BIBLIOGRAPHIC REVIEW

A REVIEW ON EXISTING DATABASES RELEVANT FOR FOOD FRAUD AND AUTHENTICITY

REVISIÓN DE BASES DE DATOS EXISTENTES Y RELEVANTES EN EL FRAUDE Y AUTENTICIDAD ALIMENTARIAS

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ADDITIONAL KEYWORDS

Food adulteration. Food safety. Food composition. Food consumption patterns. Food properties. Toxicology. Food contaminants. Traceability. Molecular information.

PALABRAS CLAVE ADICIONALES

Adulteración Alimentaria. Seguridad alimentaria. Composición alimentaria. Patrones de consumo de alimentos. Propiedades de los alimentos. Toxicología. Contaminantes alimentarios. Trazabilidad. Información molecular.

SUMMARY

Food fraud and authenticity is a growing issue with a global impact that affects all steps in the food chain. Consumers demand safe foods that meet the specifications on the label claim while the role is to implement measures to ensure safe food. Unfortunately, due to the high level of complexity to detect fraud, a wide number of undetected cases may be persistent within food supply chains. Although food manufacturing principles are responsible for delivering products according to the industry and food authorities' specifications, the complexity of the food supply chains requires that stakeholders in the chain, need to have access to trusted tools which ensure the provenance of food products. This review compiles information related to food fraud and authenticity and evaluates the accessibility of the information in on-line databases for the industry and in particular for Small and Medium Enterprises (SMEs). Several categories of tools are established, and the databases included in this review are selected and analyzed according to their structure and relevance to the users. The databases reviewed herein are all from the Internet and developed by public or private organizations, so they are intended to serve a large number of users. An overview of relevant databases that have been developed in European projects is also provided.

RESUMEN

El fraude y la autenticidad alimentaria es un problema global que va en aumento y afecta a todas las etapas de la cadena alimentaria. Los consumidores demandan que los alimentos cumplan con las especificaciones que se indican en el etiquetado y las autoridades tienen el papel de establecer medidas para garantizar que éstos sean seguros. Desafortunadamente, debido a la gran complejidad para detectar el fraude alimentario, muchos casos pasan desapercibidos provocando que se mantengan dentro de la cadena de suministro de alimentos hasta llegar al consumidor final. A pesar de que los principios de las buenas prácticas en la fabricación alimentaria deben garantizar que los productos fabricados cumplan con las especificaciones de calidad marcadas por los organismos de salud, las empresas alimentarias necesitan tener acceso a herramientas de consulta fiables para asegurar la procedencia y seguridad de los productos que reciben. Este estudio recoge información relacionada con el fraude y la autenticidad alimentaria, y evalúa el acceso que tiene la industria y en particular, las pequeñas y medianas empresas (PYMES), a la información contenida en bases de datos on-line. Se han establecido varias categorias, y todas las bases de datos contenidas en cada una de ellas, han sido analizadas y seleccionadas según su

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estructura y relevancia para los usuarios. Todas las bases de datos incluidas han sido extraidas de internet y están desarrolladas tanto por organismos públicos, como privados, por lo que están destinadas a llegar a un gran número de usuarios. También se ha realizado un estudio general de bases de datos relevantes que han sido desarrolladas en proyectos europeos.

INTRODUCTION

Food fraud is a collective term used to encompass the deliberate and intentional substitution, addition, tampering, or misrepresentation of food, food ingredients, or food packaging (Spink and Moyer, 2011). According to the Food Standard Agency, UK food fraud is committed when food is deliberately placed on the market, for financial gain and with the intention of deceiving the consumer. Two types of fraud were described: 1) the sale of food which is unfit and potentially harmful and 2) the deliberate misdescription of food, such as products substituted with a cheaper alternative. As a result of this action, food safety could be affected and the health of consumers. This happens during the process of adulteration as unconventional additives may frequently be used, of which effect in human health is not determined and therefore no established plans to detect them exist either. To this respect, the increasing demand for information on different aspects of food safety and authenticity have resulted in an increasing number of available online databases, providing information related on this issue. However, it was noted in the present analysis that the relationship between the information contained in these databases and food fraud and/or authenticity is not presented clearly enough for those less specialized Small and Medium Enterprises (SMEs) in the food sector. Thus, after the Italian organics scandal in 2011, the importance of improved certification process in Europe was highlighted and the need of harmonized information, in particular databases was seen as important by the smaller traders. Moreover, since SMEs represent 99 % of all enterprises in the food sector in Europe (European Commission), it is essential, for them to have accessible reliable information in databases on potential risks of food safety and authenticity issues concerning their supplies or ingredients. Thus, the present review provides an assessment of the current availability of databases in the area of food fraud and authenticity and various concepts relating to food fraud and authenticity are defined with the aim to inform SMEs on their existence, and potential usage for consumers.

RESEARCH DESIGN AND METHODS

LITERATURE SEARCH

Two separate systematic searches were conducted to identify current databases containing relevant information regarding food fraud and authenticity. The first was a comprehensive Internet search using Google and Google Scholars domains. Keywords used for this task included: *food composition database, food authenticity database, food properties database, food fraud database*, *Toxicology database*, *Food contaminants database*, *Biomarkers database*, *Molecular information* and *Traceability*. For each keyword synonyms were sought and combined using all fields. A second search was performed within European projects. For this purpose, Cordis website was explored. Keywords used in this search were analogous to the ones used during the Internet search. In order to identify all potentially relevant data related with the issue that concerns us, an exhaustive analysis was performed using Microsoft Excel.

