts; the main compound in this subgroup is coumestrol (1).

Bioavailability of phytoestrogens varies among individuals and depends on many factors, such as habitual diet (7–10), duration of soy consumption (10–12), gender (11), different individual metabolism patterns that might be determined by genetic factors (13), and different bacterial flora (14,15).

Structurally, coumestans and isoflavones resemble endogenous steroid estrogen and are able to bind to the estrogen receptor (ER), preferably ERβ, although their binding affinity depends on their plasma concentration and is several-fold lower than that of endogenous estradiol. Both phytoestrogen subclasses have demonstrated ER-mediated estrogenic properties (transcriptional activity). They were also suggested to act as anti-estrogens by competing with the more potent endogenous estrogen on the ER; however, it seems that their anti-estrogenic potential is not ER-mediated (16). Lignans hardly show binding affinity to ER (16). Besides their hormonally mediated influences, phytoestrogens were shown to have anti-oxidative, antiproliferative and anti-angiogenic activities.
which were not hormonally-dependant, in many in vitro and animal studies (1–5,17,18).

Epidemiological studies suggest that consumption of a phytoestrogen-rich diet, as seen in traditional Asian societies, is associated with a lower risk of the so-called Western diseases (1–4,19–21), i.e., coronary heart disease (22–25), osteoporosis (26–32), menopausal symptoms (33,34) and certain cancers (35,36), such as prostate (37,38), breast (39–47), and possibly colorectal cancer (48,49).

Accurate quantification of habitual phytoestrogen intake is difficult. Soy intake may serve as a good approximation for isoflavones intake in Asian populations that consume soy traditionally (50). However, Western populations consume soy quite infrequently, while lignan sources such as whole oil seeds, grains, fruit, vegetables and nuts are more popular (3,51–54). Estimation of isoflavones intake is mostly based on dietary questionnaires, diaries or interviews (37,39–43,48) in which soy food consumption serves as a proxy for isoflavones. Urinary levels of isoflavones may also be used (7,9,10,44–47,53,54). It was shown that the accuracy of the different assessment methods for isoflavones intake is comparable (55).

For lignans, assessment of intake was mostly done by biomarkers levels, either in blood (6,8) or in urine (7,9,47,53,54). For both subgroups of phytoestrogens, a single serum measurement may reflect, although not perfectly, an individual’s long-term intake, but mostly it is true for lignans (56).

Recently, a method of estimating daily phytoestrogen intake, based on daily intake of certain food items for which values of phytoestrogen content are available (through publications in the literature based on direct measurements in laboratories) was developed (52,57,58) and used (51,52,59,60). We used a similar measurement tool to estimate the daily intake of phytoestrogens in the Dutch women participating in the Prospect/European Prospective Investigation into Cancer and Nutrition (EPIC) cohort. In addition, the main sources of phytoestrogen consumption in this population were assessed.

**SUBJECTS AND METHODS**

**Subjects.** Our study population consisted of the Dutch participants of the EPIC cohort, conducted in Utrecht, The Netherlands (prospect-EPIC) (unpublished data). The cohort includes 17,357 women aged 49–70 y, residing in Utrecht and vicinity, who were recruited between 1993 and 1997 through a regional program for breast cancer screening (34.5% response). All signed an informed consent. At recruitment, each participant filled in a general questionnaire concerning life style factors, gynaecological and obstetric history and past and current morbidity, as well as a food frequency questionnaire (FFQ) aimed at describing the habitual diet during the year preceding enrolment. In addition, pulse rate, blood pressure and a few other food items were added to the list because of specific hypotheses (e.g., garlic) or as a result of expected changes in food patterns (e.g., low fat products). The questionnaire contained color photographs of two to four different-sized portions of 21 food items, and the given answers enabled participants to indicate whether they ate as much as any of the portions shown, less than the smallest, or more than the largest. Subjects could indicate their consumption frequency of each food item on a daily/weekly/monthly/yearly scale or as never consumed. For several food items, additional questions regarding consumption frequency of sub-items were asked. Questionnaires also included some blank-spaced questions, in which names of brands used (e.g., margarine) could be filled in. One of the questions in the FFQ referred to intake of tofu, tempeh and vegetable burgers, and it also included a blank space for filling out other similar foods taken (such as miso and soy milk).

