Food Chemistry 113 (2009) 736–747

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Review

Inventory of phytoestrogen databases

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ARTICLE INFO

Article history:
Received 23 November 2007
Received in revised form 8 September 2008
Accepted 13 September 2008

Keywords:
Phytoestrogens
Isoflavones
Lignans
Databases
Food
Analysis

ABSTRACT

In this review, 17 phytoestrogen databases (PE DBs) including three literature compendia, 11 DBs for PE intake assessment in different countries or population groups and three comprehensive DBs for nutrition research were compared with respect to several issues, specifically the number of foods and compounds covered, the data sources, the mode of data expression, the additional information presented and the quality control of the data. The problems encountered in the construction and use of PE DBs (natural variability of PE contents, incomplete coverage of foods and compounds) were discussed alongside the requirements of DBs intended for intake assessment or nutrition research. In addition, recommendations were given on which DBs are best suited for which purpose. The reviewed DBs differ in the date of construction, aim, structure and also in comprehensiveness. The greatest number of foods is covered in DBs for intake assessment based on national food consumption data, whereas most information is given in comprehensive DBs for nutrition research. Presentation of quality assessed data is of increasing importance as new developments in PE analysis and steady production of new analytical data make replacement of low quality data possible.

Contents

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doi:10.1016/j.foodchem.2008.09.051

1. Introduction

Phytoestrogens (PEs) are bioactive compounds capable of inducing a diverse range of health effects. Among these are effects on cardiovascular diseases, hormone dependent cancers, menopausal symptoms, bone density, as well as antioxidant, anti-inflammatory and vasodilatory effects (Adlercreutz, 2007; Cassidy et al., 2006; Messina, Kucuk, & Lampe, 2006; Mitjans & Vinardell, 2005; Mortensen et al., 2009; Sacks et al., 2006; Westcott & Muir, 2003). Depending on their structure, PEs can be divided into flavonoid and non-flavonoid polyphenols. The main representatives of flavonoid PEs are isoflavones and coumestans. Lignans and coumestans are the main non-flavonoid PEs.

Isoflavones, which occur mainly in soybeans, are the most studied class of PEs. The main soy isoflavones are daidzein (daid), genistein (gen) and glycitein (gly). In some legumes, formononetin (formo) and biochanin A (bio A), the methoxylated forms of daid and gen, can be found alongside with coumestrol (coum), the main coumestan. In unprocessed soybeans, isoflavones occur mainly as malonyl-β-glucosides and β-glucosides. Upon processing involving elevated temperatures, malonyl forms are degraded to acetyl forms, β-glucosides and, depending on the extent and kind of heat treatment, to aglucones (Coward, Smith, Kirk, & Barnes, 1998). The best dietary isoflavone sources are traditional soy foods, new generation soy foods (for example, soy burgers or soy desserts), and daily consumed basic foods including bakery goods and meat products, to which soy flour or soy protein had been added.

Lignans are widely encountered in the plant kingdom. Highest contents (up to the mg/g range) have been found in flaxseed and sesame seeds. Lower concentrations (medium ng/g–μg/g range) have been determined in vegetables, legumes, cereals, nuts, fruits and beverages as, for example, tea, coffee and wine. According to the current standard of knowledge, the main dietary lignans are secoisolariciresinol (seco), lariciresinol (larici), pinoresinol (pino), medioresinol (medio), syringaresinol (syringa), 7-hydroxymatairesinol (7-OH-matai), matairesinol (matai) and the sesame lignans sesaminol, sesamolinol, sesamin and sesamolin (Achouri, Boye, & Belanger, 2005; Milder, Arts, van de Putte, Venema, & Hollman, 2005; Moazzami & Kamal-Eldin, 2006; Penalvo, Adlercreutz, Uehara, Ristimaki, & Watanabe, 2008; Penalvo, Heinonen, Aura, & Adlercreutz, 2005; Smeds et al., 2007; Thompson, Boucher, Liu, Cotterchio, & Kreiger, 2006). These lignans occur in different native forms, sometimes of unknown complexity. For instance, seco, the best studied lignan, occurs as bio-oligomer consisting of seco diglucoside (SDG) units linked by 3-hydroxy-3-methylglutaric acid in flaxseed (Kamal-Eldin et al., 2001). Recent analytical findings indicate that other lignans occur partly esterified, too (Milder et al., 2005; Schwartz & Sontag, 2006; Smeds et al., 2007). This may depend on the plant, the plant variety, and on environmental factors.

