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Intake of energy and nutrients; harmonization of Food Composition Databases

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Abstract

Food composition databases (FCDBs) provide detailed information about the nutritional composition of foods. The conversion of food consumption into nutrient intake need a Food composition database (FCDB) which lists the mean nutritional values for a given food portion. The limitations of FCDBs are sometimes little known by the users. Multicentre studies have raised several methodology challenges which allow to standardize nutritional assessments in different populations and geographical areas for food composition and nutrient intake. Differences between FCDBs include those attributed to technical matters, such as description of foods, calculation of energy and definition of nutrients, analytical methods, and principles for recipe calculation. Such differences need to be identified and eliminated before comparing data from different studies, especially when dietary data is related to a health outcome. There are ongoing efforts since 1984 to standardize FCDBs over the world (INFOODS, EPIC, EuroFIR, etc.). Food composition data can be gathered from different sources like private company analysis, universities, government laboratories and food industry. They can also be borrowed from scientific literature or even from the food labelling. There are different proposals to evaluate the quality of food composition data. For the development of a FCDB it is fundamental document the most detailed way, each of the data values of the different components and nutrients of a food. The objective of AECOSAN (Agencia Española de Consumo Seguridad Alimentaria y Nutrición) and BEDCA (Base de Datos Española de Composición de Alimentos) association was the development and support of a reference FCDB in Spain according to the standards to be defined in Europe. BEDCA is currently the only FCDB developed in Spain with compiled and documented data following EuroFIR standards.

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Key words: Intake of energy. Intake of nutrients. Food Composition tables. Food composition databases. Harmonization. BEDCA.

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INGESTA DE ENERGÍA Y NUTRIENTES; ARMONIZACIÓN DE LAS BASES DE DATOS DE COMPOSICIÓN DE ALIMENTOS

Resumen

La conversión de consumo de alimentos a ingesta de nutrientes necesita una base de datos de composición de alimentos (FCDB) que recoge los valores nutricionales medios de una porción dada de alimento. Las limitaciones de las FCDBs son, en ocasiones, poco conocidas por los usuarios. Los estudios multicéntricos han planteado varios retos metodológicos que permitan estandarizar la composición de alimentos y la ingesta de nutrientes para la evaluación nutricional en diferentes poblaciones y áreas geográficas. Las diferencias entre FCDBs incluyen las atribuibles a aspectos técnicos, como la descripción de los alimentos, cálculo de energía y definición de los nutrientes, métodos analíticos y principios para el cálculo de recetas. Estas diferencias necesitan ser identificadas y eliminadas antes de comparar los datos obtenidos de diferentes estudios, especialmente cuando dichos datos dietéticos se relacionan con resultados de salud. Desde 1984 se han realizado diversas iniciativas para estandarizar los FCDBs en el mundo (INFOOD, EPIC, EUROFIR, etc.). Los datos de composición de alimentos pueden ser obtenidos de diferentes fuentes como análisis de empresas privadas, universidades, laboratorios gubernamentales e industria alimentaria. También pueden tomarse prestados de la literatura científica o incluso del etiquetado nutricional. Existen diferentes propuestas para evaluar la calidad de los datos de composición de alimentos. Para el desarrollo de una FCDB es fundamental documentar, lo más detallado posible, cada uno de los valores de los diferentes componentes y nutrientes de un alimento. El objetivo de la AECOSAN y la asociación BEDCA fue el desarrollo y mantenimiento en España de una FCDB de acuerdo con los estándares definidos para Europa. BEDCA es actualmente la única FCDB desarrollada en España con datos compilados y documentados siguiendo los estándares de EuroFIR.

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Palabras clave: Ingesta de energía. Ingesta de nutrientes. Tablas de composición de alimentos. Bases de datos de composición de alimentos. Harmonización. BEDCA.
Introduction

Food composition databases (FCDBs) provide detailed information about the nutritional composition of foods. Food composition data may be available in different formats: (a) paper-based, often referred to as food composition tables (FCT), or (b) electronic versions, known as nutrient databases or databanks.