In total, the information obtained by the FFQ enabled the estimation of the habitual daily consumption of 178 food items (in g/d). The FFQ was validated before the study (62,63).

**Scoring phytoestrogen intake.** We decided to group the literature values for phytoestrogen content in foods in seven categories instead of using the actual values to avoid implying a degree of accuracy for which the currently available data are too limited and too preliminary. The method used in our study was described elsewhere in detail (52) and was slightly modified. Briefly, using the data obtained through our literature review, we calculated and assigned for each of the FFQ relevant items, concentrations of the isoflavones daidzein, genistein, foronononetin, biochanin A, the coumestan coumestrol and the lignans matairesinol and secoisolariciresinol. We applied the following guidelines: all values found in the literature were converted to mg/100 g food; values expressed on a dry weight basis were converted to wet weight basis by using moisture content provided by the author or by assuming commonly expected moisture content for that particular food (64), or by using adjustments for the method of preparation (65); if wet and dry weights were reported from different original sources in the literature, we chose the reported wet weight value; in the case that wet weight values equaled zero in the literature while dry weight values did not, we used the dry weight values and converted them back into wet weight values; when different values were reported from the same or different original sources in the literature, the highest value reported was chosen; when a specific phytoestrogen concentration was reported as trace or traceable, 0.00001 mg/100 g was assigned, based on the sensitivity of the gas chromatography-mass spectrometry method used by Mazur et al. (66); if no information about phytoestrogen content of a certain food item was available, we assigned a proxy value based on a similar food item, i.e., from the same botanical group, if available. If not available, we assigned the value zero; if the questionnaire listed similar food items on the same question, a mean of phytoestrogen content was computed, weighted according to the frequencies of Dutch consumption of these items (61). However, if data for one or more food items were unavailable, data for a similar food item (e.g., same botanical group) were used as a proxy. If no data, accurate or proxy, could be obtained for a certain food item, its contribution to the total phytoestrogen content was considered to zero; when there was no information available on the lignan precursors matairesinol and secoisolariciresinol, we estimated these values by using data on the biologically active substances enterolactone and enterodiol, if available (67). This was done by comparing data for food items with a known content of both lignan precursors (matairesinol and secoisolariciresinol) and active substances (enterolactone and enterodiol) and subsequently estimating the general difference between the precursors and the active substances in orders of magnitude, then applying these results to those food items that lacked information regarding lignan precursor content but did have information regarding active substances values; estimation of phytoestrogen content in breakfast cereals was

**Prospect-EPIC FFQ.** The self-administered FFQ contained questions about the average consumption frequency during the past year for 227 food items. These food items were selected through the database of the Dutch National Food Consumption Survey 1987–1988 (61), and, subsequently, a list of products that accounted for at least 90% of the population mean intake of the food groups and nutrients of interest was created. A few other food items were added to the list because of specific hypotheses (e.g., garlic) or as a result of expected changes in food patterns (e.g., low fat products). The questionnaire contained color photographs of two to four different-sized portions of 21 food items, and the given answers enabled participants to indicate whether they ate as much as any of the portions shown, less than the smallest, or more than the largest. Subjects could indicate their consumption frequency of each food item on a daily/weekly/monthly/yearly scale or as never consumed. For several food items, additional questions regarding consumption frequency of sub-items were asked. Questionnaires also included some blank-spaced questions, in which names of brands used (e.g., margarine) could be filled in. One of the questions in the FFQ referred to intake of tofu, tempeh and vegetable burgers, and it also included a blank space for filling out other similar foods taken (such as miso and soy milk). In total, the information obtained by the FFQ enabled the estimation of the habitual daily consumption of 178 food items (in g/d). The FFQ was validated before the study (62,63).
done using the manufacturers’ declarations (following a mailed request) about their grains and fiber content.

Subsequently, we grouped the phytoestrogen concentration of each relevant food item into one of seven categories (Table 1), and, finally, we multiplied the phytoestrogen score of each food item by its consumption quantity per day for each participant. This final phytoestrogen score was summed across foods to obtain a total intake score for each phytoestrogen per each participant, per day (52).

**Data analysis.** General characteristics of the study population are presented. Mean intake (arithmetic and geometric) and standard deviations of phytoestrogens (in scores of intake) and certain nutrients and food groups were calculated, including medians of intake and interquartile range. For some food groups, we present the Dutch recommended daily allowances (68). The main sources of isoflavones, coumestans and lignans in the diet of our study population are also described.

