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SUPPLEMENT

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A new reference method for the validation of the nutrient profiling schemes using dietary surveys

Abstract Nutrient profiles of foods are increasingly used as the scientific basis of nutritional labeling, health claims, or nutritional education. Nutrient profiling schemes are based on sets of rules, scores, or thresholds applied to the nutritional composition of foods. However, there is a lack of scientific validation of nutritional profiling schemes. To develop a reference method using existing dietary surveys, to define a set of indicator foods that are positively or negatively associated with a "healthy diet." Such indicator foods can be used both for establishing relevant nutrient profiles and for the validation of existing or future nutrient profiling schemes. The proposed validation method is based on food and nutrient intakes of adults participating in national dietary surveys in five EU countries: Belgium (n = 2,507), Denmark (n = 3,151), France (n = 1,474), Ireland (n = 1,379), and Italy (n = 1,513). The characterization of indicator foods is divided in two steps. First, "healthy diets" of individuals are identified in the five national dietary surveys by comparison to the Eurodiet reference intakes. Second, indicator foods associated positively or negatively to the "healthy diets" are determined. With a P-value of 10^{-3} for the test of comparison of food intakes between the "most healthy eaters" and the "less healthy eaters," it was possible to identify 294 indicator foods out of 1,669 foods tested in the five countries. In all the countries except Italy, there were more indicator foods positively associated than indicator foods negatively associated with the "healthy diet." The food categories of these indicator foods were in good agreement with Food Based Dietary Guidelines like the USDA dietary guideline for Americans. A new reference method for the validation of profiling schemes was developed based on dietary intake data from using dietary surveys in five European countries. Only a minority of foods consumed in these dietary surveys could be used as indicator foods of healthy or unhealthy diets in order to subsequently test nutritional profiling schemes. Further work is needed to build a list of indicator foods that could be considered as a "gold standard."

Key words nutrition and health claims – nutrient profiles – validation

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Introduction

Nutrient profiling has been defined as "the categorisation of foods for specific purposes based on an assessment of their nutrient composition according to scientific principles" [11].

Nutrient profiling schemes are applied in different countries by private or public organizations for dif-

ferent purposes. This may include improvements of the nutritional quality of a company's portfolio of foods or management decisions with regard to the nutritional promotion of foods including labeling and the use of nutrition or health claims.

The new EU regulation on "Nutrition and Health Claims Made on Foods" entered into force in January 2007 [5]. This gives the EU commission the task to "establish specific nutrient profiles, including exemptions, which foods or certain categories of foods must comply with in order to bear nutrition or health claims and the conditions for the use of nutrition or health claims." Further, the nutrient profiles "shall be based on scientific knowledge about diet and nutrition, and their relation to health."

In order to define nutrient profiles of foods, two types of information are needed: data on food composition and rules based on scientific knowledge to assign foods to different groups. This may for instance be the group of foods that will be authorized to be promoted by nutrition and health claims. These rules, however, do not rely solely on scientific knowledge. For instance, it is difficult to decide scientifically the maximum percentage of fat that should be accepted for individual foods in order to qualify for making nutrition or health claims. The question is therefore: how is it possible to validate nutrient profiling schemes with a science-based approach? This question was asked within the International Life Sciences Institute (ILSI) Europe expert group on "Nutritional Characterisation of Foods."

At present, two methods for validating nutrient profiling schemes based on expert opinions exist. One approach is the consensus of opinions in an expert group which has been used in a first step in UK [12]. The other approach is a quantitative survey addressed to nutritionists and dieticians in order to classify indicator foods and then test the agreement between the expert classification of indicator foods and their profiles. The latter approach is more objective than the former and has been used in the UK [12] and in France [1]. However, judgments by scientists may be subjective and influenced by cultural considerations. The challenge is therefore to build a validation method that is free of subjective judgment.

One of the main criticisms concerning nutrient profiling schemes is that there are only healthy and less healthy diets, and not healthy and less healthy food. This is the reason why it may be more appropriate to try to derive a validation method from available data about healthy diets and not only from the opinion of experts on single foods.