IMPLEMENTATION OF THE SYSTEMATIC LITERATURE REVIEW

After the collection process, the databases underwent detailed review using Microsoft Excel as a practical approach tool

to collate and categorise relevant information for the databases. Thereby, for each identified database, important data were extracted. Further , all the databases were grouped according to the status during the search period, updating and availability. The functional status of the databases were categorised as follows; 1) *finalized* when the development was completed and it was functionally active, and 2) *in process* when it was under construction. The databases were considered 3) *updated* when contains current information and according to its date of addition and 4) *outdated* when current information has not been added since the database was built or when the updating date was not indicated in the application. Depending on the availability of the information, the databases could be 1) *public*: open to share the information with all the people; and 2) *private*: belonging to/or for the use of one particular group of people only. In the present review the finalized, updated and public databases were studied with special attention. Beside this, other parameters such as possible restrictions (e.g. pay for access) and areas of interest were evaluated. No language restriction was applied neither exclusion of databases based on quality. Finally, taking into consideration all extracted information, the obtained databases were divided in seven categories: (1) Fraud (2) Food properties, (3) Food consumption patterns, (4) Food composition, (5) Toxicology, (6) Contaminants, and (7) Molecular information.

RESULTS AND DISCUSSION

Among the various databases assessed regarding access to appropriate information on food fraud and authenticity for stakeholders like food industry SMEs, NGOs, and the consumers, only two of the databases could be directly categorized as a FOOD FRAUD DATABASE. More direct information to confirm this situation appears to be lacking, and this observation is supported by recent paper by Moore et al., 2012. It can therefore be concluded that a joint effort to create an accessible database on food fraud cases benefitting food transparency for relevant stakeholders in Europe, would be a justified preventive measure needed to build consumer trust in the food supply.

CATEGORIES AND INTERPRETATION THE DATABASE

FOOD FRAUD

Food fraud is a complex term, which refers to many different issues. As an emerging risk, several articles on this topic have been published (Spink and Moyer, 2011; Spink 2011). However, as explained above, only two databases focused on food

Table I. *Examples of database on food fraud.* (Ejemplos de bases de datos sobre fraude alimentario).

Country/	Database/ Link	R/S	RF
US	USP Food Fraud Database http://www.foodfraud.org/	No	No
UK	Food Fraud Database http://www.food.gov.uk/enforcement/enforcework/foodfraud/foodfrauddatabase#.UMd8XKWSg7Q	No	No

R/S= Registration/Subscription needed; RF= Required fee for acces.

fraud was found in the present study **(table I)**. The USP Food Fraud Database created by the U.S. Pharmacopeial Convention (USP), is the first ever public database compiling reports on global food fraud and economically motivated adulteration. No restriction of access is applied so all professionals such as scientists, governmental officers, policy makers and also non-professionals interested in acquiring food fraud information like farmers, consumers and environmentalists can easily access to this platform. The main purpose of this database is to collect all the existing scientific reports regarding food fraud and detection methods from 1980 to 2010, and to publish them with the objective to identify the problematic food ingredients and catalog detection methods. As explained in the database itself, beyond listing food fraud adulterants, the database provides a baseline understanding of the susceptibility or vulnerability of individual ingredients to fraud. In addition, the facility provides a library of detection methods reported in peer-reviewed scientific journals. The application uses a search box where the name of the product or adulterant should be inserted. The outcome shows a wide list of reports regarding the respective item and documented information on different ingredients or adulterant substances.

Beside this, the UK Food Standards Agency maintains the Food Fraud Database. This database collects reports with useful information regarding emerging patterns of fraudulent activity and therefore, it can be used in order to assist local authorities with their investigation into food fraud incidents. The management of the database, storage and handling of intelligence is operated in line with the National Intelligence Model, which is an information-based business model used by police and other enforcement agencies in England and Wales.

FOOD PROPERTIES

Food products have physical properties (rheological, thermal, dielectric, water activity, mechanical, optical) that influence their processing and storage, as well as, their analysis. Detection and quantification of food constituents and properties are essential processes in order to prove conclusively that fraud has occurred. However, food matrices are extremely complex and variable (Woolfe and Primrose, 2004), for such reason food properties data is needed to elaborate appropriate analytical methods to detect food fraud. The findings from this review show a lack of databases regarding food properties and, as a result, just one outcome can be provided **(table II)**. The Database of Physical Properties of Food, which contains datasets of the principal physical properties such as thermal, mechanical and rheological, sorption and mass diffusion, electrical and dielectric and optical properties from 24 food categories and 249 subcategories. The data is obtained from 11 094 bibliographic references and is

Table II. *Examples of database on food properties.* (Ejemplos de bases de datos sobre propiedades de los alimentos).

Country/ Database/ Link		R/S	RF
Europe	Physical Properties of Food http://www.nelfood.com	Yes	No

R/S= Registration/Subscription needed; RF= Required fee for acces.

Table III. *Examples of food consumption pattern databases.* (Ejemplos de bases de datos sobre modelos de consumo de alimentos).