All analyses were done by using SPSS for Windows, Version 9.0 (69), and the SAS Statistical Package, Version V8 (SAS, Cary, NC).

**RESULTS**

Phytoestrogens concentration (mg/100 g of selected food item) in the FFQ are listed in Appendix A.

Almost all participants were born in The Netherlands. Mean age at recruitment was ~57 y, and most of the study participants were postmenopausal at study entry (defined as cessation of menstruation for at least 12 mo; Table 2).

Means of daily intake of certain food groups and nutrients, including the Dutch recommended daily allowances are presented in Table 3. Approximately 16% of the mean daily energy intake derived from protein, 36% from fat and 44% from carbohydrates (Table 3).

The arithmetic means of daily intakes were 0.37 ± 1.24 mg for daidzein, 0.42 ± 1.33 mg for genistein, 0.09 ± 0.05 mg for formononetin, 0.001 ± 0.001 mg for biochanin A, 0.0002 ± 0.0002 mg for coumestrol, 0.08 ± 0.05 mg for matairesinol and 1.03 ± 0.04 mg for secoisolariciresinol. Although distribution of coumestrol and the lignans followed the normal curve, isolavone intake values were positively skewed. Therefore, phytoestrogens intake values were logarithmically transformed to produce an approximately normal distribution curve. Estimates for means for the log-transformed intakes were later exponentiated to obtain the geometric means and respective 95% confidence intervals (CI; Table 4). The median intake score and interquartile range for the phytoestrogens studied are also presented, and geometric means of isoflavones corresponded closely to its medians.

The main sources of daily intake of all phytoestrogens were studied by food groups and are presented in Table 5. Over 80% of the daily intake of all isoflavones was derived from vegetables, breakfast cereals, grain products, coffee/tea, traditional soy foods and nuts. Peas and beans served as the main source of almost all isoflavones. Nuts were an important source of biochanin A. Use of traditional soy foods was not common in this population; they were responsible for only 6.5% of the total daily intake of daidzein and genistein.

Vegetables accounted for most of the daily intake of coumestrol, most of it derived from peas and beans, and ~30% was derived from other (non-potatoes and non-leafy) vegetables.

Grain products, vegetables, fruit, coffee/tea and alcoholic beverages accounted for over 85% of the total daily intake of the lignans matairesinol and secoisolariciresinol. Grain products were the richest source of both lignans followed by coffee and tea (Table 5).

**DISCUSSION**

There is increasing interest in soy because of its perceived beneficial effects on health and its possible role in chronic disease prevention. Our study was designed to assess the habitual daily intake of phytoestrogens in middle-aged and elderly Dutch women. Intake was generally low, and most phytoestrogens were consumed in the form of lignans. These findings agree with previously published data of phytoestrogen intake in Western populations (51,52).

In our study population, total isoflavone consumption was estimated to be ~0.9 mg/d (according to arithmetic means). These results are comparable with previously published findings: total isoflavone intake among Californian women (whites, Latino-Americans and Afro-Americans) was estimated to be ~2.9 mg/d (51) and among postmenopausal American women in the Framingham study, ~0.8 mg/d (52). A comparison of the results of the three currently available descriptive studies of phytoestrogen dietary intake in Western populations is presented in Table 6. In contrast, daily intakes in Oriental diets are 10- to 40-fold higher: daily intake of isoflavones in Chinese women in Shanghai was estimated to be ~40 mg (70). Median daily intakes of daidzein and genistein among Japanese men were estimated to be ~9.5–12.1 mg and 14.9–19.6 mg, respec-

### Table 1

**Grouping of phytoestrogen concentrations into score categories**

<table>
<thead>
<tr>
<th>Phytoestrogen, mg/100 g</th>
<th>Phytoestrogen score, mg/100 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.00001–0.00099, trace</td>
<td>0.0005</td>
</tr>
<tr>
<td>0.001–0.0099</td>
<td>0.005</td>
</tr>
<tr>
<td>0.01–0.99</td>
<td>0.5</td>
</tr>
<tr>
<td>1–9.99</td>
<td>5</td>
</tr>
<tr>
<td>10 and over</td>
<td>50</td>
</tr>
</tbody>
</table>

