ePlantLIBRA: a composition and biological activity database for bioactive compounds in plant food supplements

Suggested abbreviated running title:

ePlantLIBRA: bioactives in plant food supplements database

J. Plumb [a*], J. Lyons[b], K. Nørby[c], M. Thomas[d], E. Nørby[e], Roland Poms[f], P. Restani[g], M. Kiely[b] and P. Finglas[a] on behalf of the PlantLIBRA Consortia

[a] Institute of Food Research, Norwich, NR4 7UA, UK

[b] School of Food and Nutritional Sciences University College Cork, Cork, Ireland

[c] National Food Institute, Technical University of Denmark, 2860 Søborg, Denmark

[d] Food and Environment Research Agency, York, YO41 1LZ, UK

[e] Polytec ApS, Niva, Copenhagen, Denmark

[f] International Association for Cereal Science and Technology/MoniQA Association, 1030 Vienna, Austria

[g] Università degli Studi di Milano, 20133, Milan,Italy

[*] **Corresponding author:** Jenny Plumb, Institute of Food Research, Norwich, NR4 7UA, UK. email address jenny.plumb@ifr.ac.uk FAX: +44 (0) 1603 251481

1. Abstract

The newly developed ePlantLIBRA database is a comprehensive and searchable database, with up-to-date coherent and validated scientific information on Plant Food Supplement (PFS) bioactive compounds, with putative health benefits and adverse effects, and contaminants and residues. It is the only web-based database available compiling peer reviewed publications and case studies on PFS. A user-friendly, efficient and flexible interface has been developed for searching, extracting, and exporting the data, including links to the original references. Data from over 400 publications have been quality evaluated and entered covering 49 PFS or their botanical ingredients. All plants within the database have corresponding contaminant and pesticide residue data.

Keywords: ePlantLIBRA; database; bioactive compounds; plant food supplements: risk benefit; composition; herbals; botanicals

2. Introduction

Worldwide, there is a growing demand for high-quality, safe, health-promoting or disease-risk reducing foods, including food supplements (European botanical forum, 2011, Council of Europe, 2005). The goal of the EC-financed FP7 project PlantLIBRA (PLANT food supplements: Levels of Intake, Benefit and Risk Assessment) (Larranaga-Guetaria, 2012) was to improve the PFS scientific knowledge base to better assess the risks and benefits of PFS, and enable science-based decision making by regulators and stakeholders, ultimately ensuring a safer

use of PFS by consumers. In order to make informed decisions, competent authorities and industry require better tools such as databases to provide more accessible and quality-assured information. Consequently, an objective of the PlantLIBRA project was to transfer this body of knowledge to a meta-database, easily searchable with retrievable data on chemical composition, botanical information, beneficial bioactivity data and case-reports of adverse effects, as well as potential contaminants in PFS, into a single platform to enable PFS risk-benefit assessments.

Regulators and manufacturers are very well aware of the issues relating to botanicals and the need for good quality assurance and control. They also realise that illegal marketing practices by unscrupulous manufacturers, adulteration of medicinal products, accessibility of unsafe products over the Internet, etc. are hard to address by strict rules and increased enforcement. There is, therefore, no doubt that everybody will benefit from science-based safety measures and that the data uploaded on PlantLIBRA database will contribute to that knowledge (Botanical Forum, 2011).

The European Food Safety Authority (2012) has published on its website a Compendium of Botanicals reported to contain toxic, addictive, psychotropic or other substances of concern with the purpose to assist guidance for safety assessment of botanicals and botanical preparations for use as plant supplements. This compendium lists in alphabetical order botanicals, their chemicals of concern, remarks on adverse/toxic effects and lists the references. The ePlantLIBRA provides a larger and more detailed resource, as a searchable database it allows a more detailed coverage possible than the Compendium. The database contains additional quality evaluated composition data, beneficial health effects, toxic effects,

contaminants, residues. ePlantLIBRA plants are searchable by common and scientific name, additionally reports can be led by compound name, and as extra value links to all references are downloadable.

