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A methodology to compile food metrics related to diet sustainability into a single food database: Application to the French case

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ABSTRACT

The holistic approach required to assess diet sustainability is hindered by lack of comprehensive databases compiling relevant food metrics. Those metrics are generally scattered in different data sources with various levels of aggregation hampering their matching. The objective was to develop a general methodology to compile food metrics describing diet sustainability dimensions into a single database and to apply it to the French context. Each step of the methodology is detailed: indicators and food metrics identification and selection, food list definition, food matching and values assignment. For the French case, nutrient and contaminant content, bioavailability factors, distribution of dietary intakes, portion sizes, food prices, greenhouse gas emission, acidification and marine eutrophication estimates were allocated to 212 commonly consumed generic foods. This generic database compiling 279 metrics will allow the simultaneous evaluation of the four dimensions of diet sustainability, namely health, economic, social and environmental, dimensions.

1. Introduction

Sustainable diets are defined by the Food and Agriculture Organization of the United Nations (FAO) as "protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe and healthy, while optimizing natural and human resources" (Burlingame & Dernini, 2012). Assessing the sustainability of diets requires a holistic approach to explore simultaneously the health, economic, social and environmental dimensions. Several studies performed in different geographical contexts and populations explored the relationships between the health and economic dimensions of diets and found that low cost diets are generally unhealthy although nutritionally adequate diets are not necessarily expensive (Darmon & Drewnowski, 2015). Then, with the challenge of climatic change and the availability of datasets estimating greenhouse gas emissions (GHGE) for individual food items, relations between nutritional quality and environmental impact of self-selected diets were described (Vieux, Darmon, Touazi, & Soler, 2012) and modeled (Horgan, Perrin, Whybrow, & Macdiarmid, 2016). More recent studies assessed the relationships between more than two diet sustainability dimensions. For instance, in France, affordable nutritious diets with GHGE reduced by 20% compared to the mean population level were identified among diets self-selected by adults (Masset, Vieux, et al., 2014), but modeling studies showed that GHGE reductions higher than 30% may compromise both nutritional adequacy and cultural acceptability (Perignon et al., 2016). In the United Kingdom, greater adherence to the DASH (Dietary Approaches to Stop Hypertension) dietary pattern was found to be associated with lower diet-related GHGE but higher diet costs (Monsivais et al., 2015). Although recent studies integrated several dimensions of diet sustainability, other key components such as food safety still needs to be assessed.

The assessment of diet sustainability dimensions requires to define appropriate indicators estimated with relevant food metrics

Abbreviations: ANSES, French agency for food environmental and occupational health safety (Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail); CIQUAL, The French Information Center on Food Quality (Centre d'Information sur la Qualité des Aliments); EFSA, European Food Safety Authority; FAO, Food and Agriculture Organization of the United Nations; FFQ, food frequency questionnaire; GHGE, greenhouse gas emission; INCA2, second French individual cross-sectional food consumption survey; INFOODS, International Network of Food Data Systems; INRA, French national institute of agricultural research (Institut national de la Recherche Agronomique); LCA, life-cycle assessment; LOD, limit of detection; LOQ, limit of quantification; ND, non-detected; NQ, non-quantified; TDS, total diet study; USDA, United States Department of Agriculture; WHO, World Health Organization.

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(Fanzo, Cogill, & Mattei, 2012). A metric is considered as a quantitative measurement used to calculate indicators which, in turn, allow to estimate "how much", "how many", "to what extent", or "what size" a system, a dimension, a concept is (Ahi & Searcy, 2015). The assessment of diet sustainability dimensions may be improved by the introduction of metrics which have not yet been considered. For instance, nutrient bioavailability, defined as the efficiency with which a nutrient is used systemically through normal metabolic pathway (Aggett, 2010) strongly varies with food sources. zinc, iron, protein and vitamin A bioavailability in particular is known to be strongly dependent on their animal or plant origin (Gibson, 2007; Hunt, 2003). Therefore, nutrient bioavailability should not be overlooked when assessing nutritional adequacy in a context promoting a reduced consumption of animal-based products to mitigate the environmental impact of diet (Millward & Garnett, 2010).