Nutritional assessment by diet analysis is a process of two steps: the first step is the evaluation of food consumption, and the second the conversion of food into nutrient intake. To accomplish this, we need a FCDB which lists the mean nutritional values for a given food portion. We then multiply food intake by the mean nutrient content of that amount of food (obtained from the FCDB). As most professionals conducting nutritional assessments are primarily concerned with the evaluation of food intake, a large part of the literature on nutritional assessment focuses on minimizing errors at this step. However, errors and discrepancies may arise in nutrient estimation from the FCDB.

Apart from this important use, FCDBs or FCT, this tool is also needed for the development of nutritional guides about food information, consumer education, labelling, food legislation, marketing, development and reformulation of food products, medical practice, etc. Information on food composition is of great importance for scientists and practitioners working in the fields of nutrition and public health. The most apparent role is to provide the basis for dietary assessment and the formulation of healthier diets. Nutrition, food-based dietary guidelines and health claims have to be supported by scientific evidence including data on food content in nutrients and energy. Today, the close relationship between nutrition and health requires additional information like the content of bioactive compounds, mainly in plant foods and also of potentially harmful compounds, the contaminants.

Limitations of Food Composition Databases (FCDBs)

The limitations of FCDBs are sometimes little known by the users. Food are based on the animal and vegetal kingdom. Are biologic products and due to that, they show changes in their composition. This variability lies in

a. Differences in the plant or animal species, and even intraspecies differences.

b. Environmental factors like the soil type or the climate. The presence of different amount of nutrients, especially minerals like iodine or selenium, can determine the mineral content in vegetables and also indirectly the compositional of animals that feed on them.

c. Differences in the agricultural and livestock practices and in the storage like the cultivation on irrigated or dry lands, in the case of vegetables. Regarding livestock, the type of feed and the composition of feed and pastures. The place and status of the storage (humidity, light, oxygen, etc.) can also modify the food composition.

d. The food processing and packaging. This technological and culinary processes (temperature, hydrogenation, light, pH, etc.) present in the industry and homes, have an important influence in the food composition as many of the nutrients and food compounds are affected by them.

Furthermore, not all the nutrients and food components are affected in a similar way. Macronutrient changes (carbohydrates and proteins) are less than micronutrients ones (minerals and vitamins). Regarding several nutrients like fats from macronutrients and Vitamin C and folates from micronutrients, the variance range is very wide.

There are also errors and discrepancies in the nutrient content of FCDBs foods which origin is the methods of analysis used for the estimation, sampling procedures and the data the food is gathered to be analysed.

Harmonization of Food Composition Data

With the objective of establish and harmonize several actions in the nutrition and public health fields, it has been necessary to carry out multicentre studies. This kind of studies have raised several methodology challenges which allow to standardize nutritional assessments in different populations and geographical areas for food composition and nutrient intake. FCDBs needed for the calculation of the nutrient intake from food consumption are a source of random and systematic errors in the determination of the intake composition.

National FCDBs and calculation procedures of nutrient intake differ between many countries in the world or between different national FCDBs within the same country. The use of different countries FCDBs or different national databases are particularly prone to error when used to estimate nutrient intake. To mitigate this scenario, there exists a strong need to harmonize and standardize existing data and collect new data on food composition.

Differences between FCDBs include those attributed to technical matters, such as description of foods, calculation of energy and definition of nutrients, analytical methods, and principles for recipe calculation. Such differences need to be identified and eliminated before comparing data from different studies, especially when dietary data is related to a health outcome.

Several studies have been carried out to compare nutrient intake data calculated by different dietary analysis programs used in the same country. Significant differences have been disclosed between the databases.
In recognition of these difficulties there are ongoing efforts since 1984 to standardize food composition databases over the world. This is a continuous process because of increased global trade in foods, changes in fortification policies, development of newer assays for nutrient estimation, and addition of new foods in the global diet. In Europe, this effort was followed by other regional initiatives and proposals such as EUROFOODS COST99 and NORFOODS and more recently, an EU concerted action, EFCOSUM, proposed recommendations to harmonize methodology for monitoring national nutritional surveys in Europe, including the use of NDBs. In 2009 EFSA published a guide which contains the general principles for the collection of national food consumption data from the view of a pan-European dietary survey, including those related to FCDBs.