Since the ePlantLIBRA database combines literature on the beneficial and adverse biological effects of PFS in a single platform, it is particularly useful in the risk-benefit assessment of botanicals for use in PFS using the methods described by the European Food Safety Authority. To ensure that claims about the health benefits of foods and food constituents are accurate and not misleading to consumers, the European Commission (EC) adopted a regulation on the use of nutrition and health claims in December 2006 [Regulation (EC) 1924/5 2006] (European Parliament and Council, 2006) (Buttriss and Benelam, 2010).

In this work the development of the ePlantLIBRA database is described including retrieval of quality evaluated data from over 400 publications covering 49 PFS or their botanical ingredients. All plants and processed foods are described using LanguaL, an international framework for food description (www.langual.org), with accompanying data including scientific name, synonyms, common name in 15 European languages, colour photograph identification and links to the Germplasm Resources Information Network (GRIN, http://www.ars-grin.gov). The database contains a sophisticated data retrieval system, allowing users to search for specific information to suit their requirements. Searches can be limited by plant, PFS, compound, compound class, composition data, beneficial bioeffects data, adverse effects biomarker, quality and contaminants, or any combination of these. Each report contains a number of links, including a link to the original input form submitted

by the evaluator, giving full details of the study, a link to the original abstract or full text article (if their institutional access allows) and a link to detailed plant information. All reports are immediately downloadable as a spreadsheet, enabling the user to manage the data as required.

3. Database status and functionality

The meta-database ePlantLIBRA development is based on three existing databases; eBASIS (Bioactive Substances in Food Information System), developed by EuroFIR (http://ebasis.eurofir.eu); the MoniQA contaminants database, EU FP6-funded MoniQA (Monitoring and Quality Assurance in the total food supply chain) database (www.moniqa.eu); and Fera's HorizonScan database (www.horizon-scan.com)

The previously developed EU-financed eBASIS database provides easy sourcing and analysis of quality-evaluated compositional and biological activity data on bioactive compounds in plant-based foods (phytochemicals). eBASIS has its origins in earlier composition databases covering natural toxicants in food plants, which are described in full elsewhere (Gry *et al*. (2007). eBASIS has been shown to be a useful tool for regulators to independently check the completeness of health claims applications relating to phytochemicals, as well as a potentially valuable resource to assist claimants in the compilation of dossiers on functional foods and health claims (Buttriss and Benelam, 2010).

The basic structure and function of the eBASIS database have been retained in developing the ePlantLIBRA database. However, systems have been updated to enable the input of data on bioactive compounds in PFS. In addition, the biological

activity component of the database has been extended to include case-reports of adverse events from the consumption of PFS, as well as literature on beneficial effects. Detailed work has been carried out to connect the plants in ePlantLIBRA with the corresponding commodities in the database (www.moniqa.eu), (Poms, 2013) with links through to appropriate pesticide maximum residue levels (MRLs) and other contaminants. Furthermore, data on global occurrences of safety issues in traded commodities from the HorizonScan database has been linked to the ePlantLIBRA plants to provide current examples of the range of residues and contaminants likely to be encountered in such commodities. The structure of ePlantLIBRA database is shown in Figure 1

[Fig 1 near hear]

The ePlantLIBRA application is developed in classic ASP, utilising JavaScript for e.g. field validation and generation of dynamic HTML. All input screens are generated by an internal Content Management System, facilitating an advanced help system and online modification of input forms. The system is hosted on a Windows server with IIS and Microsoft SQL Server, operated by EuroFIR.

3.1 Database design for data entry and quality

The aim of the data entry is to source, extract, and critically assess data from published reports concerned with the composition and biological effects of bioactive compounds in PFS. The provision of quality data was one of the most important goals when developing the ePlantLIBRA database and the consideration of quality

aspects is necessary for data management systems (Castanheira, 2009). A standardised, quality-assured approach to literature searching, data evaluation and data reporting has been incorporated throughout the design, construction and delivery of ePlantLIBRA. All quality assurance systems are supported by standard operating procedures (SOPs), with full documentation of decisions and procedures. The implementation of SOPs ensures the quality of each step of the compilation process from reference collection to final data point. The compilation procedure together with critical steps are shown in Figure 2.