Country/ Database/ Link	R/S	RF
Europe Eurostat http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/	No	No
USA USDA International Food Consumption Patterns http://www.ers.usda.gov/data-products/international-food-consumption-patterns.aspx	No	No
USA Nutrition and Food Intake Database http://foodrisk.org/databases/nutrition/	No	No
Belgium IDF Dairy Nutrition http://www.idfdairynutrition.org/ListPage.php?siteID=260&ID=334&specialHeaderID=325	No	No

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presented with the experiment details and the experimental data. A registration is needed to access to the datasets.

FOOD CONSUMPTION PATTERNS

Food consumption patterns of a population are referred to a set of food most frequently used for the majority of this population. Outlining food consumption patterns is a key in assessing dietary adequacy and safety, representing important aspects in evaluating the relationship between diet and health, including the role of consumers' attitudes, preferences and lifestyle related to socio-economic situation and cultural models (Turrini *et al.*, 2001). Therefore, for example, when a food safety risk appears or a food fraud is detected, data of food consumption patterns is needed in order to know the scope of the problem and to predict the exposure of a hazard in a population. For this reason, food consumption patterns' category is included in this review **(table III)**. The Eurostat portal is a public, completed and continuously updated database which purpose is to provide a framework for the quantitative evaluation of data on the safety of products used for human or animal consumption in the EU, irrespective of whether these products are produced within the EU or imported. Thereby, it offers access to various sets of statistics related to food products and the information is collected from different statistical sources and covers *from farm to fork*. The domain includes as well statistics on *products with distinctive marks* like products issued from organic farming and GMO (Genetically Modified Organisms). The USDA International food Consumption Patterns contains estimates, using 2005 data, total and marginal budget shares, income and price elasticity for nine broad consumption groups as well as eight food subgroups across 144 countries. Countries are listed by per capita income which is reported in the marginal share files. Similar estimates based on 1996 ICP data, which also includes cross-price elasticity are available in a zip file. Regarding the product coverage, there are 8 food sub-categories including bread and cereals, meat, fish, dairy products, fruits and vegetables, oils and fats, beverages, tobacco and other food products. There is also one broad consumption category relating to food which includes food prepared and consumed at home, food away from home, and beverages and tobacco. The Nutrition and Food Intake Database presents a collection of 48 food consumption patterns and food

surveys databases which can support public health policy and scientific research in the field of food intake, nutrition intake, additives and contaminant intake. More specific information is contained in the IDF Dairy Nutrition database. This is also a public, completed and continuously updated database and provides information regarding dairy, nutrition and health. The data is obtained from peer-reviewed scientific articles independent of their scientific content and conclusions. All the references in this database are grouped per topic.

FOOD COMPOSITION

Food composition databases provide detailed information on the nutritional composition of foods and can be used in a variety of ways by a spectrum of users (Rand *et al.*, 1987; Williamson, 2005; Egan *et al.*, 2007). In this respect, food composition information allows consumers to make knowledgeable choices about their diet and is essential in order to assess dietary profiles and to perform nutrient analysis. Beside this, the food composition databases provide information on the nutrient content of foods and can facilitate the assessment of food ingredients replacement. For this reason, food composition databases are important information sources, which can contribute to transparency regarding food authenticity and minimize economic fraud.

The collection and analysis of dietary intake data in a country is essential for establishing dietary inadequacies/excesses as well as the role of diet in the prevalence and development of diet-related health risks, which in turn impact on policy formulation for the country (Wolmarans *et al.*, 2009). Due to this, it is common for food composition databases to focus on the collection of data from a given country. **Table IV** shows an overview of the found databases in this category. The Japanese food composition database developed by the Sugiyama Jogakuen University and based on the *Standard Table of Food Composition in Japan*, of the Resources Council of the Science and Technology Agency of Japan is an example. The facility contains information focused in food composition of Japan and is organized in 3 tables: *The Standard Table of Food Composition in Japan, Fifth revised edition, The Table of Amino Acid*

Table IV. *Examples of food composition databases.* (Ejemplos de bases de datos sobre composición de los alimentos).

Country/ Database/ Link		R/S	RF
Japan	Japanese food composition database http://database.food.sugiyama-u.ac.jp/index_asia.php	No	No
USA	USDA National Nutrient Database for Standard Reference (SR) http://ndb.nal.usda.gov/	No	No
Norway	NIFES http://www.nifes.no/sjomatdata/?lang_id=2	No	No
Europe	EuroFIR http://www.eurofir.net/	Yes	Yes
Austria	Michael Murkovic *et al.* Databases on Carotenoids http://www.foodscience.tugraz.at/pumpkins/pumpkins.htm http://www.foodscience.tugraz.at/vegetables/vegetables.htm	No	No

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Composition of Foods in Japan, Revised edition and *The Table of Fat-Soluble Composition of Foods in Japan*. However the last updated version available is from 2004/02/09, so its use would be restricted to studies before that time. The USDA National Nutrient Database for Standard Reference (SR) is a scientific and bibliographic database focused on the collection and dissemination of food composition data. The most updated version of the application (Release 25) contains data on 8194 food items and up to 146 food components, providing data for all the food groups. According to the information published in the database, this makes USDA National Nutrient Database for Standard Reference, the major source of food composition data in the United States. The database is organized in 26 food groups such as baby food (with 333 entries), baked products (785 entries) and pork products (341 entries) for example. The data contained in this network have been collected from published sources, including the scientific literature but also from unpublished sources such as food industry data or other government agencies. It incorporates a search box and provides search options through a drop-down menu. This option makes the database user-friendly and intuitive.