The European prospective investigation into cancer and nutrition (EPIC) was designed to investigate the relationships between diet, nutritional status, lifestyle and environmental factors and the incidence of cancer and other chronic diseases. In the absence of a pan-European food composition database, EPIC developed a method to improve the comparability of the nutrient databases among its 10 participating countries (Spain included) and built the EPIC Nutrient Database (ENDB). The main objective of the ENDB project was to provide a standardized nutrient database for calibrating the EPIC dietary data and investigating diet-disease relationships at the nutrient level. The ENDB constitutes the first real attempt to improve the comparability of NDBs across European countries. This methodological work provides a useful tool for nutritional research as well as end-user recommendations to improve NDBs in the future.

In the last ten years, the former Network of Excellence (NoE) of the VI Framework programme of the European Union, European Food Information Resource (EuroFIR), now EuroFIR AISBL (http://www.eurofir.org) has contributed in the harmonization of the FCDBs in Europe. It has developed nutrient databases and other food components (bioactive components) that can be compared across more than twelve European countries. One of the results of this work has been the development of a tool, FoodExplorer that allows the comparison of different values of different nutrients for a set of similar foods from different European databases and databases from Australia, Canada and United States. Besides, this organization is supporting the food plant bioactive component database along with NORTOX, formerly known as BioActive Substances in Food Plants Information System (eBASIS, http://ebasis.eurofir.org).

Nowadays, the information provided by EuroFIR AISBL includes more than 60,000 foods, 13,000 recipes and 3,500 branded foods, included in the tool FoodExplorer. Apart from the food composition information, this tool provides the information related the method of analysis of each component, bibliographic references and further details about the source of the food data. Another important feature is the adoption of the LanguaL thesaurus for describing foods.

### Food composition data quality

The outstanding growing of FCDBs has provoked that food compilers needed to know the limitations of food composition data to inform the final user about these by following a quality criteria (Finglas, 2014).

Food composition data can be gathered from different sources like private company analysis, universities, government laboratories and food industry. They can also be borrowed from scientific literature or even from the food labelling. Regarding labelling food information, they can be calculated from analytical data of similar products or similar ingredients in case of composite foods. This variability makes the need of having a set of criteria to evaluate the quality of this data. This criteria should include the representativeness of the food data to be published in a FCDB, as well as the availability and the clarity of the information in order to be reviewed and properly selected for a specific use.

There are different proposals to evaluate the quality of food composition data. For EuroFIR, data which origin is a report or scientific paper, the quality of the food, based on previous system such as the ones from USDA, AFFSA (ANSES), BASIS, CSPO, BSL, has been classified in different categories: Food Description, Component identification, sampling plan, number of samples for analysis, sample handling, method of analysis, and quality control analysis. For each of these categories it is established a scale from one to five (low quality, medium and high, with two additional values). From this rating it is calculated a quality index (QI) which ranges from seven to thirty-five. Categories and criteria are included in table.

### Documentation of Food component values

For the objective of informing the FCDB user about the quality of food data and the harmonization for the exchange which other FCDBs, it is necessary a process of documentation that includes detailed description of the foods and their values for each of the food components. Due to this, EuroFIR has developed a complete description and documentation system (Quality...
### Table I
Categories and criteria for quality assessment to original data from scientific literature and reports in EuroFIR interchange data. (From: 20)