[Figure 2 near hear]

3.2 Online input forms

ePlantLIBRA uses online forms originally developed for the eBASIS system in order to enter quality evaluated data into the database using a systematic approach, described by Gry *et al.* (2007). Integral to the design of the form is the category of data to be extracted (i.e. numerical, fixed text such as yes/no, pick lists); free text fields are intentionally limited to simplify reporting/data analysis of the database contents. The forms are designed to be unambiguous and simple to use and come with clear instructions for completion in the form of on-screen help text. As part of eBASIS, input forms were carefully developed, piloted and seen to be used successfully (through usability testing). Systems for entering quality assessed composition and biological effects data from peer-reviewed publications as noted by Gry *et al*. (2007) and Kiely *et al.* (2010), were inherited and revised for ePlantLIBRA.

171 Since eBASIS covered only plant-based foods, revised input systems have been
172 included to allow data on PFS and related processed foods to be included.
173

174 New data entry systems have been developed to allow for the addition of case
175 reports of adverse effects into ePlantLIBRA. As with the composition and beneficial
176 bioeffects data inputting, data are entered using forms which are split into sections,
177 with fields either free text or via pick lists.
178 Table 1 shows example input fields appearing in the different sections within the
179 database:
180

181 Table 1 near here
182

183 Table 1: ePlantLIBRA field types for data entry
184

Field types	**ePlantLIBRA input form type**
Bibliographic reference: authors, title, citation details, web link to the original document and a brief description of the study.	**Composition** **Beneficial Bioeffects** **Adverse Effects**
Plant/ PFS information: plant species, plant part and country of origin *or* Plant Food Supplement information, including generic and commercial product name **Processing:** if documented, technological treatment e.g heat treatment and preservation	**Composition** **Beneficial Bioeffects** **Adverse Effects**

method *	
Plant information: season, growing conditions, sample size, sample plan. **Sampling:** including sample plan, primary and analytical sample sizes, number of replicates **Compositional information**: levels, method details, standard source, extraction and identification methods	**Composition**
Test material: including compound, compound class, source, purity and measured quantity **Human study information:** gender, route of administration, experimental design, dose, treatment duration and major parameters studied **Results:** including experimental outcome, effective and non-effective levels and adverse effects **Biomarkers:** including a description of the biomarker studied (e.g. HDL cholesterol) and whether a significant effect was observed or not.	**Beneficial bioeffects**
PFS: Plant food supplement, remarks, additional information, bioactive compounds **Event History:** Administration, gender,	**Adverse Effects**

description of event, main clinical effects, clinical aspects, dose ingested, intake duration, treatment of Adverse Effect, dechallenge/rechallenge, gender specific effects, outcome, causality assessment, conclusion, effective dose, reviewer comments.	

185 * the processing defined is based on Langual systems (http://langual.org)

186

187 **3.2 Data Quality**

188 The quality of composition and beneficial bioeffects data extracted from the
189 literature is assessed and documented according to several criteria described in
190 (Kiely *et al*., 2010 and Gry *et al.,* 2007) in line with criteria normally used to evaluate
191 the scientific methodology, study implementation, statistical approaches, data
192 reporting and interpretation. For example, if the methodology is not sufficiently
193 documented or is considered inadequate, a poor quality grading will be allocated to
194 the paper and the results are either allocated a low score or in some cases not
195 included within the database. However the previously documented criteria used to
196 evaluate the quality data extracted from peer-reviewed articles for input are not
197 appropriate to use with adverse effects case reports in ePlantLIBRA. Thus, the
198 quality assessment section of the input form for case reports has been re-designed,
199 based on the principles outlined by Hung, Hillier and Ernst in 2011. The seven
200 areas assessed and scored for quality using a scale of 1 (poor) to 5 (excellent) are:

PFS information; Intake; Patient history; Concurrent diseases; Concomitant medicines; Adverse effect; Herbal preparation.