### Table 2

**Characteristics of the study population**

| Married/living together, % | Born in The Netherlands, % | Academic education, % | Past/current smoker, % | Age, y | Height, cm | Weight, kg | BMI, kg/m² | Waist to hip ratio | Age at menarche, y | Ever pregnant, % | Ever at first delivery, y | Median number of children, n | Ever use of oral contraceptives, % | Menopause Total, % | Natural, % | Age at menopause, y | Age at natural menopause, y | Ever use of HRT, % |
|----------------------------|-----------------------------|------------------------|------------------------|--------|------------|------------|------------|-------------------|---------------------|------------------|--------------------------|---------------------------|----------------------|--------------|------------------|------------------------|------------------|
| 77                         | 95                          | 16                     | 56                     | 57.1   | 164.3      | 70.2       | 26.0       | 0.8               | 13.4               | 88               | 21.5                    | 2                   | 64                    | 75            | 37               | 47.4                   | 49.6             | 26               |
Not only are intakes of isoflavones among Western subjects substantially lower compared to oriental subjects, types and sources of phytoestrogens consumed differ as well. The phytoestrogen intake, up to 48 h (4,12), and are influenced by the bioavailability of phytoestrogens consumed (gut microflora, use of antibiotics, gender, etc.). However, since the instrument was not specifically designed for assessing phytoestrogen intake, it did not include information concerning certain food items that might have contributed to the total phytoestrogen intake in our population. Therefore, our results probably underestimate the true intake of phytoestrogens. Moreover, unsuspected and hidden sources of soy could not be accounted for and may also lead to an underestimation of phytoestrogen intake in our population. Soy protein has been long utilized in food production systems, i.e., whole soybeans processed into snack foods, beverages and fermented foods; soy flour and grits blended into corn, wheat or sorghum and used in cereal mixtures or baked goods; soy proteins used in processed meat products or added to soup stock cubes and doughnuts (75–77). In addition, lack of data concerning presence and content of lignans in foods could lead to additional inaccuracies when assessing phytoestrogen intake in Western populations, which tend to consume more lignans than Oriental populations.

### TABLE 3

<table>
<thead>
<tr>
<th>Food group</th>
<th>Mean ± sd</th>
<th>Median (interquartile range)</th>
<th>Recommended daily allowance1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes, g/d</td>
<td>85.08 ± 56.03</td>
<td>73.05 (45.71–111.96)</td>
<td>150–250</td>
</tr>
<tr>
<td>Bread, g/d</td>
<td>124.00 ± 46.69</td>
<td>120.99 (93.00–151.84)</td>
<td>150–180</td>
</tr>
<tr>
<td>Wheat products, g/d</td>
<td>35.94 ± 35.26</td>
<td>25.71 (12.00–47.94)</td>
<td>NA2</td>
</tr>
<tr>
<td>Fruit, g/d</td>
<td>232.38 ± 139.15</td>
<td>231.58 (125.31–306.86)</td>
<td>200</td>
</tr>
<tr>
<td>Vegetables, g/d</td>
<td>143.68 ± 53.38</td>
<td>136.65 (106.92–174.05)</td>
<td>150–200</td>
</tr>
<tr>
<td>Soy products, g/d</td>
<td>10.62 ± 12.28</td>
<td>0.00 (0.00–0.00)</td>
<td>NA</td>
</tr>
<tr>
<td>Nuts and snacks, g/d</td>
<td>12.65 ± 13.85</td>
<td>7.99 (3.33–16.61)</td>
<td>NA</td>
</tr>
<tr>
<td>Soup, g/d</td>
<td>69.06 ± 72.14</td>
<td>35.71 (16.67–71.43)</td>
<td>NA</td>
</tr>
<tr>
<td>Total beverages, mL/d</td>
<td>1553.52 ± 516.37</td>
<td>1489.08 (1194.79–1837.68)</td>
<td>≥1,500</td>
</tr>
<tr>
<td>Nutrients</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total energy, kJ/d</td>
<td>7525.79 ± 1826.02</td>
<td>7383.22 (6293.32–8564.83)</td>
<td>7800–8200</td>
</tr>
<tr>
<td>Total protein, g/d</td>
<td>71.68 ± 17.99</td>
<td>70.47 (59.74–82.13)</td>
<td>52</td>
</tr>
<tr>
<td>Total fat, g/d</td>
<td>71.51 ± 23.03</td>
<td>68.85 (55.49–84.40)</td>
<td>30–35% of total energy</td>
</tr>
<tr>
<td>Total carbohydrates, g/d</td>
<td>199.82 ± 53.46</td>
<td>195.18 (163.17–231.48)</td>
<td>55% of total energy</td>
</tr>
<tr>
<td>Total fiber, g/d</td>
<td>22.59 ± 5.58</td>
<td>22.32 (18.87–25.98)</td>
<td>NA</td>
</tr>
<tr>
<td>Total water, mL/d</td>
<td>2521.17 ± 620.29</td>
<td>2453.38 (2100.02–2878.91)</td>
<td>≥1500</td>
</tr>
</tbody>
</table>

