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IODINE DATABASE: CONTENT OF THIS TRACE ELEMENT IN FOOD

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Abstract – Iodine is an essential trace element in human and animal diets. However iodine deficiency is reported in most of the countries. Food is the natural source of iodine. Traceable analytical values to SI units are required to guarantee reliable measurement results which are used to estimate iodine intake overtime at national and international level. The aim of this study was to create an iodine database containing analytical values, methods of analysis and metrological concepts, described in scientific publications reporting food data. This database will be used as a starting tool to define the iodine key foods as part of national diet programme.

Keywords: Iodine, Database, food, thyroid hormones

1. INTRODUCTION

Iodine is an essential trace element and its nutritional importance is well established. It is required for the synthesis of the thyroid hormones thyroxine and its active form T3, as well as the precursor iodotyrosines. The major role of thyroid hormones is related to the growth and development of the body. Iodine deficiency is the most common cause of preventable mental impairment. Chronic iodine deficiency can lead to disorders which include mental impairment and retardation, and formation of goiter (thyroid dysfunction), an enlargement of the thyroid gland which implies inadequate thyroid hormones production [1].

In Europe according to the latest WHO and EURRECA publications there is a shortage of consumption of foods with adequate iodine content [2, 3]. In Portugal recent studies showed significant deficiencies in pregnant women [2] and other reported that iodine intake was inadequate in 47% of Portuguese children [4]. The authors suggested an iodine supplementation during pregnancy with 150-200 µg/day and a global prophylaxis with salt iodization. Face to these results, the National Program for Promotion of Healthy Diet (II Fórum Nacional de Investigação em Saúde, INSA 2012,) pointed out the need to obtain data on iodine content of foods and iodine intake as a research priority in order to provide the country with evidence to define nutritional policies to meet the WHO recommended daily intakes [1]. The current Portuguese Food Composition Table does not include data on iodine [5]. For this reason the aim of this work was to develop a database with content of iodine in foods to predict nutritional adequacy of dietary intake. This is a first task of a large project to improve iodine intake through food consumption.

2. MATERIALS AND METHODS

2.1. Database development

The development of iodine database included four main steps: research of literature, data compilation, data evaluation and data aggregation (Figure 1). Furthermore the database has the main aims: To standardize concepts and associated terms to ensure a common language and consequent understanding among beneficiaries; To gather information on the monitoring systems of quality and authenticity of food products rich in iodine to create a database and make it available in harmonized and widely accessible form and to promote the integration exchange in the Scientific Community

Iodine database was performed by search scientific publications in peer-reviewed journals. This search was carried out in the Web of Science and built from a template using the most representative food in the food group, associated to the iodine and to identify keywords related to quantitative information. The bibliographical references were imported in a Mendeley, Ltd. (Elsevier) library.

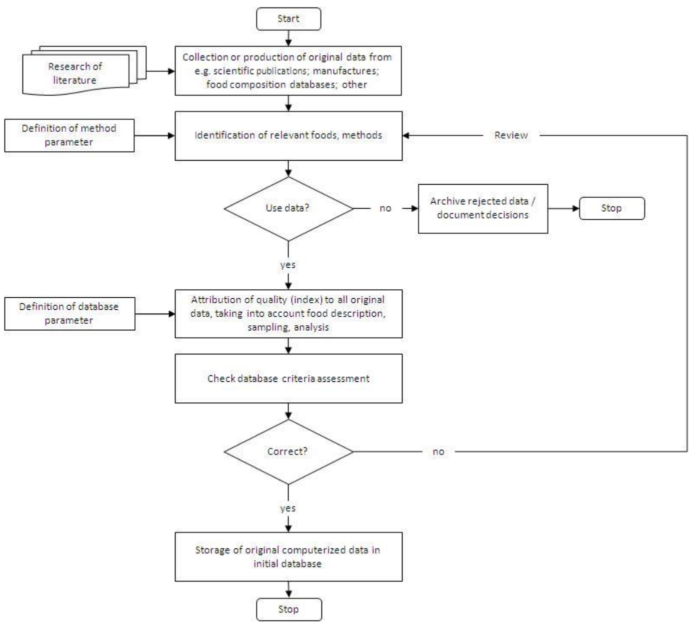

Figure 1: Flowchart of the development of the Iodine-database

The references that provide quantitative information on iodine in food were selected based on their title, abstract and scientific level of publication.