There are numerous national food composition databases. However, these databases often contain data on formulated food and their use is of value for national dietary studies to observe a general trend, but they are not a reliable source to be used for labeling of food due to the fact that food formulation varies among countries. A European initiative on food databases is the EuroFIR eSearch facility, an innovative scientific and bibliographic database, which provides online access to a wide range of harmonized and documented food composition data. The innovative software tools used in the *EuroFIR partner food composition database* allows the access to databases from more than 20 European standardized and specialized food composition databases. In this unification process of the European databases, the methodology used plays a key role,

Table V. *Examples of databases on seafood, North Atlantic species).* (Ejemplos de bases de datos sobre alimentos de origen marino, especies del Atlántico Norte).

Country/	Database/ Link	R/S	RF
Iceland	ISGEM, Matís http://www.matis.is/ISGEM/is/leit	No	No
Denmark	Danmarks Tekniske Universitets Fødevareinstituttets Fødevaredatabank http://www.foodcomp.dk/	No	No
Norway	Matvaretabellen http://www.matportalen.no/matvaretabellen	No	No
Norway	National Institute of Nutrition and Seafood Research http://www.nifes.no/sjomatdata/?lang_id=2	No	No
Sweden	Livsmedelsdatabasen http://www7.slv.se/Naringssok/SokLivsmedel.aspx	No	No
USA	USDA National Nutrient Database for Standard Reference http://www.nal.usda.gov/fnic/foodcomp/search/	No	No
Canada	Health Canada http://www.hc-sc.gc.ca/fn-an/nutrition/fiche-nutri-data/index-eng.php	No	No

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highlighting the use of standardized food description (LanguaL) and standard vocabularies (standardized component and value description through the use of thesauri). EuroFIR has prioritized forty nutrients in their effort to improve databases on food composition in Europe (Møller *et al.*, 2007). Besides, the main components (fat, nitrogen, cholesterol, protein, and water) the priority components suggested by EuroFIR are: fatty acids, fat soluble vitamins (A, D, E), water-soluble vitamins, minerals and trace elements (Na, K, Ca, Mg, Fe, Zn, Cu, P, Se and I). The search mechanism incorporates options to search on food name, food description and a combination of both as well as the possibility to compare the component values between foods from European food composition databases. The information obtained can be downloaded as spreadsheets. In addition to the above mentioned EuroFIR offers direct access to subsets of food composition databases as a contribution to the EPIC project and is linked with USDA National Nutrient Database for Standard Reference. Moreover, is possible to access to other datasets such as EuroFIR eBASES, Phenol-Explorer on Polyphenols, InformAll (Food Allergen Database), GEMS (Food Codex Classification for Foods and Feeds) and GRIN (Germplasm Resources Information Network - Taxonomy for Plants). Food composition-related scientific articles, reports and other relevant documents related to food composition are included in the facility as a bibliographic database. EuroFIR is a public and periodically updated database; however the access to the facility is restricted so it is needed to become a member and to pay a fee. Examples of databases providing information on specific raw material (e.g. wild fish and seafood) are for example the NIFES Seafood Database, developed and maintained by the National Institute of Nutrition and Seafood Research in Norway.

Table VI. *Examples of toxicology databases.* (Ejemplos de bases de datos sobre toxicología).

Country/	Database/ Link	R/S	RF
USA	TOXNET (Toxicology Data Network) http://toxnet.nlm.nih.gov/	No	No
International	IPCSINCHEM http://www.inchem.org/	No	No
Italy	EDID (Endocrine Disrupting Chemicals Diet Interaction Database) http://www.iss.it/inte/edid/cont.php?id=110&lang=2&tipo=17	No	No
USA	Distributed Structure-Searchable Toxicity (DSSTox) http://www.epa.gov/ncct/dsstox/	No	No
USA	ECOTOX Database http://cfpub.epa.gov/ecotox/	No	No
USA	OEHHA Toxicity Criteria Database http://oehha.ca.gov/tcdb/index.asp	No	No
USA	Agency for Toxic substances and Disease Registry (ATSDR) http://www.atsdr.cdc.gov/	No	No
USA	Food safety Acute Toxicity Database http://www.leadscope.com/product_info.php?cPath=1_16&products_id=113	Yes	Yes
Canada	Registry of Toxic Effects of Chemical Substances (RTECS) http://www.ccohs.ca/products/rtecs/	Yes	Yes

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In this database historic data on the nutrients is available providing information on the origin of samples and year. Data on undesirable components of seafood are also available in the NIFES database. Other examples of databases on seafood composition for species in the North Atlantic are shown in **table V**.

Also very specific are the following databases of Michael Murkovic et al. Databases on carotenoids in Austrian Pumpkins and Database on Carotenoids on Austrian Vegetables that contain carotenoid values in a variety of pumpkins grown in the year 2000 in Austria and Romania, and carotenoid values in a variety of Austrian vegetables respectively.

All the databases included in this category are providing users important information regarding food composition and, therefore, are important when considering food authenticity. However, it is very important to standardize data of nutrient and energy content of food products along the European Union countries because food quality and safety issues are complex and extend beyond national boundaries (Egan *et al.*, 2007).