3.3 Literature searching

Within the PlantLIBRA project, systematic searches and reviews were carried out to identify literature on the composition and biological activity of PFS to be added to ePlantLIBRA.

For Adverse effects data the literature review covered adverse effects reported in Human Case reports or Human trial studies, only papers for those of the plants where the adverse effects have been classified with the causality: certain, probable or possible have been collected and coded for data input (Dell'agli et al, Di Lorenzo et al[a], Di Lorenzo et al[b] all 2013). Adverse effects data for inclusion in ePlantLIBRA have been sourced via a systematic review in the scientific literature of case reports related to side effects due to the intake of PFS or a botanical ingredient, adverse effects or poisoning due to misidentification of plants or interactions between PFS/botanicals with nutrients or conventional drugs. A list of 67 plants to be searched was established based on information collected by researchers and stakeholders having a long experience in the field of food supplements containing botanicals (Restani, 2013). The literature searches were conducted at a number of PlantLIBRA project partner institutions. Two scientific databases of references and abstracts on life sciences and biomedical topics (PubMed/MEDLINE which comprises more than 21 million citations for biomedical literature, and Embase which contains over 24 million indexed records and more than 7'500 journals) were systematically searched. The following search strategy and selection criteria were

used: PubMed/MEDLINE and Embase were searched from database inception to December 2013, with the terms “adverse effect/s”, “poisoning/s”, “plant food supplement/s”, “misidentification/s”, and “interaction/s” in combination with the respective plant name (Restani, 2013) Each report identified during the review was considered and evaluated according to the WHO causality standard approach. The assessment was based on: 1) the association in time between administration of the PFS and the adverse event; 2) the outcome of de-challenge and re-challenge (when present); 3) known pharmacology; 4) medical or pharmacological plausibility (the sequence of symptoms, signs and laboratory tests and also pathological findings and knowledge of mechanisms); 5) likelihood of other causes or their exclusion; 6) testing for adulterants or contaminants that could be the source of adverse events; 7) inappropriate use (WHO 2004)).

For beneficial data the protocol employed for systematic literature searching for composition data remained largely the same as it was during eBASIS. Beneficial data searches were carried out as part of a review of evidence for PFS benefit from epidemiological, clinical and intervention studies and covered five priority health areas: cardiovascular health, digestive health, inflammation, menopausal symptoms and post-menopausal bone health and only include human biomarkers. Figure 3 indicates a typical search for bioactive composition data. Searches were conducted at a number of project partner institutions using a minimum of two relevant databases. Frequently, the ISI Web of Knowledge (WoK) Science Citation Index Expanded (1945-present) was used to search multiple databases simultaneously (e.g. Web of Science (WoS), MEDLINE, CAB Abstracts, BIOSIS). Similar search strategies were employed in searching for composition and biological activity data.

In searching for literature on the beneficial effects of PFS, for instance, three groups of search terms were used: (i) biological effect terms (e.g. “cardiovascular OR hypertension); (ii) plant name (e.g. “tea OR Camellia OR sinensis”); (iii) human intervention study terms (e.g. “random* OR control* OR trial*). These were combined within each area using the OR Boolean operator, and the three areas combined with the AND Boolean operator. Thus, literature would only be returned by the search engine if it contained one of the designated biological effect terms AND one of the designated plant name terms AND one of the designated human intervention study terms. Using the WoK tool, terms were searched for within the ‘topic’ field, which includes the title, abstract, author keywords and Keywords Plus® of the paper. Wildcards (in this case *) were used at the start and/or end of words or partial words to pick up additional variations that shared common trunks; this was particularly useful in searching for compounds within composition data searches, e.g. *catechin* would pick up epicatechin, catechins etc. In general, an English language limitation was applied to searches, and use of the NOT operator was avoided. All search strategies were fully documented, including the date of the search, limits applied and the number of references returned by the search. Search results were imported into EndNote (Thomson Reuters, New York) and copies of the libraries created were stored on file. For each search, the initial number of search results, the number of duplicates removed and the remaining references to screen were recorded on search results forms. For each reference, titles and abstracts were screened and any non-relevant publications eliminated, possible reasons for exclusions of references from ePlantLIBRA are: a) Insufficient documentation for evaluation; b) Data on compounds not used in the database; c) Non-target area; d) Review articles; e) No control included in trial (non-RCT) - Bioeffects papers; f)