1 Refer to (69).
2 Not available.

### TABLE 4

<table>
<thead>
<tr>
<th>Phytoestrogen</th>
<th>Mean intake score (95% CI)1 (geometric mean)</th>
<th>Median intake score (interquartile range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daidzein</td>
<td>0.151 (0.021; 1.220)</td>
<td>0.134 (0.094–0.191)</td>
</tr>
<tr>
<td>Genistein</td>
<td>0.161 (0.025; 0.899)</td>
<td>0.141 (0.091–0.224)</td>
</tr>
<tr>
<td>Formononetin</td>
<td>0.077 (0.026; 0.234)</td>
<td>0.079 (0.055–0.117)</td>
</tr>
<tr>
<td>Biochanin A</td>
<td>0.001 (0.0003; 0.004)</td>
<td>0.001 (0.0008–0.0017)</td>
</tr>
<tr>
<td>Coumesterol</td>
<td>0.0002 (0.00005; 0.00006)</td>
<td>0.0002 (0.0001–0.0003)</td>
</tr>
<tr>
<td>Matairesinol</td>
<td>0.065 (0.016; 0.262)</td>
<td>0.073 (0.043–0.106)</td>
</tr>
<tr>
<td>Secoisolariciresinol</td>
<td>0.926 (0.577; 1.494)</td>
<td>0.988 (0.676–1.285)</td>
</tr>
</tbody>
</table>

1 CI, confidence interval.
In conclusion, phytoestrogen intake is rather low among Dutch middle-aged and elderly women. Foods other than the traditional soy-based foods are the major source of phytoestrogen intake among this population, as in other Western populations (51, 52). The relative contribution of the various foods to total intake of phytoestrogens may vary by population demographics (habitual dietary patterns), brands of certain foods consumed and studied (i.e., soy additives) and the food frequency instruments used. Future research on the associations between phytoestrogen intake and certain endpoints should examine a large variety of foods in addition to the traditional soy-based foods and will benefit from using a measurement tool aimed primarily at assessing phytoestrogen intake, such as recently presented by Horn-Ross et al. (58).

ACKNOWLEDGMENTS

We thank Sheila Bingham, Witold Mazur and Herman Adlercreutz for their contributions to the data and Hanneke J. H. Den

