Isoflavone intake in four different European countries: the VENUS approach

Marie-Agnes J. van Erp-Baart¹*, Henny A. M. Brants¹, Mairead Kiely², Angela Mulligan³, Aida Turrini⁴, Colomba Sermoneta⁴, Annamari Kilkkinen⁵ and Liisa M. Valsta⁵

¹TNO Nutrition and Food Research, Department of Nutritional Epidemiology, PO Box 360, 3700 AJ Zeist, The Netherlands
²Department of Food Science, Food Technology and Nutrition, University College Cork, Ireland
³Department of Public Health and Primary Care, University of Cambridge, and MRC Dunn Human Nutrition Unit, Cambridge CB2 2XY, UK
⁴National Institute for Research on Food and Nutrition, Via Ardeatina 546, 00178 Rome, Italy
⁵National Public Health Institute (KTL), Department of Epidemiology and Health Promotion, Nutrition Unit, Mannerheimintie 166, FIN-00300 Helsinki, Finland

The aim of this study was to identify the level of isoflavone intake (total isoflavones, daidzein and genistein) in four European countries: Ireland, Italy, The Netherlands and the UK. For this purpose national food composition databases of isoflavone content were created in a comparable way, using the Vegetal Estrogens in Nutrition and the Skeleton (VENUS) analytical database as a common basis, and appropriate food consumption data were selected. The isoflavone intake in Ireland, Italy, The Netherlands and the UK is on average less than 1 mg/d. Small groups of consumers of soya foods could be identified in Ireland, The Netherlands and the UK. The estimated intake levels are low compared with those found in typical Asian diets (~20-100 mg/d) and also low compared with levels where physiological effects are expected (60~100 mg/d). The results (including a subgroup analysis of soya product consumers) showed that such levels are difficult to achieve with the European diets studied here.

Isoflavones in Europe: Daidzein: Genistein: Oestrogen-like compounds

Introduction

It is already established that relatively high isoflavone intakes can be found in typical Asian diets, where soya foods are consumed more commonly than in Western diets. Recent estimates indicate intakes of 20–50 mg/d (Adlercreutz et al. 1991; Nagata et al. 1997; Chen et al. 1999) or even higher: 102 mg/d (Ho et al. 2000).

It has been suggested (Cassidy & Faughnan, 2000; Mazur & Adlercreutz, 2000) that intakes of isoflavones in Western Europe are very low, but, until now, no valid quantification has been available. One major reason was that, at both European and national levels, only limited data on isoflavone contents in foods were available (Reinli & Block, 1996). The United States Department of Agriculture (USDA) and Iowa State University created a database of isoflavones, which is available on the Internet (USDA–Iowa State University Isoflavones Database; http://www.nal.usda.gov/fnic/foodcomp/Data/isoflav/isoflav.html). This database includes mainly soya-based foods and some figures on isoflavones in pulses and peanuts. At that time it was less well known that some other foods might contain isoflavones as well. Soya derivatives in many forms can serve as ingredients for diet products (e.g. replacing cow’s milk), act as an alternative for meat products (vegeburgers, etc.) or are included as food ingredients for technological (bread) or cost-effective reasons (high-quality protein at low cost). Moreover, in Finland (Mazur et al. 1998) and in the UK (Liggins et al. 2000a,b, 2002), additional analytical results made clear that more foods contain isoflavones in measurable amounts.

The aim of this study was to estimate the isoflavone intake in different European countries, making use of available food consumption data and available data on isoflavones in foods (Kiely et al. 2003).

Methods

In order to arrive at data that would be comparable across countries, decisions had to be made on two major issues.

Abbreviations: SD, standard deviation; USDA, United States Department of Agriculture; VENUS, Vegetal Estrogens in Nutrition and the Skeleton.
*Corresponding author: Dr A. M. J. van Erp-Baart, fax +31 30 6957952, email vanerp@voeding.tno.nl
First was the establishment of an isoflavones database (the Vegetal Estrogens in Nutrition and the Skeleton (VENUS) database) that could serve as a starting point for the compilation of national isoflavones databases. Second was the selection of food consumption data that were comparable across countries. The following countries, participating in the VENUS project, were willing to make an estimate of isoflavone intake: Ireland, Italy, The Netherlands and the UK.