Commentaries to the Editor; g) Unacceptable experimental/analytical procedures; h) Compositional data expressed in graphical/picture format i) Development of analytical methods for identification only, no analytical data

Of the remainder, full-text articles were obtained for more detailed analyses. Papers were subsequently included or excluded according to several criteria, which differed for biological effects and composition references. A final list of papers for each PFS ingredient was then sent to the database manager and the references were coded into the database. For data entry of beneficial bioeffects papers are selected in reverse chronological order, and human studies are prioritised. Target biological systems and pathologies include cardiovascular health, obesity, metabolic health, type 2 diabetes, cancer and bone health. References are selected to ensure adequate compound coverage, with emphasis on the PlantLIBRA priority PFS.

[Figure 3 near here]

Composition references included within ePlantLIBRA have been prioritised based on plants that occur in both adverse effects and beneficial effects searches.

3.4 Data inputting procedures

There are 3 types of data entry “evaluators”; all selected from within the PlantLIBRA project those dealing with the composition, beneficial effects and adverse effects data. All evaluators are fully trained in the use of the form, and regular evaluator assessments are conducted to check performance and ensure uniformity between evaluators.

Completed input forms are submitted to a PlantLIBRA database manager for auditing, checking for any inconsistencies and ensuring that text boxes provide clear and sufficient information, including explanations of any abbreviations. If necessary, the input form is returned to the evaluator for revision before the data is accepted into the database.

3.5 Contaminants

Information on contaminant issues is provided in two ways into the ePlantLIBRA system. Firstly, plants are linked to the appropriate category of commodities covered by the legislation for that particular contaminant or pesticide residue. In many cases, this is straightforward as the plant under question is directly named within legislation, for example lemon within pesticide residue legislation. In other cases, the plant is covered by more general categorisation, for example “Fruit, excluding berries and small fruit”, which is one of the categories within lead legislation and covers lemons mentioned above. This broad-based categorisation for most contaminants allows many of the plants within the ePlantLIBRA list to be accommodated by appropriate legislation, though large non-leguminous seeds, such as water caltrop (*Trapa natans* L.) or resins such as Indian frankincense (*Boswellia serrata* Roxb. Ex Colebr.) do not easily fit into any current categories covering pesticide residue or contaminant legislation within the EU. The actual regulatory categorisation for each plant is listed in the output; Table 2a indicates a typical output table. Appropriate pesticide maximum residue levels and contaminant maximum permissible limits are held within the MoniQA contaminants database for all appropriate commodities and these are linked to the plants in the ePlantLIBRA list to provide the information passed to

the database by a regular web service. The second data set comes from Fera's HorizonScan database (www.horizon-scan.com), which contains global information on issues of contamination in commodities traded around the world. Joins from the ePlantLIBRA plants are made in the same way, as both systems use a common commodity list, but in some cases no examples of issues are available for specific plants in the ePlantLIBRA list, so examples from similar commodities are given. These data provide current information on the issues likely to be encountered in plants and give a good indication of what contaminants and residues should be sought in a due diligence exercise of risk monitoring (Table 2b).