TOXICOLOGY

Most compounds used in food fraud are classical chemicals with a well-established dose-effect relationship, but in the non-conventional substances the dose-effect relation can be far from linear and the migration and concentration through the food chain can play an important role (Hofman, 2005). Toxicological databases allow the access to scientific data regarding toxicological chemical compounds in foodstuffs and human health. The findings from this review **(table VI)** show a wide number of databases the majority being developed by United States institutions while a smaller number is created by European ones. TOXNET (Toxicology Data Network) developed by The National Library of Medicine of United States is a public collection of 16 databases on toxicology, hazardous chemicals, environmental health, and toxic releases. The portal allows the user to search in one particular database or in all of them at the same time. Regarding the search methodology, data can be found through keywords inserted into the search box (e.g. milk), small phrases (e.g. nitrates in food) orusing the CAS number or the chemical name. Out of the 16 databases which are identified in the present paper (in the toxicology category), only the ones considered with a high relevance to food fraud and authenticity are highlighted: The Carcinogenic Potency Database provides results of animal cancer test on 1457 chemicals. The carcinogenic potency is measured by TD50, which is the daily dose rate in mg/kg body weight/day to induce tumors in half of test animals. ChemIDplus database provides name, synonyms and structures of over 370,000 chemicals. A full report of each chemical substance is available and besides the items mentioned before, it also comprise toxicity aspects, physical properties and links to other resources (such as NLM, Pubmed or Medline). TOXLINE database is organized for easy usage and provides a wide number of toxicology literature references of chemical substances. It is possible to use search limiters and search for synonyms, search words in the full record or in the title, year of publication, language and search sites available. Chemical Carcinogenesis Research Information System (CCRIS) database provides mutagenic and carcinogenic studies in animals of over 8000 chemicals. The search can be bounded at substance identification, carcinogenesis studies and mutagenic studies. References of the study and its results can be also obtained. Integrated Risk Information System (IRIS) database shows reports of dose-response of over 500 potentially toxic chemicals. Data of chronic health hazard assessment for non-carcinogenic effects and

carcinogenicity assessment for lifetime exposure is presented. The International Toxicity Estimates for Risk (ITER) database is similar to the previous database but includes chemicals authorized worldwide. The IPCS INCHEM developed by the International Programme on Chemical Safety (IPCS) and the Canadian Centre for Occupational Health and Safety (CCOHS) has a similar structure as Toxnet. It contains information on risk of chemicals used throughout the world and are likely to contaminate the environment and food and offers similar search methodology. Concise International Chemical Assessment Documents (CICADs) database allows the user to obtain a wide summary of the effect of chemicals in human health and environment. Further information as analytical methods, sources of human and environmental exposure, environmental levels and human exposure and effects on laboratory animals (kinetics and metabolism), can be obtained through a comprehensive report. The IPCS INCHEM Database contains the International Chemical Safety Cards (ICSCs) where data of acute hazards, symptoms of exposure, environmental data of bioaccumulation, physical properties of the substance and other important data is provided. The information is presented in a clear way and is intended to be user- friendly. The JECFA (Joint Expert Committee on Food Additives) is another source of data within IPCS INCHEM. It compiles toxicological information of food additives and residues of drugs in foodstuffs. Data is provided in written documents and consider aspects such as substances' identity, uses, biological data, biochemical aspects, acute toxicity and studies of long and short term exposure. Generally all sources of information used by the IPCS INCHEM have much relevance in food fraud aspects and authenticity, so useful information can be extracted from them. EDID (Endocrine Disrupting Chemicals Diet Interaction Database) is developed by Instituto Superiore di Sanità (Italy). Data of the interaction of endocrine-xenobiotics and natural food components since 1978 until 2012 is collected. The information is provided with published documents of international and national scientific studies. Distributed Structure-Searchable Toxicity (DSSTox) Database Network is developed by EPA-United States Environmental Protection Agency. This database is focused on chemical structures and toxicological information. The structure and the description of the substance appear in

Table VII. *Examples of food contaminants databases.* (Ejemplos de bases de datos sobre contaminantes de los alimentos).

Country/ Database/ Link		R/S	RF
International	International Food Contaminants and Residue Information System (INFOCRIS) http://www-infocris.iaea.org/en/default.htm	No	No
Norway	Seafood Data http://www.nifes.no/sjomatdata/?lang_id=2	No	No
International	GEMS/Food contaminants https://extranet.who.int/gemsfood/	No	No
Europe	FC24 database http://www.fera.defra.gov.uk/foodDrink/decisionSupportTools/fc24.cfm	Yes	Yes

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this website but also external links to other databases are provided. The ECOTOX Database is also developed by EPA-United States Environmental Protection Agency and is interesting to find toxicological reports of chemicals analyzed in aquatic and territorial animals and plants. The OEHHA Toxicity Criteria Database is developed by Office of Environmental Health Hazard Assessment (OEHHA). A wide list of chemicals is collected and data regarding its acute or chronic exposure levels is showed. For some chemicals there are also data concerning the carcinogenic potency. However, data is not completed in all items for all the chemicals presented in the database. The Agency for Toxic substances and Disease Registry (ATSDR) presents wide information about many toxic substances which are in the environment and can be found in food. There is a description of the chemical and the effect in health. There are also many links to other sites to complete the data regarding the chemical substance. Two publically available databases restricted by a fee were found in the present study regarding toxicology: The Food safety Acute Toxicity Database developed by Leadscope® which provides a wide amount of toxicological data of food additives and chemicals tested in laboratory animals. The Registry of Toxic Effects of Chemical Substances (RTECS) database interesting for containing details of critical toxicological information with citations on over 174 000 chemical substances from more than 2500 sources.