Information on foods, iodine content, analytical methods and reference materials was manually inserted in the Microsoft Excel database. The database is organized in five main tables (Figure 2):

- Foods. In this table were collected the food group and subgroup based on EuroFIR food description. Scientific name and common food name were also included. Foods were divided in nine groups: Protein Foods (e. g. meat, fish, shellfish, egg), Horticultural (e. g. vegetables, fruit, starchy tubers), Grain Foods (e. g. cereals and pasta, breads, pastry, breakfast cereals), Dairy foods (e. g. milk products, cheese), Beverages, Sugars, Fat and Oils, Baby Foods and Botanical Foods.
- Analytical Methods. It contains the information about methods of analysis including method performance (Applicability, Range, Limit of Detection, Limit of Quantification, Precision, Recovery and Trueness).
- Reference materials. It contains full information on the reference materials. Code of reference material analysed, matrix, certified value, found value and uncertainty.
- Iodine in food. It contains value reported for iodine content in food, the number of analysed samples and mode of expression.
- Publications. DOI, Author, year of publication, title, journal (journal, volume, page and year of publication) and URL.

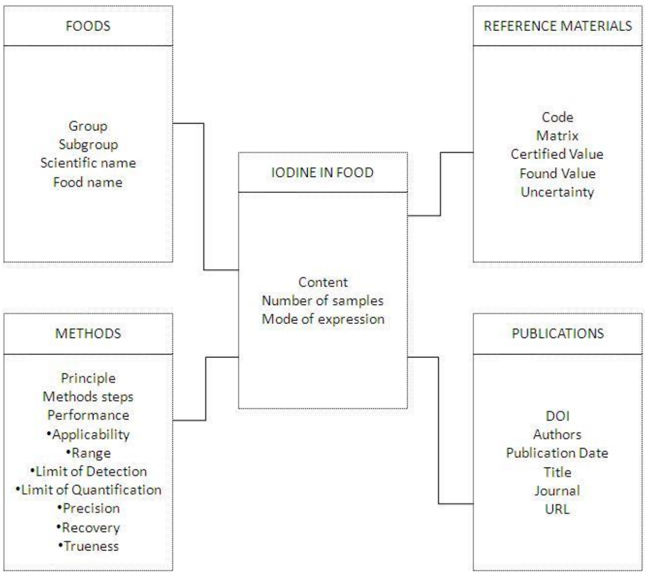

Figure 2: The different tables in the Iodine-database

2.2. Inclusion/exclusion criteria

A set of inclusion/exclusion criteria were applied to all the scientific publications. The optimization of analytical conditions, including the sample digestion process and Internal Quality Control procedure implemented in laboratory and in accordance with international guidelines are the most critical inclusion criteria. Laboratory performance demonstrated at appropriate collaborative studies are as well as relevant inclusion criteria.

The exclusion of a composition data was justified with one or more of the following condition:

- Samples: nature of the samples analyzed with lack information; analyzed samples with non-edible parts;
- Analytical methods: methods of analysis for quantification of iodine with less information or lack on information; method performance non identification or inaccurate information;
- Expression of results: No information on moisture content provide when food content expressed per weight units; content values reported in graph; number of samples analyzed not identified when mean contents are reported
- Publication: date of publication upper to 2000; journal; scientific publications not in peer-reviewed journals;

3. RESULTS AND DISCUSSION

3.1. Food

Iodine content in foods was initially organized by type of foods: Baby Foods, Botanical Foods and Foods commonly consumed by national population.

Highest iodine content was reported in seaweeds (Botanical Foods) then Baby Foods. The maximum iodine content found was more than 8000 mg/kg. When compared Baby Foods and Foods for adult population highest levels of iodine content was reported in Baby food (Figure 3). However Protein Food group has the highest iodine content among the groups of foods consumed by adult population. In all scientific publication of iodine database maximum value of iodine was found in shellfish (10.16 mg/kg). Second type of food with more content is fish (2.5 mg/kg).

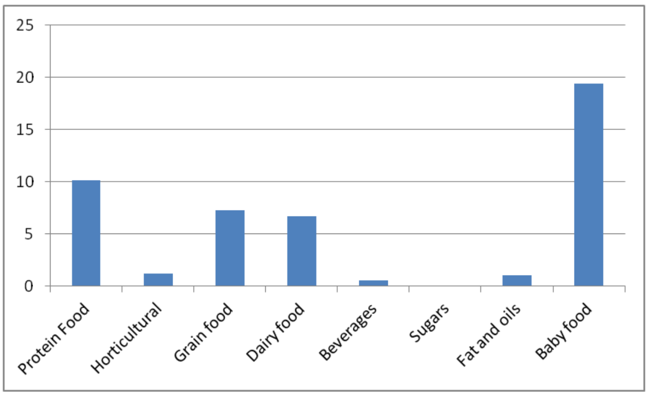

Figure 3: Maximum iodine content in scientific publications per different food groups

In Figure 4 showed iodine content in different fish species.