### TABLE 5

**Intakes of phytoestrogen by food groups by Dutch women**

<table>
<thead>
<tr>
<th>Food group</th>
<th>Daidzein</th>
<th>Genistein</th>
<th>Formononetin</th>
<th>Biochanin A</th>
<th>Coumesterol</th>
<th>Matairesinol</th>
<th>Secoisolariciresinol</th>
</tr>
</thead>
<tbody>
<tr>
<td>% daily intake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td>31.8(^1)</td>
<td>31.0(^1)</td>
<td>49.8(^1)</td>
<td>35.2</td>
<td>97.2(^1)</td>
<td>6.4</td>
<td>8.2</td>
</tr>
<tr>
<td>Peas/beans</td>
<td>28.6</td>
<td>25.7</td>
<td>49.8</td>
<td>35.2</td>
<td>62.2</td>
<td>&lt;0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Potatoes</td>
<td>2.1</td>
<td>4.1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>4.8</td>
<td>5.6</td>
</tr>
<tr>
<td>Leafy vegetables(^2)</td>
<td>0.6</td>
<td>0.4</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1.1</td>
<td>1.9</td>
</tr>
<tr>
<td>Other</td>
<td>0.5</td>
<td>0.8</td>
<td>&lt;0.1</td>
<td>—</td>
<td>35.0</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Fruit</td>
<td>4.3</td>
<td>2.1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>3.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Berries</td>
<td>0.1</td>
<td>0.8</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2.8</td>
<td>4.1</td>
</tr>
<tr>
<td>Non-berries</td>
<td>4.2</td>
<td>1.3</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.8</td>
<td>9.9</td>
</tr>
<tr>
<td>Fruit/vegetable juice</td>
<td>1.5</td>
<td>&lt;0.1</td>
<td>—</td>
<td>—</td>
<td>0.3</td>
<td>0.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Fruit juices</td>
<td>1.0</td>
<td>&lt;0.1</td>
<td>—</td>
<td>—</td>
<td>0.2</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Vegetable juices</td>
<td>0.5</td>
<td>&lt;0.1</td>
<td>—</td>
<td>—</td>
<td>0.1</td>
<td>1.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Coffee/tea</td>
<td>16.3</td>
<td>4.8</td>
<td>24.3</td>
<td>—</td>
<td>—</td>
<td>12.2</td>
<td>22.8</td>
</tr>
<tr>
<td>Coffee</td>
<td>14.5</td>
<td>4.8</td>
<td>24.3</td>
<td>—</td>
<td>—</td>
<td>12.2</td>
<td>7.0</td>
</tr>
<tr>
<td>Tea</td>
<td>1.8</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Traditional soy foods</td>
<td>6.5</td>
<td>6.5</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Breakfast cereals</td>
<td>17.2</td>
<td>14.4</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>7.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Grain products</td>
<td>15.5</td>
<td>11.9</td>
<td>6.2</td>
<td>0.1</td>
<td>2.3</td>
<td>62.9(^1)</td>
<td>40.8(^1)</td>
</tr>
<tr>
<td>Bread</td>
<td>15.4</td>
<td>11.8</td>
<td>6.2</td>
<td>0.1</td>
<td>2.3</td>
<td>54.2</td>
<td>40.7</td>
</tr>
<tr>
<td>Cakes/cookies</td>
<td>0.1</td>
<td>0.1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>5.5</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Pasta/rice</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>3.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Nuts (mostly peanuts)</td>
<td>3.8</td>
<td>16.2</td>
<td>2.1</td>
<td>45.0(^1)</td>
<td>—</td>
<td>0.1</td>
<td>4.8</td>
</tr>
<tr>
<td>Alcohol</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>—</td>
<td>6.4</td>
<td>1.1</td>
<td>1.3</td>
</tr>
<tr>
<td>Other</td>
<td>3.1</td>
<td>13.1</td>
<td>17.5</td>
<td>19.6</td>
<td>0.3</td>
<td>1.1</td>
<td>6.4</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

\(^1\) Main sources (by foodgroups) for isoflavones, coumestans and lignans intake.
\(^2\) Leafy vegetables = cabbage/lettuce/chicory/endive/spinach.

### TABLE 6

**Intakes of phytoestrogen in Western populations—a comparison of the available data**

<table>
<thead>
<tr>
<th>Population</th>
<th>Horn-Ross et al. 2000 (52)</th>
<th>De Kleijn et al.(^1) 2001 (53)</th>
<th>Present study(^1) The Prospect-EPIC study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>American white, Latina and Afro-American women</td>
<td>American white women</td>
<td>Dutch white women</td>
</tr>
<tr>
<td>n</td>
<td>447</td>
<td>964</td>
<td>17,140</td>
</tr>
<tr>
<td>Age, y</td>
<td>50–79</td>
<td>35–81</td>
<td>50–69</td>
</tr>
<tr>
<td>mg/d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daidzein</td>
<td>1.48</td>
<td>0.29</td>
<td>0.37</td>
</tr>
<tr>
<td>Genistein</td>
<td>1.28</td>
<td>0.34</td>
<td>0.42</td>
</tr>
<tr>
<td>Formononetin</td>
<td>0.08</td>
<td>0.12</td>
<td>0.09</td>
</tr>
<tr>
<td>Biochanin A</td>
<td>0.03</td>
<td>0.01</td>
<td>0.001</td>
</tr>
<tr>
<td>Total isoflavones</td>
<td>2.87</td>
<td>0.76</td>
<td>0.88</td>
</tr>
<tr>
<td>Coumesterol</td>
<td>0.21</td>
<td>0.01</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total coumestans</td>
<td>0.21</td>
<td>0.01</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Matairesinol</td>
<td>0.04</td>
<td>0.02</td>
<td>0.08</td>
</tr>
<tr>
<td>Secoisolariciresinol</td>
<td>0.14</td>
<td>0.62</td>
<td>1.03</td>
</tr>
<tr>
<td>Total lignans</td>
<td>0.18</td>
<td>0.64</td>
<td>1.11</td>
</tr>
</tbody>
</table>