<table>
<thead>
<tr>
<th>Categories</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Description</td>
<td>A. FOR ALL TYPES OF FOOD</td>
</tr>
<tr>
<td></td>
<td>Is the food group (e.g. beverage, dessert, savory snack, pasta dish) known?</td>
</tr>
<tr>
<td></td>
<td>Was the food source of the food or of the main ingredient provided (best if scientific name included, cultivar/variety, genus/species, etc.)?</td>
</tr>
<tr>
<td></td>
<td>Was the part of plant or part of animal clearly indicated?</td>
</tr>
<tr>
<td></td>
<td>If relevant was the analyzed portion described and is it clear if the food was analyzed with or without the inedible part?</td>
</tr>
<tr>
<td></td>
<td>Is the extent of heat treatment known?</td>
</tr>
<tr>
<td></td>
<td>If the food was cooked, were satisfactory cooking method details provided?</td>
</tr>
<tr>
<td></td>
<td>Was relevant information on treatment applied provided?</td>
</tr>
<tr>
<td></td>
<td>Was information on preservation method provided?</td>
</tr>
<tr>
<td></td>
<td>If relevant, was information on packing medium provided?</td>
</tr>
<tr>
<td></td>
<td>If relevant, was information about the geographical origin of the food provided?</td>
</tr>
<tr>
<td></td>
<td>If relevant, was the month or season of production indicated?</td>
</tr>
<tr>
<td></td>
<td>Was the moisture content of the sample measured and the result given?</td>
</tr>
<tr>
<td>B: FOR MANUFACTURED PREPACKED FOOD ONLY</td>
<td>Was the generic name provided (e.g. chocolate paste with hazelnuts)?</td>
</tr>
<tr>
<td></td>
<td>Was the commercial name provided (e.g. Nutella)?</td>
</tr>
<tr>
<td></td>
<td>Guidelines for quality index attribution to original data… 12/10/2009</td>
</tr>
<tr>
<td></td>
<td>If relevant, Was the brand provided (e.g. Ferrero)?</td>
</tr>
<tr>
<td></td>
<td>Was relevant information on consumer group/ dietary use/label claim provided?</td>
</tr>
<tr>
<td>C: FOR HOME MADE DISHES OR FOODS SOLD IN RESTAURANTS</td>
<td>Was the complete name and description of the recipe provided?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component Identification</th>
<th>Component Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the component described unambiguously?</td>
<td></td>
</tr>
<tr>
<td>Is the unit unequivocal?</td>
<td></td>
</tr>
<tr>
<td>Is the matrix unit unequivocal?</td>
<td></td>
</tr>
</tbody>
</table>

Evaluation system for original data from SC(Scientific) literature or REPort, QE-SCIREP) which is being described below.

**Food description.** For the harmonization task it is necessary that the foods are correctly and accurately described. A food that has composition data of high quality could be a source of error if it is not well described, as it may lead to confusion because of synonyms, not accurate names or a food processing previous to marketing, among other reasons.

There are two types of system to solve this problem, classification and description systems. LanguaL is a Multilanguage description system (it is translated to Czech, Danish, English, French German, Italian, Portuguese, Spanish and Hungarian) and was created at the end of 1970 by the Centre of Food Safety and Applied Nutrition (CFSAN) in the United States, and it is the one that was chosen by EuroFIR.

It is a multilevel thesauri formed by fourteen different food facets. The set of terms that form this Thesauri is organized in facets and for each facets, terms are grouped in different levels. As an example the Facet A is the one that classifies the food in all the systems that LanguaL includes. Before entering foods in a FCDB, it is necessary to describe them using the LanguaL thesauri.

For the correctness of the codification process, it is necessary in many of the foods, to gather information regarding the nutritional labelling and the ingredients composition, as well as know the technological pro-
Table I (cont.)

Categories and criteria for quality assessment to original data from scientific literature and reports in
EuroFIR Interchange data. (From: 20)

<table>
<thead>
<tr>
<th>Categories</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling Plan</td>
<td>Was the sampling plan developed to represent the consumption in the country where the study was conducted?</td>
</tr>
<tr>
<td>(For All Types Of Foods)</td>
<td>Was the number of primary samples &gt; 9?</td>
</tr>
<tr>
<td></td>
<td>If relevant, were samples taken during more than one season of the year?</td>
</tr>
<tr>
<td></td>
<td>If relevant, were samples taken from more than one geographical location?</td>
</tr>
<tr>
<td></td>
<td>If relevant, were samples taken from the most important sales outlets (supermarket, local grocery, street market, restaurant, household etc)?</td>
</tr>
<tr>
<td></td>
<td>If relevant, was more than one brand (for manufactured pre-packed product) or more than one cultivar (for plant foods) or subspecies (for animal foods) sampled?</td>
</tr>
<tr>
<td>Sample Handling</td>
<td>If relevant, were appropriate stabilization treatments applied (e.g. protection from heat/air/light/microbial activity)?</td>
</tr>
<tr>
<td></td>
<td>Were the samples homogenized?</td>
</tr>
<tr>
<td>Analytical Method</td>
<td>Does the analytical method used in the source match the list of appropriate analytical methods given in the guidelines for analytical methods?</td>
</tr>
<tr>
<td></td>
<td>Are the key method steps appropriate for the method described?</td>
</tr>
<tr>
<td>Analytical Quality Control</td>
<td>Were analytical portion replicates tested?</td>
</tr>
<tr>
<td></td>
<td>Was the laboratory accredited for this method or was the method validated by performance testing?</td>
</tr>
<tr>
<td></td>
<td>If available, was an appropriate reference material or a standard reference material used?</td>
</tr>
</tbody>
</table>