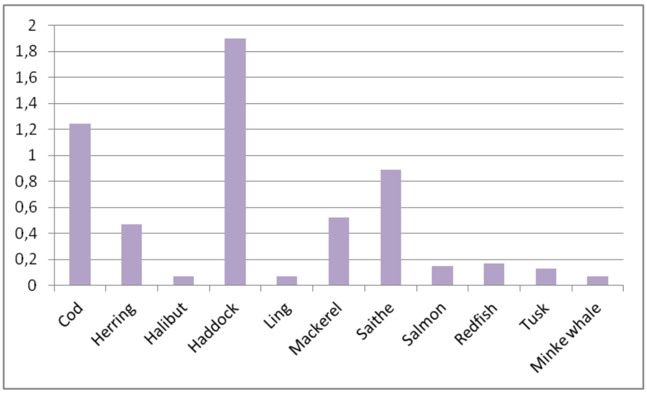

Figure 4: Iodine content in fish reported in scientific papers

High iodine content is reported for haddock followed by cod. In Portugal, cod is one of the most consumed fish. The iodine content in cod reported in scientific papers varies with fish size. It is reported that fish categorized as large had the highest iodine concentration which indicates that iodine accumulates with age.

3.2. Analytical Methods

Different analytical methods and principles for qualitative and quantitative information on iodine food samples are reported. In literature several methods to determine iodine in foods are reported: neutron activation analysis (NAA), inductively coupled plasma mass spectrometry (ICP-MS) or atomic emission spectrometry (AES), isotope dilution mass spectrometry (IDMS) and Gas Chromatography (GC-MS) [6]. The ICP-MS is the golden standard to determination of iodine in foods due to method performance parameters such as high level of accuracy, reproducibility and repeatability, associated with low limit of quantification. The publication of EN 15111:2007 facilitated the comparability of iodine values produced by different laboratories, because most of them adopted the standard practices.

Sample preparation is a critical analytical step for iodine determination. Acid extraction should be avoided due to formation of iodine volatile species. To suppress these difficulties, tetramethylammonium hydroxide extraction is recommended by European Standard.

Several papers reported iodine speciation as a relevant topic of iodine in foods. It gives information on bioavailability, and essentiality of the chemical form of iodine in foods [7, 8]. Hyphenated techniques based on coupling chromatographic separation with inductively coupled plasma mass spectrometric (ICP-MS) detection are now established as the most realistic and potent analytical tools available for real-life speciation.

Iodine bioavailability defined as the fraction of an ingested nutrient that is available for utilization in normal physiological functions and/or for storage is described in several papers. Studies reported bioaccessibility as the amount of nutrient released from the food matrix and accessible for absorption are more frequently reported to study iodine pathway. Iodine bioacessibility is usually measured by in vitro methods such as simulated digestion. Simulation of oral, gastric and small intestine is achieved by applying a set of digestive enzymes and pH conditions to assess the effects of food on the digestive stability and bioaccessibility of iodine.

3.3. Reference materials

Reference materials are a very important tool to evaluate the accuracy of measurements by laboratories. RMs are used by sources of analytical data operating under ISO/IEC 17025 or GLP practices for assuring the accuracy and precision of assigned values and for demonstrating source competence. When the purpose is comparing iodine content produced by different laboratories RMs play an important role in quality assessment systems where they are used as criteria for evaluating the analytical quality of values. In this database we follow quality framework under debate in EuroFIR [9, 10], RMs are proposed as quality indicators which ensure that values are representative of the foods and meet the needs of different user groups. However, a realistic grading of RMs has to take in consideration the availability of food matrix RMs.

One of the quality-assurance tasks in the process of iodine database was to identify the availability and relevance of RMs for the compilation process. The application of RMs is presented in Figure 5

Figure 5 represents quality systems implemented in this database and illustrates the application of RMs within these systems to the analysis, compilation and interchange of iodine data in food composition databank processes.