FOOD CONTAMINANTS

Food contaminants are substances as

Table VIII. *Examples of molecular information databases.* (Ejemplos de bases de datos con información molecular).

Country/ Database/ Link		R/S	RF
UK	EBI-European Bioinformatics Institute http://www.ebi.ac.uk/	No	No
USA	Genomes Online Database (GOLD) http://www.genomesonline.org/cgi-bin/GOLD/index.cgi	No	No
Switzerland	ExPASy database http://www.expasy.org/	No	No
Germany	Munich Information Center for Protein Sequences (MIPS) http://www.helmholtz-muenchen.de/en/ibis	No	No
Netherlands	EXProt http://www.cmbi.kun.nl/EXProt/	No	No
Germany	European VITIS Database http://www.eu-vitis.de/index.php	Yes	No
International	Biobase http://www.biobase-international.com/	Yes	Yes
Europe	GMOINFO http://gmoinfo.jrc.ec.europa.eu/	No	No
	GMOMETHODS http://gmo-crl.jrc.ec.europa.eu/gmomethods/	No	No
UK	PRINTS http://www.bioinf.man.ac.uk/dbbrowser/PRINTS/index.php	No	No

R/S= Registration/Subscription needed; RF= Required fee for acces.

chemicals, natural toxins, metals, pesticides, microbiological organisms or other physical materials, present in food products and that are susceptible to cause a risk to health. Derived hazards of food contamination could have a global reach level. In today´s world it is crucial to understand and deal with the global implication of the foodborne diseases in order to prevent them. Databases or other tools regarding food contaminants are needed so that outbreaks, be they due to microorganisms or chemical substances, can be studied more rapidly and the causes identified, reported and eliminated (Ingelfinger, 2008). The findings of the present review **(table VII)** have reported interesting sources concerning food contaminants. Is the case of the International Food Contaminants and Residue Information System (INFOCRIS) developed by FAO and IAEA. In this database a wide list of reports of food and environmental contaminants are available for public use. Reports are presented containing items like identity, uses, mode of action, toxicology, fate, ecotoxicology among others. Another interesting database already mentioned is Seafood Data, which has been created by National Institute of Nutrition and Seafood Research (NIFES). There is information about undesirable compounds found in seafood species and nutritional data about them. The database is specific for seafood, but limited to species that are regarded as economically the most important species for Norwegian export. It is publically available and continuously updated. There is a need for a similar database for other seafood species consumed by the European population. GEMS/Food contaminants, is also a public database and is developed by WHO. It is possible to look for contaminants in different food products of 6 different regions of the world. Among other information, it can be found data of sampling period, food origin, LOQ, LOD and state of analyzed food. The database is in progress and there are only reports for Western Pacific Region and Region of the Americas.

The FC24 database developed by The Food and Environment Research Agency (Fera), is a guide of EU food contaminants legislation and residue limits. It is publically available but a fee to register is needed.

MOLECULAR INFORMATION

Foodstuffs are generally of plant or animal origin. Therefore, the reliable identification of the species is a key issue for food authenticity (Lüthy, 1999). Molecular information of proteins or nucleic acids, are suitable to be used for that purpose. They act as identifiers of the origin of the food products. Databases with molecular information and molecular techniques to detect them are useful tools to food authenticity assessment. **Table VIII** shows the found databases regarding molecular information. The EBI-European Bioinformatics Institute hosts a biological database with a compilation regarding nucleotide sequence, protein sequences, biological structures, functional genomics and small molecules. Free data can be obtained from them. The Genomes Online Database (GOLD) is a resource of genomic and metagenome sequencing projects around the world. It has been developed by JGI-DOE Joint Genome Institute and currently has 18486 files of genomes, being last updated date on 2012/10/26. ExPASy database is the SIB (Swiss Institute of Bioinformatics) Resource Portal which provides access to scientific databases and software tools of several categories as proteomics, genomics, structural bio-informatics and population genetics among others. At the same time, these categories are subdivided into subcategories which result an easier way to focus the search. The database also allows the user to search in all databases at the same time or take the information from a specific one. The Munich Information Center for Protein Sequences (MIPS) contains and maintains the systematic comparative

Table IX. *Examples of databases from projects.* (Ejemplos de bases de datos de proyectos).

Project/ Database/ Link	R/S	RF
SUCONDA/ EFSA European Food consumption Concise Database http://www.efsa.europa.eu/en/datexfoodcdb/datexfooddb.htm	No	No
FACET/ Food intake database http://www.ucd.ie/facet/	-	-
MONIQA/ MoniQa Methods database http://www.moniqa.eu/database	Yes	No
SAFE FOODS/ SAFE FOOD Expert Database http://www.safefoods.wur.nl/UK/ExpertDatabase/	Yes	-
CEFSER/ ChemContDATABASE http://www.tf.uns.ac.rs/CEFSERweb/CHEMCONTDatabase.html	-	-
DOOR database http://ec.europa.eu/agriculture/quality/door/list.html	No	No
Identification of Structure Activity Relationship (SAR) Alerts (Combination of Functional Groups) for Substances with Low NOELs Rep-Dose (repeated dose toxicity) http://www.fraunhofer-repdose.de/	Yes	-
Art. 36 project CFP/EFSA/SCAF/2008/01/ Toxicological database http://www.efsa.europa.eu/en/supporting/pub/42e.htm	-	-