[Table 2a near here]

[Table 2b near here]

Table 2a: An example of contaminant and residue information in ePlantLIBRA for Okra

Information from MoniQA

Contaminant	Regulatory plant classification	Level	Unit	Analysis
Cadmium	3.2.15. Vegetables and fruit, excluding leafy vegetables, fresh herbs, leafy brassicas, fungi, stem vegetables, root vegetables and potatoes	0.05	mg/kg wet weight	Regulation (EC) 333/2007 EFSA Opinion - cadmium
Lead	3.1.10. Vegetables, excluding brassica vegetables, leaf vegetables, fresh herbs, fungi and seaweed. For potatoes the maximum level applies to peeled potatoes.	0.1	mg/kg wet weight	Regulation (EC) 333/2007 EFSA Opinion - lead
Pesticides	023. Fruiting vegetables - Solanacea	MRLs for okra (lady's fingers) (0231040) apply	mg/kg	Regulation (EC) No 396/2005 and its Annex amendments

345 **Table 2b.** An example of food safety issues reported for the commodity cumin

Plant	Latin name	Commodity showing issue	Origin/exporting country	Issue
Cumin	Cuminum cyminum L.	Cumin seed	Canada	Salmonella detected in cumin powder
Cumin	Cuminum cyminum L.	Cumin seed	India	Profenofos (0.12ppm) detected in cumin seed powder
Cumin	Cuminum cyminum L.	Cumin seed	India	Profenofos detected (0.11ppm) in cumin powder
Cumin	Cuminum cyminum L.	Cumin seed	Pakistan	Salmonella in cumin powder
Cumin	Cuminum cyminum L.	Cumin seed	Syria	Salmonella in cumin seed
Cumin	Cuminum cyminum L.	Cumin seed	Turkey	Bacillus cereus (50000 CFU/g) in cumin from Turkey
Cumin	Cuminum cyminum L.	Cumin seed	Turkey	Salmonella spp. (presence /25g) in cumin from Turkey, via Germany

346

347

348 **3.6 Plant Food Supplement information**

349 Systems have been developed within ePlantLIBRA to allow the addition and
350 reporting of PFS information. The input system for PFS information includes the
351 following fields, in the form of pick lists or free text: Identification, Plant, Trade name,
352 Category or claimed effect, Active substances (labelled), Dose form, Weight of
353 dose, Target group, Interactions, Reference information, Links.
354 Information is provided to the user if the PFS botanical is included in either the EFSA
355 "Compendium of botanicals reported to contain naturally occurring substance of
356 possible concern for human health when used in food and food supplements"
357 (EFSA, 2012) or the EFSA "Compendium of botanicals that have been reported to
358 contain toxic, addictive, psychotropic or other substances of concern" (EFSA 2009).
359 Contraindications, interactions and legislation have been sources using the website
360 MedlinePlus. If no listing was found that the information was concluded as "none

known" with a date, allowing further information to be added. References are listed for all information provided.

3.7 Plant information

For all plants within ePlantLIBRA scientific name, plant family, synonyms, common name in 15 European languages, colour photograph identification and links to the Germplasm Resources Information Network (GRIN, http://www.ars-grin.gov) are included.

4. Data Querying and Output Formats

Sophisticated data retrieval reporting systems have been developed for ePlantLIBRA. The database allows users to search for specific information to suit their requirements. Searches can be limited by plant, PFS, compound, compound class, composition data, beneficial bioeffects data, adverse effects biomarker, quality and contaminants, or any combination of these. Each report contains a number of links, including a link to the original input form submitted by the evaluator, giving full details of the study, a link to the original abstract or full text article (if their institutional access allows) and a link to detailed plant information. All reports are immediately downloadable as a spreadsheet, enabling the user to manage the data as required. The ability to produce and print a reference report from a search has been implemented, together with a system to export the reference information to EndNote.

The database main search page, leads users to search for the following 7 search areas, user help text is included for every section; Search for Beneficial effects; Search for Adverse effects ; Search for Composition data; Search for Contaminant

information; Search for Food plant information; Search for PFS information; Search for Additional information such as supplementary information on compound classes, quality assurance documentation and links to grey literature.

Grey literature on traditional herbal products enhances the content of ePlantLIBRA, the database has links to further information leading to the 11 most important publications covering grey literature, as well as complementary databases and documentation that stakeholders in the food supplements industry consider as crucial for their work in the safety assessment of botanicals.