In Finland, Valsta et al. (2003) had already developed a national database. They were invited to advise on the procedures for the establishment of the VENUS database. Furthermore, in Finland as well as in The Netherlands, some preliminary calculations were carried out and this experience was used for the establishment of the VENUS guidelines.

Selection of relevant food consumption data

Comparability of food consumption data depends on aspects such as the methodology chosen, the population group, the year of collection, etc. The aim of the VENUS project was to arrive at mean intake and distribution figures of isoflavone intake.

In Ireland (Harrington et al. 2001) and Italy (Turrini et al. 1999), recent national surveys based on 7d diary records were available. In The Netherlands, a nationwide survey, based on a 2d record, had recently been carried out (Löwik et al. 1998, 1999). In the UK, a large prospective cohort study investigating the relationship between diet, cancer and chronic disease, with 7d diary data, was identified (Day et al. 1999). In Italy, Ireland and The Netherlands the age group of 18–64 years was selected. Recent data on the 18–45 year age group were not available in the UK; therefore, the age group of 45–64 years was selected. Table 1 presents the food consumption surveys used to calculate isoflavone intakes. For further details the reader is referred to the individual papers.

Table 1. Overview of selected food consumption data

<table>
<thead>
<tr>
<th>Country</th>
<th>Survey</th>
<th>Sample description</th>
<th>Dietary method</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireland</td>
<td>North/South Ireland Food Consumption Survey, 1997–99</td>
<td>men and women, aged 18–64 years</td>
<td>7d record</td>
<td>Harrington et al. (2001)</td>
</tr>
<tr>
<td>Italy</td>
<td>Nationwide Nutritional Survey – Food Behaviour, 1995</td>
<td>men and women, aged up to 94 years</td>
<td>7d record</td>
<td>Turrini et al. (1999)</td>
</tr>
<tr>
<td>UK</td>
<td>EPIC–Norfolk, 1995–97</td>
<td>men and women, aged 40–64 years</td>
<td>7d record</td>
<td>Day et al. (1999)</td>
</tr>
</tbody>
</table>

EPIC, European Prospective Investigation into Cancer and Nutrition.
a priority list of food groups to be included in the national isoflavones database:

1. soya products;
2. legumes and (pea)nuts;
3. bread;
4. breakfast cereals;
5. other single foods relevant for the country and where data were available.

Compilation of the four national isoflavones databases

In the VENUS database, an isoflavone figure was included for about 700 foods, of which soya foods or soya-based foods were the most common. In Western countries the use of soya foods is less common; however, other foods containing soya ingredients or soyabeans might be more important in estimating isoflavone intakes.

The compilation of national databases was necessary to ensure that all relevant foods were included. It was important not only to identify the soya foods, but also to identify foods that might contain relevant amounts of soya ingredients or foods with low amounts but very frequently consumed. For these foods an isoflavone figure had to be present in the database in order to avoid underestimation because of missing data.

The compilation of the four national databases was carried out in accordance with the following criteria:

1. Identification of all foods that have no isoflavones: i.e. foods from animal origin and foods not containing vegetable proteins. These foods get a 'zero' in the national database.
2. Selection of all foods for which an isoflavone figure can be taken directly from the VENUS database. In situations where more than one analysis is present for a food, the mean value of these results will be included when one value cannot be selected as the preferred one.
3. Selection of those foods for which a comparable food with a figure can be selected and, for this food, the isoflavone content can be borrowed.
4. Selection of those items for which a relevant figure can be calculated using conversion factors; for example, conversion from raw pulses to cooked pulses.
5. Use of recipe calculation for mixed dishes, in which isoflavone-containing foods are included.
6. For other foods that may contain relevant isoflavone levels and that are consumed regularly or in large amounts, an educated guess on the basis of ingredient specifications is made.