R/S= Registration/Subscription needed; RF= Required fee for acces.

analysis of microbial, fungal, and plant genomes. It contains two different databases: Pedant Database and Plant Genomes Database, which are available for free. The first one is organized for easy usage however due to hardware crash since July 2012 it is switched to maintenance mode and not all genomes are available. The Plant Genomes Database presents the results of the genomic analysis of maize, *Medicago truncatula*, *Lotus*, rice, tomato, sorghum, barley and others. Data is obtained with the analysis of 9 databases related. EXProt (database for proteins with an experimentally verified functions) has 6491 entries of experimentally verified functions of protein sequences. A set of three databases is the source to obtain data (PseudoCAP, GenProtEC and EMBL Nucleotide Sequence Database). There are also more specific databases about molecular information. As an example, The European VITIS Database which contains genetic resources of grapes. It is for public domain but a subscription is needed.

However, taking into consideration the fraud and food authenticity, biomarkers play an essential role. Biomarker is a specific (bio) chemical with a particular molecular feature that makes it useful for measuring (Zolg and Langen, 2004; Raspor, 2005). Generally we need biomarkers to chase and trace quality and safety of foodstuffs during their production or consumption and we have to select such biomarkers which can be used in many different places and different circumstances along the food chain (Raspor, 2005). Therefore, in order to select and obtain information regarding biomarkers, databases can be very useful as there are different types of biomarkers with high potential to be used to ensure the authenticity and quality of foodstuffs. Databases regarding profiles of the most frequently biomarkers are important for this objective. Biobase is a biological database which provides a set of 6 public databases

with molecular information. It is needed a subscription and pay a fee to use them. From this database collection, some of them are specially focused in human genome variations. Interesting information can be obtained concerning gene sets of mammalian, yeast, worm and plant species in some others which are susceptible organisms to use as food products. As explained above the Joint Research Center provides a list of useful databases regarding food fraud and authenticity. Two of them are suitable to obtain data of GMOs detection: the GMOINFO (Database on the notification for GMO releases) and the GMOMETHODS (on-line database on GMO detection methods).

Protein fingerprints, are also important molecules to consider in order to study food fraud and authenticity. A protein fingerprint is defined as the pattern of fragments obtained when a protein is digested by a proteolytic enzyme, usually observed following two-dimensional separation by chromatography and electrophoresis. It is susceptible to serve as identity mark. The present review has provided a relevant database according to food fraud and authenticity: PRINTS. This is a database of protein family *fingerprints* offering a diagnostic resource for newly determined sequences (Attwood *et al.*, 1997), and is a public domain database of Manchester University. Nowadays it contains 2,156 fingerprints, encoding 12,444 single motifs.

DATABASES FROM PROJECTS

As food fraud is a growing problem and there is a lack of reliable global data, studies in this field are needed. To this respect, the European Commission is launching many projects in this direction. Some examples of databases from projects are show in **table IX**. Thus, due to the relevance of food consumption patterns for the health assessment and its relationship with food fraud, the objective of some current projects is to develop or support the development of databases focused on this issue. Is the case of SUCONDA EU Project (Support to complete EFSA's food Consumption Concise Database) where BfR (Das Bundesinstitut für Risikobewertung) in collaboration with EFSA are carrying out work on the setting up and development of the EFSA European Food consumption Concise Database. The purpose of this database is to provide food consumption data for exposure assessments on the EU level. Other example is the FACET EU Project, which will estimate exposure to flavors, additives and food contact materials across Europe. For this, a database is being developing so will be possible to analysis consumption patterns regarding flavors, additives and food contact materials in EU countries. Concerning, food contaminants, there are three European projects involved in databases development: The MoniQa Methods database, the SAFE FOOD Expert Database and ChemCont Database. The SAFE FOOD Expert Database and ChemCont Database are private databases. The MoniQa Methods database is public but registration is needed and also to pay for access. The EU-funded project MONIQA (*Monitoring and Quality Assurance in the Total Food Supply Chain*) is developing reliable methods and tools to assess the food we eat. Funded under the Sixth Framework Programme (FP6) of the European Union, provides a database on the quality and safety of food and analytical tools to promote a safer and secure food supply chain. The SAFE FOOD Expert Database was also developed under the Sixth Framework Programme, in particular within the SAFE FOODS project (Promoting Food Safety through a New, Integrated Risk Analysis Approach for Foods). The database is defined as an electronic library containing experts and expertise in the field of food safety research and food safety assessment. The objective is the early detection of food related emerging risks. DATABASE on chemical contaminants in

Table X. *Examples of traceability databases.* (Ejemplos de bases de datos sobre trazabilidad).

Country/	Database/ Link	R/S	RF
Europe	TRACE Molecular Biology Database http://www.trace.eu.org/mbdb/	No	No
Europe	FISHTRACE Online Database of European Marine Fishes https://fishtrace.jrc.ec.europa.eu	No	No
Europe	FISHPOPTRACE FishPopTrace database https://fishpoptrace.jrc.ec.europa.eu/home	Yes	-
Europe	Anchovy ID Authentication Tools for Anchovy Products https://anchovyid.jrc.ec.europa.eu/	Yes	No

R/S= Registration/Subscription needed; RF= Required fee for acces.

food (ChemContDATABASE) is still under development and is integrated in the EU-poject CEFSER under the Seventh Framework Programme (FP7).