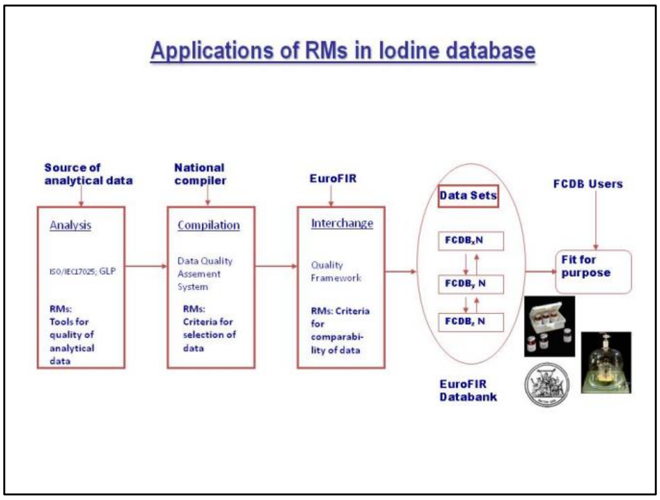

Figure 5 - Use of Reference materials in DQES

RMs are used by sources of analytical data operating under ISO/IEC 17025 or GLP practices for assuring the accuracy and precision of assigned values and for demonstrating source competence. For national compilers, RMs play an important role in quality assessment systems where they are used as criteria for evaluating the analytical quality of values. When it comes to the interchange of data between compilers, RMs serve as criteria for data comparability.

RMs are proposed as quality indicators which ensure that values are representative of the foods and meet the needs of different user groups. However, a realistic grading of RMs has to take in consideration the availability of food matrix RMs. One of the quality assurance tasks was to identify the availability and relevance of RMs for assisting the compilation process.

For the determination of iodine there is a very extensive range of RMs for different matrices. These matrices include typical diet, potato, cabbage, spinach, fish, milk, pine needles, oyster, Sargasso, egg, peach, hay, bovine, wheat, seaweed, citrus, corn, apple, tomato and rice.

3.4 Data Quality Evaluation System

A data quality evaluation system (DQES) was developed to guarantee comparability and data management and interchange with available systems in place like EuroFIR.

Application of Data Quality Evaluation System and Metrological Principles in the use of Iodine database are presented in Figure 6

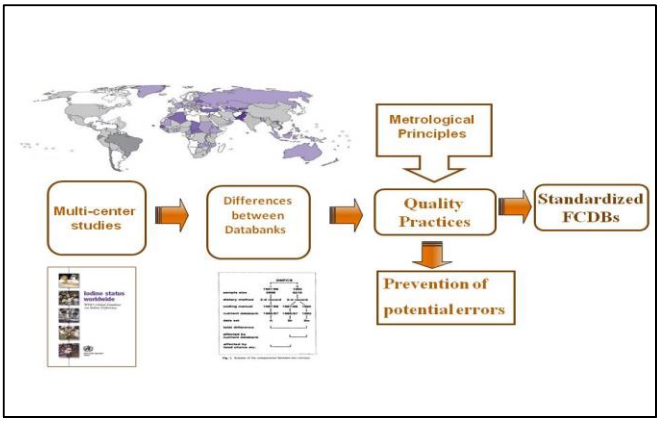

Figure 6 – Metrological principles and practices used in Iodine Database

Metrological principles were studied in three steps. Firstly the performance criteria for analytical methods were defined based on available documentation. Methods chosen by laboratories to calculate LOD and LOQ were then researched since they are key method parameters. This step consisted of collecting available documentation through literature searches by using MEDLINE (PubMed) and Scopus. The third step focussed on information about types of methods for uncertainty evaluation used by iodine generated laboratories. This information was obtained through a questionnaire. The questionnaire consisted of three groups of questions: information about methods used to estimate uncertainty; information for which substances uncertainty is evaluated and information about papers and other publications was registed.

Highest and lowest values for Limit of Detection, Limit of Quantification, Precision (repeatability reproducibility) Trueness and Selectivity were reported for all selected chemical substances. Most of the calculated LOD and LOQ results were respectively defined as being equal to 3 and 10 times the standard deviation of the mean of independent blank tests (n> 15).

It was possible to make a distinction between uncertainty evaluation carried out by the laboratory itself (called intra-laboratory approach) and uncertainty evaluation based on collaborative studies (called inter-laboratory approach) associated with each chemical substance, even though few laboratories published scientific papers on uncertainty calculation.

4. CONCLUSIONS

Iodine database seems very useful to define key foods and methods of analysis. This is a database on methods of analysis to include links to other important datasets associated with iodine value documentation. The availability of information of integrated comprehensive information including datasets such as AOAC OMA, CEN, COMAR, EPTIS and PubMed is expected to prioritize the analytical data of interest to the users. Another feature is all the data and information are possible to connect again to the original publications. For example all methods of analysis for each food can be display by one query. Metrological tools such as method performance and reference materials gather in this database are important.

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