\(^1\) Results presented as scores of phytoestrogen intake.
LITERATURE CITED


## APPENDIX A

### Concentration of phytoestrogens in selected foods items (EPIC-FFQ)—the basis for scoring

<table>
<thead>
<tr>
<th>Isoflavones</th>
<th>Coumestans</th>
<th>Lignans precursors</th>
<th>Lignans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daidzien</td>
<td>Genistein</td>
<td>Formonon.</td>
<td>Coumesterl</td>
</tr>
</tbody>
</table>

**mg of phytoestrogens/100 g product**

### Breakfast cereals and other grains
- **Muesli**: 1.33768058 1.373014 0.000852 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965
- **Cornflakes**: 0 0 0.000000 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965
- **White rice**: 0 0 0.000000 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965
- **Brown rice**: 0.169 0.128
- **Wheat pasta**: 0.0009083 0.00000083 0.0000003 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965

### Bread and baked goods
- **White bread**: 0.00000058 0.00000058 0.0000003 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965
- **Whole grain bread**: 0.01 0.01 0.0024 0.0707 0.483006
- **Brown bread**: 0.00000058 0.00000058 0.0000003 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965
- **Rye bread**: 0 0 0 0 0 0 0
- **Breakfast rye cake**: 0 0 0 0 0
- **Apple cake**: 0.00125196 0.00000073 0.0000003 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965
- **Fruit cake**: 0.0001088 0.0000372 0.03030 0.0492
- **Cookie filled with almonds**: 0.00011038 0.00000034 0.0000003 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965

### Fruit
- **Apples**: 0.00227292 0.000001 0 0 0 0 0 0 0
- **Pears**: 0.00000486 0.00008748 0.01129 0.027 0.012
- **Oranges**: 0 0 0 0 0
- **Mandarins**: 0.0003 0.0029 0 0 0 0 0 0 0
- **Grapefruit**: 0 0 0 0 0 0 0
- **Citrus fruit, mixed**: 0 0 0 0 0 0 0 0 0
- **Banana**: 0 0 0 0 0 0 0 0 0
- **Strawberries**: 0.0000005 0.0000046 0.0000003 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965
- **Grapes**: 0.00125196 0.00000073 0.0000003 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965
- **Peaches (proxy: plum)**: 0.0000005 0.0000003 0.0000003 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965
- **Cherries (proxy: plum)**: 0 0 0 0 0 0 0 0 0
- **Kiwi**: 0.00125196 0.00000073 0.0000003 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965
- **Melon**: 0 0 0 0 0 0 0 0 0
- **Watermelon**: 0.00000001 0.00000004 0.00000001 0.00000001 0.00000001 0.21899621 0.02116253 0.029130 0.032965

### Vegetables
- **Potatoes, fries**: 0.0010 0.0027 0 0 0 0 0 0 0
- **Garlic**: 0.00005 0.0009364 0.0162 0.1713 0.081 0.326
- **Regular lettuce**: 0.00005 0.00001 0.000001 0.000001 0.000001 0.21899621 0.02116253 0.029130 0.032965
- **Cucumber**: 0 0 0 0 0 0 0 0 0
- **Tomato**: 0.0033 0 0 0 0 0 0 0 0
- **Carrots**: 0.00019968 0.00021216 0 0 0 0 0 0 0
- **Cabbage**: 0.0001 0.0029 0 0 0 0 0 0 0
- **Red cabbage**: 0.0000495 0.00029 0.001089 0.0000003 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965
- **Cauliflower**: 0.00004225 0.0007605 0.0000003 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965
- **Broccoli**: 0.000468 0.000624 0.000624 0.001794 0.032292 0.161 0.065
- **Brussels sprouts**: 0.0000005 0.0000003 0.0000003 0.0000003 0.0000003 0.21899621 0.02116253 0.029130 0.032965
- **Green pepper**: 0 0 0 0 0 0 0 0 0
- **Red pepper**: 0 0 0 0 0 0 0 0 0
- **Chicory**: 0.0005 0 0 0 0 0 0 0 0
- **Mushrooms**: 0.0016564 0.0009594 0.0083 0 0 0 0 0 0
- **Green regular beans**: 0 0 0 0 0
- **Green string beans**: 0 0 0 0 0
- **Red beet**: 0 0 0 0 0
- **Spinach (proxy: beet)**: 0.0005 0 0 0 0 0 0 0 0
- **Endive (proxy: chicory)**: 0.0005 0 0 0 0 0 0 0 0
- **Onion**: 0 0 0 0 0 0 0 0 0
- **Leek**: 0 0 0 0 0 0 0 0 0
### APPENDIX A (Continued)