Among these projects, the European Commission is also implementing the so-called three EU schemes known as PDO (protected designation of origin), PGI (protected geographical indication) and TSG (traditional specialty guaranteed) promote and protect names of quality agricultural products and foodstuffs. The objectives of these schemes are to encourage diverse agricultural production, to protect product names from misuse and imitation and to help consumers by informing them regarding the specific character of the products. Thus, PDO covers agricultural products and foodstuffs which are produced, processed and prepared in a given geographical area using recognized know-how. PGI covers agricultural products and foodstuffs closely linked to the geographical area. At least one of the stages of production, processing or preparation takes place in the area. And TSG- highlights traditional character, either in the composition or means of production. In order to get informed about which product names have been registered in this schemes, the DOOR database have been created. Therefore, the products names registered as PDO, PGI or TSG as well as names for which registration has been applied can be consulted in this database. Besides the European Union, other institutions are working in the development of databases. Is the case of The Rep-Dose (repeated dose toxicity) database developed by Fraunhofer ITEM as part of a project sponsored by CEFIC LRI, B1.1: *Identification of Structure Activity Relationship (SAR) Alerts (Combination of Functional Groups) for Substances with Low NOELs (RepDose Database*). It is a public database which requires registration and provides the basis to perform analyses on repeated dose toxicity. It contributes to the Sixth Framework Programme OSIRIS (which develops and integrates testing strategies) in order to replace or reduce animal tests e.g. under REACH. Other example is the Art. 36 project CFP/EFSA/SCAF/2008/01 funded by EFSA which aims to develop a toxicological database of chemical mixtures relevant to food safety. The database is been developed by FERA (The Food and Environmental Research Agency, UK) and has restricted access to key people.

Under EU law, *traceability* means the ability to track any food, feed, food-producing animal or substance that will be used for consumption, through all stages of production, processing and distribution. This opportunity to follow the product `from

farm to fork`, ensures a rapid intervention in the event of a food risk alert. Besides, the system allows the possibility to verify the origin of food and its authenticity along the food chain. This is the main purpose of TRACE project developed under the Sixth Framework Programme. TRACE project has created a database of data regarding original features of food as molecular information (DNA or protein) and the development of detection methods of them. At the moment, this database is focused on mineral water, cereals, meat and honey and has a public access. The Common Fishery policy of the European Union is a driver for the management of interesting databases (like FISHTRACE and FISHPOPTRACE) **(table X)** to protect fish stocks and stop illegal fishing and also work on more species is resulting in development of a specific Anchovy ID database (Jerôme *et al.*, 2008). They contain data to determining frauds in species substitution cases. They also provide information for rapid assays developments.

Other databases

The aim of disseminating or sharing information and data produced worldwide may be limited by inappropriate terminology that often hampers efficient communication and discussions at the intergovernmental level (Degrassi *et al.*, 2003). In this context, the Food and Agriculture Organization of the United Nations (FAO) as a knowledge organization plays a key role by creating and sharing information regarding food, agriculture and natural resources publically available worldwide. Many databases are included in this platform and in order to help users, and to give them more efficient and comprehensive access to the information, 50 alphabetically-listed entries can be found in the glossary of FAO-managed databases and information systems.

With respect to this review, many of the above mentioned categories can be consulted e.g. food consumption patterns, food composition, fishery statistics, etc. However, besides the need to harmonize the obtained data and methodologies of dissemination, it is also essential to harmonize the analytical methods used. In this regard, the Association of Analytical Communities (AOAC INTERNATIONAL), is working on the development, use and harmonization of validated analytical methods and laboratory quality assurance programs and services. The Joint Research Centre of the European Commission under the Institute for Health and Consumers Protection (IHCP) which also has a compilation of databases with sources of analytical methods to detection of genetically modified organisms and chemicals, which are susceptible of food fraud. The databases support the European legislation and most of them can be accessed for free. The IHCP's main research lines are associated with the study of nanomaterials but also nutritional aspects. Related to this, analytical tools for the prevention of fraud and to help ensure the safety of food and consumer products including detection of genetically modified organisms are provided. The databases included in this platform are the following: AIRMEX (European Indoor Air Monitoring and Exposure Assessment Project), DB-ALM (Database on Alternative Methods), ExpoFacts (European Exposure Factors Database), ESIS (European chemical Substances Information System), EDEXIM (European Database of EXport and Import) of certain dangerous chemicals, GMOINFO (Database on the notification for GMO releases), GMOMETHODS (on-line database on GMO detection methods), JRC (Q)SAR Model Inventory, NANOhub database, Reference collection of monomers and additives (EURL-FCM).

CONCLUSION

The global impact and complexity of food fraud and authenticity makes the information infrastructure a critical com-

ponent. The lack of compilation/clustering of useful and directly related information regarding food fraud and authenticity, leads to the fact that search process, selection of data and how to handle it become a difficult task for regulatory authorities, as well as for SMEs, NGOs, associations and consumers. Therefore, harmonization and coordination of relevant databases are important driving force in order to set the basis for transparency and trust in the food supply and disseminate relevant information and capacity building through the diverse stakeholders.

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