cesses behind the development of them, their handling and packaging. There is a software named LanguaL Product Indexer to index foods, developed by EuroFIR and LanguaL.21

Recently the EFSA has developed a new food codification system for the identification of food called FoodEx2 (Food classification and description system).22 This system has been developed with the aim of being used for trans European studies for nutritional assessment and the exposure of the population to contaminants and other harmful components that are present in food.

**Documentation of nutrient data and food components**.20,21 For the development of a FCDB it is fundamental document in the most detailed way, each of the data values of the different components and nutrients of a food. This should be achieved in case of data from scientific publications, borrowed from other FCDBs or FCT, calculated, estimated or assumed.

For this documentation process, it has been developed a set of Thesaurus for this task by EuroFIR. These are:

- **Acquisition type.** It includes the different categories of the data value origin, for example, data published in a journal with reviewers, nutritional labelling, other FCT, etc.
- **Reference type.** It includes the categories for the bibliographic reference of the data value. For example, book, journal article, web page, etc.
- **Unit.** It includes terms that describe the measurement used for the quantity. It also includes terms for numbers without units. Grams, milligrams, niacin equivalents, ratio, percentage, etc.
- **Matrix unit.** It includes terms for the quantity of food that contains the value of the described component. Some examples are per 100g dried food, per 100 ml, per 100g of edible portion, etc.
- **Value type.** It includes the categories for a better description of the data value or for giving a qualitative description of the value when it cannot be chosen a concrete value. Value types can be: media, median, logic zero, trace, less than, etc.
- **Method type.** It includes the categories assigned to a data value to describe a general description of the type of method used for obtaining it. Analytical, calculated as a recipe, estimated, are some of the terms used.
• Method indicator. It includes the categories and descriptors that identify the method of analysis or calculation that is being used to obtain the value published in the FCT or FCDB. Some example are polarimetry, animal bioassay, gas chromatography, by difference, etc.
• Component. In this last thesaurus it is included the codes and definitions of the different food components. It includes terms such as Energy, saturated fatty acids, beta-carotene calculated from total Vitamin A, vitamin D activity calculated as ergocalciferol, etc.

Including this information in a FCDB gives the possibility of the data values to be evaluated by the users as well as knowing the quality of a concrete value based on criteria such as the value type (analytic, borrowed or calculated), the used method, the quality of the source and the reference, etc. (Figure 1). On the other hand, the standardization and harmonization in the definition of a component, the unit and matrix unit as well as the value type, etc. allow the interchange of the source and the reference, etc. (Figure 1). On the other hand, the standardization and harmonization in the definition of a component, the unit and matrix unit as well as the value type, etc. allow the interchange of food composition data across different FCDBs. All the aforementioned ease the development of transnational multicentric studies in the field of Food, Nutrition and Public Health.[15]

Spanish FCDB, BEDCA

In Spain, the first works directed toward the publication of food composition information date from 1932[23, 24]. Several FCTs elaborated by different authors have been published since, although it was in 1996 when the Ministry of Health published an official one[24].

Numerous FCTs exist in Spain, developed by different authors of different Research Centers and Universities. Each of them has been developed with different methods and technologies chosen based on the requirements and the available sources of data. Because of this, it exists a great variability in the description of the foods, and, in general terms, the data of the different components is not analytical but borrowed from bibliography, FCTs or FCDBs and not documented individually[25, 26]. Besides, after reviewing the different studies carried out in Spain in population and group of people like national surveys (ENRICA, DRECE, etc.), regional ones (País Vasco, Comunidad de Madrid, Andalucía, Canarias, etc.) it is found that the transformation of the food consumption data to nutrient intake has been done with different food composition data, some of them coming from one FCT or from on-demand FCTs developed with different national and not national FCTs. Given this, as it has been mentioned before, it cannot be compared, in a reliable way, the results of the intakes obtained in different populations or group of people, even if the applied method to know the food consumption is the same.