An overview of the type of isoflavone data for each country is given in Table 2.

Preliminary calculations based on the USDA–Iowa State University isoflavones database in The Netherlands (van Erp-Baart, 2000) already revealed that a group of consumers of soya foods could be identified. This relatively small group had a significant impact on the outcome of the mean and distribution figures of the total population. Therefore, it was decided that intakes would also be calculated excluding these soya food consumers.

Results

Total isoflavone intake in Ireland, Italy, the Netherlands and the UK is presented in Table 3. Mean intake varies across countries. On average, the lowest intake was found in Italy, 554 μg/d. The highest intake was found in the Netherlands, 913 μg/d.

Calculations excluding the consumers of soya foods showed lower mean intakes: 683 (standard deviation (SD) 372) μg/d in The Netherlands, 545 (SD 337) μg/d in Ireland and 602 (SD 350) μg/d in the UK. In Italy, no consumers of soya foods could be identified.

Daidzein and genistein intakes are presented in Tables 4 and 5. In general, daidzein intake is lower than genistein intake.

Small groups of soya food consumers could be identified in The Netherlands, Ireland and the UK. Mean isoflavone intake in the group of soya food consumers was 11111 (SD 6728) μg/d in The Netherlands (n = 85), 5996 (SD 8123) μg/d in Ireland (n = 42) and 3176 (SD 4034) μg/d in the UK (n = 15).

Mean intakes of daidzein and genistein excluding consumers of soya foods were as follows: 327 (SD 187) and 356 (SD 199) μg/d, respectively, in The Netherlands; 272 (SD 176) and 282 (SD 171) μg/d, respectively, in Ireland; and 270 (SD 160) and 332 (SD 193) μg/d, respectively, in the UK.

The isoflavone intakes for men and women are presented in Tables 6 and 7. In general, the mean isoflavone intake was lower in women than in men.

Discussion

The aim of this study was to identify the level of isoflavone intake in different European countries. In total, four countries were able to provide data on isoflavone intakes:

Table 2. Overview of type of data in the four national databases

<table>
<thead>
<tr>
<th>Country (number of foods)</th>
<th>VENUS data</th>
<th>Borrowed</th>
<th>Converted</th>
<th>Recipe</th>
<th>Missing</th>
<th>Not relevant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireland (3060)</td>
<td>4</td>
<td>2</td>
<td>–</td>
<td>7</td>
<td>12</td>
<td>75</td>
</tr>
<tr>
<td>Italy (1714)</td>
<td>5</td>
<td>6</td>
<td>–</td>
<td>23</td>
<td>3</td>
<td>62</td>
</tr>
<tr>
<td>The Netherlands (1140)</td>
<td>16</td>
<td>10</td>
<td>7</td>
<td>6</td>
<td>9</td>
<td>52</td>
</tr>
<tr>
<td>UK (1524)*</td>
<td>15</td>
<td>5</td>
<td>4</td>
<td>24</td>
<td>13</td>
<td>37</td>
</tr>
</tbody>
</table>

VENUS, Vegetal Estrogens in Nutrition and the Skeleton.
*A total of 2935 foods were consumed by the UK sub-sample but, due to the design of the food list and data entry program, these foods are covered by 1524 items for which nutritional data are available.
three from Northern Europe and one from Southern Europe. The results of this study showed that the mean intake of isoflavones does not exceed the level of 1 mg/d.

In Finland, a comparable level of total isoflavone intake was found (Valsta et al. 2003). As previously mentioned, Finland had already compiled a national database, and the procedures for compilation of the VENUS database were similar. The only difference between Finland and VENUS was that, in Finland, the database is mostly based on analyses performed in Finnish laboratories, whereas in the VENUS database recent UK data are preferred.