Exploring simultaneously the health, economic, social and environmental dimensions of diets is currently hindered by lack of food databases compiling indicators related to each dimension within one dataset. Until now, the different public or private agencies concerned with food consumption and food expenditure carried out their own surveys and elaborated databases according to their own needs. Data were collected at different periods, with various levels of aggregation and without a common food categorization, hampering their matching. For instance, household food budget surveys and food purchase panels provide detailed information (quantities purchased, amount of money spent, brand, type of packaging, capacity, ingredient list, nutritional labeling, claims, ...) for a very high number of food products, whereas in Total Diet Studies (TDS), the content of contaminants in food are generally estimated on a limited list of generic foods due limited analytical capacities and the high cost of the analyses.

A food database compiling information collected by different bodies for several dimensions of sustainability would be beneficial to study holistically the sustainability of diets. The aim of this study was therefore to develop a general methodology to compile food metrics describing diet sustainability dimensions into a single database and apply it to the French context.

2. Method

2.1. General methodology

Fig. 1 outlines the methodology proposed to compile food metrics required to estimate the indicators of diet sustainability into a single food database entitled 'SUStable'. This methodology is composed of four main sections (A. Data collection, B. 'SUStable' food list definition, C. Data compilation and D. 'SUStable' completion). The first section is divided into 5 steps that allow to identify and to select relevant indicators and food metrics and the corresponding data sources. In section B., foods which will constitute the 'SUStable' database are selected. Different approaches are proposed in section C. to assign values to the 'SUStable' foods, according to the type of matching with the data sources. The last section D. corresponds to complete the 'SUStable' database, by describing the unit of measurement and data source for each food metric.

2.2. Application to the French case

2.2.1. Data collection (Section A)

2.2.1.1. Selection of diet sustainability dimensions and diet-related indicators (Step A1). Measurable indicators representing the health, economic, social and environmental dimensions of diet sustainability were identified. The health dimension was represented by two "sub-dimensions", namely the nutritional adequacy and the food safety. The economic, social and environmental dimensions were respectively represented by economical affordability, cultural acceptability and environmental friendliness. The diet-related indicators selected for the French study are presented in Table 1.

2.2.1.2. Identification and collection of relevant food metrics and corresponding data sources (Steps A2 to A5). The food metrics collected to evaluate each diet-related sustainability indicator and the data sources able to provide these metrics are presented in Table 1 and described below.

The nutritional adequacy domain of the health dimension required collecting the content of nutrients and other components in foods. It also includes nutrient bioavailability factors, which were obtained from national and international standard nutrient composition tables. When required information was not available in standard databases, values were collected from scientific literature. Nutritional adequacy was also depicted by decomposing food recipes into their ingredients in order to calculate the proportion of animal/plant origin of each food.

The food safety domain of the health dimension involved the acquisition of food contaminant content to evaluate the toxicological exposure. In this work, robust food contamination data were provided by a national database.

Integration of the cultural acceptability dimension required to evaluate dietary patterns. The distribution of dietary intakes in the French population was collected, as well as standard food portion sizes. In the present study, food consumption data were collected using a dietary record, however, several types of dietary surveys may be used such as food frequency questionnaire (FFQ) or multiple 24-h dietary recall (Thompson & Byers, 1994). Standard portion sizes were retrieved from scientific literature and national agencies, but might also be estimated using food consumption data.

The economic dimension was captured by the financial affordability of diets, which implied the collection of food prices. For the French case, food prices were provided by national food survey, rather than collected directly from supermarkets or internet. Before estimating the cost of diets, prices of purchased foods were converted into prices of edible foods by adjusting for weight changes associated with cooking process and waste.

Regarding the environmental friendliness dimension, several diet-related environmental indicators exist, but reliable national metrics remain scarce. For the French case, estimations of GHGE, marine water eutrophication and air acidification related to foods were collected to evaluate the environmental impact of diet.

2.2.2. Choice of the food list (Section B)

The final list of foods of the French 'SUStable' was chosen based on the data source which provided data for the smallest number of foods. At this step, each 'SUStable' food was assigned to one food category.

2.2.3. Data compilation (Section C)

Step C1 consisted in matching each 'SUStable' food with one or several foods of each data source. The matching was done either based on link tables provided by the bodies who have collected the data, or by manual food matching using the food label. Except for cultural acceptability, the step C2 consisted in assigning values to each 'SUStable' food. Two cases of value assignment were possible depending on the type of relationship between the 'SUStable' food and the data source. When 'SUStable' food matched with only one food from the data source (relationship one to one), values of the food from the data source were directly assigned to their related 'SUStable' food. When 'SUStable' food matched with several foods from the database source (relationship one to many), values of the 'SUStable' food was computed using a weighting factor,