In 2004, the AESAN (Spanish Agency of Food Safety and Nutrition) set up a work group including two of the partners of EuroFIR network, INYTA from the University of Granada and CESNID from University of Barcelona. Based on this core, other research centers and universities have incorporated, as well as associations of food industry such as FIAB and foundations related to nutrition (Triptolemos). All of them formed the BDECA network, funded by the Ministry of Science and Education. The objective of this network was the development and support of a reference food composition database in Spain according to the standards to be defined in Europe by the NoE EuroFIR, by working closely with them. For this purpose, the main sources of food data in Spain and other potential sources were identified as well as a website as a platform for the network, its activities and a host for the food composition database was designed and developed[24].

To develop the database, BDECA members which belonged to EuroFIR, ask for candidate food sources to the rest of the BDECA members. Once they were identified a compilation and documentation process began according to the standard EuroFIR was developing. The sources of data for BEDCA database (www.bedca.net) were the different FCTs published in Spain and analytic data granted by University researchers and Public Research Centers[25, 24].

The chosen method for the compilation of data was the indirect method with a detailed scrutiny, unification and processing of the data and metadata granted by the network members. To accomplish this task, an information system developed by the University of Barcelona was used[26]. This system added basic information about the food, components, values and methods and sources related the food composition. (Figure 1)

The compilation model of the data includes:

a. Language codification of foods
b. Documentation of the values of the components from each food according to EuroFIR thesauri regarding value acquisition method, reference, unit, matrix unit, method type, method indicator and component[20, 21, 22, 23, 24]. (Fig. 1).

Nowadays BEDCA is an association that along with AECOSAN which gives it institutional support and funding, develop and support the FCDB, being as well, the national compilers for EuroFIR AISBL in Spain, which they belong to. BEDCA release 1 has a total of 950 foods and 34 components.

BEDCA has been used in the ENIDE study developed by AECOSAN, a national survey about the food consumption with more than 3.000 adult individuals and more than 300.000 food inputs.

For the transformation from food consumption surveys into nutrient intake data in ENIDE study, a food matching algorithm was developed. The algorithm, with a heuristic and ruled based design, allowed us to identify one or more candidate BEDCA foods for a food entry and then calculate the intakes based on the composition of the matched foods. The algorithm results were reviewed manually by nutritionists who were calibrating the algorithm during the development.
Fig. 1. — Screenshots of the Web site of BEDCA Database (www.bedca.net). Documentation of the foods and components.
The use of this algorithm implied a great improvement in time and manual work efficiency as well as a unified criteria for transforming a diary food consumption into a list of database foods. It is also a basis for further work with food consumption data.

It is not sufficient to standardize and harmonize the process of compiling food composition data but also how this information is shared with humans, and also with machines. With this objective several groups in EuroFIR worked on a standard to share food information in electronic format. Using XML as the language to define it, the Food Data Transport Package (FDTP) was developed, nowadays in its 1.4 version. It serves as a container for food composition information and also a basis to validate the information based on a mandatory/optional data definition.

Based on the development of FDTP, EuroFIR designed a strategy to share food information between EuroFIR and the national FCDBs that were partners. It was chosen a decentralized mechanism using web services. A set of different operations based on Food Data Query Language (FDQL) were defined thus EuroFIR could search information from different national FCDBs in real time. BEDCA participated in its design and was one if the first partners to implement this web services that nowadays are still available to EuroFIR and other agents.

As a conclusion BEDCA is currently the only food composition database developed in Spain with compiled and documented data following EuroFIR standards and it is included in the tool FoodExplorer. Moreover, for its 2.0 version it has been added all the food that are present in the surveys from the ENIDE study.

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Our thanks to all members of BEDCA and AECO-SAN for their advice and support.

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