De Kleijn et al. (2001) estimated the isoflavone (genistein and daidzein) intakes in Caucasian postmenopausal women in the USA. They also found an isoflavone intake of less than 1 mg/d. Recently, Keinan-Boker et al. (2002) estimated the isoflavone intake in ten European countries to be less than 2 mg/d. They used the USDA-Iowa State University database, and only soya foods were included in the calculations.

The small groups of soya food consumers had a higher intake level, namely ~11 mg/d in The Netherlands and ~6 mg/d in Ireland. However, even this intake is not as high as the intake data presented for Asian countries (Adlercreutz et al. 1991; Nagata et al. 1997; Chen et al. 1999; Ho et al. 2000), where intakes ranging from 20 to 100 mg/d can be found.

If we look to the intake distribution and particularly the figures for the 95th percentile, it is more apparent that the isoflavone intake in Western Europe is not likely to induce potential positive health effects, because at least 60–100 mg/d are probably required (Valsta et al. 2003).

Underestimation of intake because important foods are missing in the isoflavones database is always possible. Therefore the completeness of the database was given serious consideration and specific guidelines were established to keep the missing data to a minimum.

In Table 2, approximately 13–50% of all foods have an isoflavone figure. This is mainly due to the fact that not only are the typical soya foods included, but also much

Table 3. Isoflavones intake of adult populations in four European countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Total isoflavones intake (μg/d)</th>
<th>Mean</th>
<th>SD</th>
<th>P5</th>
<th>P95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireland</td>
<td>1379</td>
<td>726</td>
<td>1770</td>
<td>172</td>
<td>1318</td>
</tr>
<tr>
<td>Italy</td>
<td>1513</td>
<td>554</td>
<td>1072</td>
<td>163</td>
<td>958</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>4085</td>
<td>913</td>
<td>1898</td>
<td>197</td>
<td>1538</td>
</tr>
<tr>
<td>UK</td>
<td>335</td>
<td>718</td>
<td>1041</td>
<td>170</td>
<td>1486</td>
</tr>
</tbody>
</table>

sd, standard deviation; P5, 5th percentile; P95, 95th percentile.

Table 4. Daidzein intake of adult populations in four European countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Daidzein intake (μg/d)</th>
<th>Mean</th>
<th>SD</th>
<th>P5</th>
<th>P95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireland</td>
<td>366</td>
<td>906</td>
<td>81</td>
<td>687</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>252</td>
<td>434</td>
<td>76</td>
<td>448</td>
<td></td>
</tr>
<tr>
<td>The Netherlands</td>
<td>397</td>
<td>628</td>
<td>87</td>
<td>760</td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>314</td>
<td>405</td>
<td>73</td>
<td>648</td>
<td></td>
</tr>
</tbody>
</table>

sd, standard deviation; P5, 5th percentile; P95, 95th percentile.

Table 5. Genistein intake of adult population in four European countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Genistein intake (μg/d)</th>
<th>Mean</th>
<th>SD</th>
<th>P5</th>
<th>P95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireland</td>
<td>368</td>
<td>848</td>
<td>91</td>
<td>654</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>302</td>
<td>640</td>
<td>90</td>
<td>512</td>
<td></td>
</tr>
<tr>
<td>The Netherlands</td>
<td>516</td>
<td>1296</td>
<td>102</td>
<td>828</td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>389</td>
<td>499</td>
<td>92</td>
<td>839</td>
<td></td>
</tr>
</tbody>
</table>

sd, standard deviation; P5, 5th percentile; P95, 95th percentile.

Table 6. Isoflavone intakes (μg/d) in adult men from four European countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Total isoflavones</th>
<th>Daidzein</th>
<th>Genistein</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Ireland</td>
<td>717</td>
<td>857</td>
<td>2092</td>
</tr>
<tr>
<td>Italy</td>
<td>686</td>
<td>634</td>
<td>1125</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>1879</td>
<td>1007</td>
<td>1708</td>
</tr>
<tr>
<td>UK</td>
<td>167</td>
<td>773</td>
<td>586</td>
</tr>
</tbody>
</table>

sd, standard deviation.