The isoflavone and lignan patterns and contents in foods are influenced by a variety of factors, which include natural variability, variability caused by processing and variability introduced by the use of different ingredients and formulations (Eliasson, Kamal-Eldin, Andersson, & Aman, 2003; Lee et al., 2003; Moazzami & Kamal-Eldin, 2006; Mortensen et al., 2009; Setchell et al., 2001). This high variability of PE contents in foodstuffs of the same type is one of the main problems in creating phytoestrogen databases (PE DBs), independent of their structure, data sources and uses.

In the following, a short chronology of the development of PE DBs will be given, introducing the individual DBs. Then, the individual PE DBs will be compared with respect to the selection of foods and compounds, the data sources, the mode of data expression, the amount of additional information and the quality control of the data. At the same time, difficulties in the compilation of PE DBs will be highlighted, and advantages and limitations of the different approaches will be discussed. Finally, recommendations will be given on which DB should be chosen for which purpose.

2. Chronology

In order to relate the consumption of PEs to health effects, it is essential to have a thorough overview of the PE contents in the foods consumed by the population under study. Early data collections summarising PE contents in selected foodstuffs from different references were aimed mainly at identifying dietary PE sources, summarising existing values, comparing analytical methods used and giving recommendations for future analyses (Mazur & Adlercreutz, 1998; Meagher & Beecher, 2000; Reinli & Block, 1996), or at assessing the dietary intake of a population subgroup or of participants in epidemiological studies by means of a food frequency questionnaire (FFQ) containing only a limited number of foods (de Kleijn et al., 2001; Fink, Steck, Wolff, Kabat, & Gammon, 2006; Horn-Ross et al., 2000; Pillow et al., 1999). The first isoflavone DB, which was freely accessible to the research community and to the public and could be used independently of the paper describing its construction, was released in 1999 (US Department of Agriculture, 2002). However, only a limited number of food items were covered at that time. In 2001, the BASIS DB, a DB for bioactive compounds (including isoflavones, lignans and coumestrol) in ~300 food plants, became available on CD-ROM. Two years later, reports of two further PE DBs were published, one of them containing PE values for ~800 (Kiely, Faughnan, Wahala, Brants, & Mulligan, 2003), the other for ~1400 (Valsta et al., 2003) foods. The main aim of these and of the following DBs was intake assessment in different countries and populations. In 2005, a free access internet-based comprehensive isoflavone DB comprising ~6000 foods was produced (Ritchie, n.d.; Ritchie et al., 2006), and the first DB containing values for the lignans larici, pino, seco and matai was published (Milder et al., 2005). One year later, a DB providing values for the major isoflavones, lignans and coumestans in foods, according to the present standard of knowledge, was established by the simultaneous analysis of the three classes of PEs in the same foods (Thompson et al., 2006). Most recently, the inclusion of lignan (seco and matai) values into an existing food composition table listing ~1500 foods was reported (Blitz, Murphy, & Au, 2007). In addition, one further comprehensive DB with multiple uses containing detailed information about the food and data generation is currently being developed (Scalbert, 2007) and one is being updated (US Department of Agriculture, 2002). Finally, the BASIS DB is currently being both enlarged to the EuroFIR BASIS DB and updated (Gry et al., 2007). Table 1 gives an overview of the reviewed PE DBs, sorted by their main aims and uses.

3. Comparison of phytoestrogen databases: recommendations and current status

3.1. Types and uses of phytoestrogen databases

PE DBs can be divided into three groups according to their main aims: literature compendia aiming at identifying PE sources, providing a collection of available data and helping to prioritise future analyses; DBs for dietary intake assessment either by means of food frequency questionnaires (for population sub-groups or participants of epidemiological studies) or by means of national food consumption studies and DBs providing sufficiently detailed additional information on the food sample, the analytical method used to generate the data and on the quality of the individual values so that they can be used as resource for the regulatory affairs sector, the food industry and scientists.