Table 3 below summarises data content of ePlantLIBRA, from peer reviewed publications on composition and bioeffects and case studies for adverse effects. Bioeffects data are provided on 56 validated biomarkers, mainly relating to cardio-metabolic and bone health outcomes.

[Table 3 near here]

Table 3; Summary of data included within ePlantLIBRA

	Plants covered	PFS covered	Compounds	References	Datapoints
Composition	240*	22	511	360* 191**	25,500*
Beneficial Bioeffects	71*	19	161	563* 82**	894*
Adverse Effects	67	23	-	210	243
Contaminants	374				

*Includes data inherited from eBASIS database

**New references evaluated and entered specifically for ePlantLIBRA

5. Users and applications

This novel database is a powerful source of information on PFS with its primary users from will be the regulatory affairs sector (e.g. assessment of PFS supporting health claims/risk assessment), food industry (e.g. evaluation and development of PFS) and researchers and epidemiologists. In addition, PFS data and information are widely used to underpin academic research into links between diet and health. Research outcomes are likely to influence policy at a national and/or international level (e.g. EU, EFSA & globally) and policy may dictate future dietary monitoring programmes or research. (Lyons et al, in preparation). The database access is flexible and different several routes: Membership (organisations & individuals) or Pay-for-view.

6. CONCLUSION

Food supplements containing plants or botanical preparations (plant food supplements, PFS) are potentially beneficial to human health due to their high concentrations of biologically active compounds. However, they may also be associated with adverse biological effects in humans. ePlantLIBRA (http://ePlantLIBRA.eurofir.eu) is a comprehensive web-based database on the content of bioactive compounds in PFS, and published literature on their beneficial and adverse biological effects.

The newly developed ePlantLIBRA database is a comprehensive and searchable database, with up-to-date coherent and validated scientific information on Plant Food Supplement (PFS) bioactive compounds, with putative health benefits and adverse effects, and contaminants and residues. It is the only web-based database available

compiling peer reviewed publications and case studies on PFS. A user-friendly, efficient and flexible interface has been developed for searching, extracting, and exporting the data, including links to the original references.

The role of bioactive compounds in health is of increasing interest to both the scientific community and the food industry. The ePlantLIBRA database combines information on bioactive compounds and analytical methods, case-reports of adverse events, literature on beneficial effects and potential contaminants in a single platform. It is a valuable resource for food regulatory and advisory bodies, risk authorities, epidemiologists and researchers interested in diet and health relationships, as well as product developers within the food industry. Because ePlantLIBRA combines literature on the beneficial and adverse biological effects of PFS in one place, we envisage it to be particularly useful in the risk assessment of botanicals for use in PFS, using the approach described by EFSA (2009). It will also be of use in the public health domain in the estimation of exposure to bioactive compounds in PFS from food consumption surveys. The database has been designed to accommodate continual expansion as research develops to ensure that it remains a current and useable resource.

7. Acknowledgement:

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 245199, and has been carried out within the PlantLIBRA project

(www.plantlibra.eu). This paper does not necessarily reflect the Commission's views or future policy in these areas. The authors acknowledge the assistance of all members of PlantLIBRA Work Package 6.

References

Botanical Forum (2011) Quality Guide for Botanical Food Supplements Guidance for the manufacture of safe and high quality botanical food supplements across the EU http://www.botanicalforum.eu/uploads/11076EBF%20Artwork%201%20Web.pdf

Buttriss, J.L. and Benelam, B. (2010) Nutrition and health claims: the role of food composition data. *European Journal of Clinical Nutrition 64*, S8-S13

Castanheira I., Roe M. A., Westenbrink S., Ireland J., Moller A., Salvini S., Beernaert H., Oseredczuk M., Calhau M and Finglas P. (2009) Establishing quality systems for food composition databanks. *Food Chemistry, 113,* 776-80