**Concentration of phytoestrogens in selected foods items (EPIC-FFQ)—the basis for scoring**

<table>
<thead>
<tr>
<th>Isoflavones</th>
<th>Coumestans</th>
<th>Lignans precursors</th>
<th>Lignans</th>
</tr>
</thead>
</table>

**mg of phytoestrogens/100 g product**

#### Legumes
- Green peas: 0.0490383, 0.0460719, 0.00001, 0.013
- Marrowfat peas (proxy: peas): 0.0490383, 0.0460719, 0.00001, 0.013
- Brown & white beans: 0.00511368, 0.24827022, 0.0043512, 0.22664, 0.00001, 0.006293
- Lentils: 7.3, 0.00001, 0.0043512, 0.22664, 0.00001
- Dried green peas: 0.0286518, 0.0011, 0.035139, 0.00001, 0.006293
- Broad beans: 0.0286518, 0.0011, 0.035139, 0.00001, 0.006293

#### Soy foods
- Vegetarian schnitzel: 1
- Temphe: 27.3, 39.8
- Tofu: 25.34, 42.15

#### Nuts
- Almonds: 0.003792, 0, 0.00001, 0.101436
- Cashew: 0.0039052, 0.2509
- Hazelnuts: 0.0055, 0.185, 0.035139, 0.00001
- Walnuts: 0.004893, 0.00001, 0.1595
- Mixed nuts: 0.009823, 0.064825, 0.0025, 0.00001, 0.00001
- Peanuts: 0.03, 0.24, 0.01, 0.00001, 0.013, 0.0412543

#### Fruit and vegetables juices
- Apple juice: 0.00227292, 0.00001
- Orange juice: 0, 0.01129, 0.027, 0.012
- Grapefruit juice: 0.00049875, 0.0250368
- Currant juice: 0, 0.0199782
- Raspberry juice: 0.0000036, 0.0000036
- Mixed fruit drinks: 0.000495, 0.00001, 0.1595
- Tomato juice: 0.0048255, 0.0038313, 0.0165, 0.015
- Beetroots juice: 0, 0.0220108
- Carrot juice: 0.000198602, 0.000211039

#### Hot drinks
- Coffee: 0.00102168, 0.0004892, 0.00120747, 0.01108368
- Black tea: 0.0001947, 0.0012095, 0.0077644

#### Alcoholic drinks
- Beer: 0.0000646, 0.0001821, 0.0004024, 0.0001376, 0.0019285
- White wine: 0, 0.0005623, 0.006324, 0.0001376, 0.0019285
- Red wine: 0, 0, 0, 0, 0.000098, 0.1280
- Port (proxy: red wine): 0, 0, 0, 0, 0.000098, 0.1280
- Whiskey: 0, 0, 0, 0, 0, 0.00598386

#### Mixed dishes
- Soup + vegetables: 0.000001685, 0.00403598, 0.00000026, 0.00000026, 0, 0.00031671, 0.011102, 0.012220
- Soup + legumes: 0.001022736, 0.049654, 0.05412, 0.00048912, 0, 0.000416, 0.0004316, 0.00175, 0.01375
- Pizza: 0.001289756, 0.00038626, 0.002395047, 0.000958, 0.00422
- Spring roll: 0.0000057, 0.0004103, 0.0000013, 0, 0.000534508, 0.0008736, 0.000612, 0.01868

---

1. A reference list is available as supplemental data in the online posting of this paper at www.nutrition.org.
LITERATURE CITED (for appendix A)