Table 7. Isoflavone intakes (μg/d) in adult women from four European countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Total isoflavones</th>
<th>Daidzein</th>
<th>Genistein</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Ireland</td>
<td>662</td>
<td>603</td>
<td>1392</td>
</tr>
<tr>
<td>Italy</td>
<td>827</td>
<td>489</td>
<td>1022</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>2206</td>
<td>834</td>
<td>2042</td>
</tr>
<tr>
<td>UK</td>
<td>168</td>
<td>662</td>
<td>1349</td>
</tr>
</tbody>
</table>

sd, standard deviation.
attention is given to identify other foods that might contain isoflavones. While 4–16% of the foods could be obtained directly from VENUS, the remaining 9–33% were calculated using conversion and recipe procedures, a time-consuming and largely underestimated job. However, in this way we are confident that we are not missing any major contributors to isoflavones.

Under-reporting of intake figures may also depend on the method used for the collection of food consumption data. A diary method is open-ended so all foods eaten at that moment are included and as such it can be expected to be complete. Based on the consumption data, special attention was given to include all relevant foods in the VENUS database, and not only obvious isoflavone providers (soya foods and pulses). Bread and breakfast cereals especially are products that are consumed on a regular basis and it was important that isoflavone data for these foods were included in the database. Ireland estimated the contribution to isoflavone intake of bread, and it appeared to be around 95% of the total isoflavone intake. In Italy 90% of isoflavone intake comes from bread.

It should also be mentioned that mean as well as distribution figures can be influenced by the data collection method used. In three countries, a 7d diary was used and the comparison is not affected by the time frame. In The Netherlands, a 2d diary was used. This implies that the figures for the mean as well as the distribution are not completely comparable with the 7d records of the other countries (Löwik et al. 1999).

When irregularly consumed foods with high levels of isoflavones are included, the upper tail of the distribution will be influenced (Lambe et al. 2000). Exclusion of the soya food consumers leads to lower means and more normal distributions in Ireland, The Netherlands and the UK.

Inclusion of bread in the isoflavones database did not lead to appreciable amounts of isoflavone intake in the different countries.

The intake figures derived from soya food consumers must be treated with caution, and regarded as an indication of what to expect in people consuming typical soya foods. Looking at the 95th percentile values, it is clear that high intakes of isoflavones are rare in the four countries under study. A maximum intake of 36 000 µg/d was found in The Netherlands, whereas in the UK, the maximum was 17 000 µg/d. It is clear that a typical European diet (either a Northern or a Southern type) is not likely to meet the level assumed to have a physiological effect: 60–100 mg/d (Valtuñea et al. 2003).

As VENUS had to rely on available food consumption data and because it was decided that relatively recent data should form the basis for these calculations, an age difference exists between the UK data set and the three other countries. In the UK, recent data could only be selected from both Italy and The Netherlands. Total isoflavone intake for this age group was 873 µg/d in The Netherlands and 570 µg/d in Italy. Distribution figures were also of the same order of magnitude. So it can be expected that age itself will have a negligible effect on the intake of the adult groups in this study.

Conclusion

The isoflavone intake in Ireland, Italy, The Netherlands and the UK is very low in comparison with that in Asian countries, with most people eating on average less than 1 mg/d. In Ireland, The Netherlands and the UK, a small group of soya food users could be identified. In this group, the isoflavone intake is higher, at 3–11 mg/d on average. The inclusion of regularly eaten foods with relatively low isoflavone contents did not contribute to the total isoflavone intake in substantial amounts.

Acknowledgements

This review has been carried out with financial support from the Commission of the European Communities, Food and Agroindustrial Research programme CT-98-4456 'Dietary exposure to phyto-oestrogens and related compounds and effects on skeletal tissues (VENUS)'. It does not reflect its views and in no way anticipates the Commission’s future policy in this area.

References