Council of Europe (2005) 'Guidelines on the Quality, Safety and Marketing of Plant-based Food Supplements www.coe.int/t/e/social_cohesion/soc-sp/public_health/nutrition_food_consumer_health/Guidelines%20food%20supplements%20%2023.06.05.pdf

Dell'agli, M., Di Lorenzo, C., Badea, M., Sangiovanni, E., Dima, L., Bosisio, E., and

Restani, P. (2013): Plant Food Supplements with Anti-Inflammatory Properties: A Systematic Review (I), *Critical Reviews in Food Science and Nutrition, 53 (4)* 403-413

Dew, T.P. and Williamson, G. (2013) Controlled flax interventions for the improvement of menopausal symptoms and postmenopausal bone health: a systematic review. *The Journal of The North American Menopause Society, 20*, (11) 1207-15

Di Lorenzo[a], C., Dell'agli, M., Badea, M., Dima, L., Colombo, E., Sangiovanni, E., Restani,P. and Bosisio, E. (2013), Plant Food Supplements with Anti-Inflammatory Properties: A Systematic Review (II), *Critical Reviews in Food Science and Nutrition, 53 (5)*, 507-516.

Di Lorenzo[b], C., Dell'Agli,M., Sangiovanni, E., Dos Santos, A., Uberti, F., Moro,E., Bosisio, E., and Restani, P. (2013) *Plant Foods for Human Nutrition, 68(2),* 149-54 .

EFSA (2012) Compendium of botanicals reported to contain naturally occuring substances of possible concern for human health when used in food and food supplements, *EFSA Journal 10(5),* 2663-2723.

EFSA SCIENTIFIC COOPERATION (ESCO) REPORT (2009) EFSA Compendium of botanicals that have been reported to contain toxic, addictive, psychotropic or other substances of concern *EFSA Journal 2009; 7(9):*281

Gry, J., Black, L., Eriksen, F.D., Pilegaard, K., Plumb, J., Rhodes, M., Sheehan, D., Kiely M. and Kroon, P.M. (2007) EuroFIR-BASIS—a combined composition and biological activity database for bioactive compounds in plant-based foods. *Trends in Food Science and Technology, 18,* 434–444.

HorizonScan: www.horizon-scan.com

Hung, S.K., Hillier, S, Ernst, E. (2011). Case reports of adverse effects of herbal medicinal products (HMPs): A quality assessment. *Phytomedicine 18,* 335-343.

Kiely M., Black L.J., Plumb J., Kroon P.A., Hollman P.C., Larsen J.C., Speijers G.J., Kapsokefalou M., Sheehan D., Gry J. and Finglas P. (2010) EuroFIR eBASIS: application for health claims submissions and evaluations. *European Journal of Clinical Nutrition, 64 (Suppl 3),* 101-107

Langual: http://www.langual.org/

Larranaga-Guetaria, A. (2012). PlantLIBRA: PLANT food supplements, levels of Intake, Benefit and Risk Assessment The Regulatory Framework for plant food supplements in the EU. *Agro FOOD Industry Hi-tech*, *23* (5), 20-22.

Lyons et al in preparation

524 Poms, R. E. (2013) MoniQA's contribution towards a global harmonisation of
525 foodstuff quality and safety assessment and monitoring strategies. *Quality*
526 *Assurance and Safety of Crops and Foods, 5* (1), 3-6
527
528 WHO 2004. WHO guidelines on safety monitoring of herbal medicines in
529 pharmacovigilance systems. World Health Organization, Geneva.
530
531
532
533 Figure captions:
534 **Figure 1.** Structure and composition of ePlantLIBRA database
535 **Figure 2.** Compilation procedure for ePlantLIBRA
536 **Figure 3.** A typical search for bioactive composition data.
537
538 **Table 1**. ePlantLIBRA field types for data entry
539 **Table 2a**. An example of contaminant and residue information in ePlantLIBRA for
540 Okra
541 **Table 2b .** An example of food safety issues reported for the commodity cumin
542 **Table 3.** Summary of data included within ePlantLIBRA