The definition of "healthy diets" is often discussed among scientists in the field of nutrition. There is some scientific consensus at the national or international level that can be used to define a "healthy diet." For instance, the Eurodiet project gathered nutritionists and epidemiologists from different EU countries in order to "formulate a strategy and action plan for developing and implementing European dietary guidelines"[8]. This project defined 15 quantitative objectives regarding diet and physical activity. WHO-Europe also published a set of population goals for dietary recommendations in different countries of the European region [15]. Several EU member states have developed national nutrition action plans with indicators or nutritional objectives defining healthy diets [9].

The main question addressed in this article is the following: Is it possible to derive a reference method for the validation of nutrient profiling schemes using a definition of a "healthy diet" which is based on dietary surveys in selected EU countries? To answer this question three types of data are necessary: nutritional endpoints, dietary surveys, and food composition databases.

Materials and methods

Nutritional endpoints

Nutritional endpoints are based on scientific consensus; they are expressed as Dietary Reference Intakes (DRIs) for populations. DRIs take into account the scientific literature on nutritional requirements and are the main endpoints used to evaluate diets. There are national DRIs for instance in the USA [6] or in other countries, but there are also international DRIs, for instance for Austria, Germany, and Switzerland [2]. At the European level, EFSA is working on new DRIs that will be published in the near future. For this reason, we decided to use the Eurodiet criteria as reference endpoints. The nutritional endpoints in the Eurodiet consensus are based on macronutrients and constituents – total carbohydrates, sugar and dietary fiber, total fats and saturated fatty acids – and micronutrients like vitamins and minerals. There are also endpoints based on food groups, like fruit and vegetables or fish, where there is some epidemiological evidence on the prevention of diseases by foods without sufficient information on the nutrients or non-nutrients involved in this prevention. In order to compare nutrient intakes to nutritional endpoints it is necessary to combine dietary intake data with food composition data.

Dietary surveys

Dietary surveys are available at the national or regional level. In most of the European countries there are na-

Table 1 Dietary surveys used for the present study

Country	Year	Method	*N*	No. of total foods	No. of tested foods	Ref.
Belgium	2004	2 × 24-h recall	2,507	1,781	400	[3]
Denmark	2000–2002	7 days precoded record	3,151		231	[10]
France	1999	7 days open-ended record	1,474	1,093	400	[14]
Ireland	1997–1999	7 days open-ended record	1,379	3,000	406	[7]
Italy	1994–1996	7 days open-ended record	1,513	42,000 (foods)	331 (food categories)	[13]

tional dietary surveys. They are not standardized, but different EU programs like the EFCOSUM project [4] have increased the cooperation between dietary survey managers. The main methodologies are repeated (twice or three times) 24-h recalls (Belgium, Germany) or records with 2–7 consecutive days (UK, Sweden, Denmark, Ireland, France, Italy). The number of foods recorded varies between hundreds and thousands. The sample size is between 1,000 individuals and more than 20,000. There are other surveys used for epidemiological studies, usually cohorts, but they are not nationally representative and were thus not chosen for this work. Five National dietary surveys comprising the adult population were available in the following five countries: Belgium, Denmark, France, Ireland, and Italy.

In Belgium, dietary data were available from the "Enquête de consommation alimentaire belge 2004" [3], which included 2,507 adults aged 18 and over based on two repeated 24-h recalls (Table 1). A total of 1,781 semi-aggregated foods were described and among them, the 400 foods with the highest mean intake were selected for the present study. In Denmark, 3,151 adults aged 18–75 participated in The "Danish National Survey of Dietary Habits and Physical Activity 2000–2002" [10]. Dietary intake was recorded for seven consecutive days in supplied booklets with pre-coded and open-ended answer possibilities. For the present study, 231 semi-aggregated food groups were used. In France, the last national dietary survey, the "INCA study" took place in 1999; 1,474 adults aged between 15 and 80 filled an open-ended 7-day record. Among the 1,093 foods of the food composition table used for the survey, 400 with the highest mean intakes were used for the determination of the indicator foods [14]. In Ireland, the North–South Irish Survey 1997–1999 was also based on an open-ended 7-day record methodology; 1,379 individuals aged 18–64 participated in the study. Among more than 3,000 foods coded in the database of the survey, 403 foods with the highest mean intake were selected [7]. In Italy, 1,513 adults participated in the INN-CA national dietary survey in 1994–1996. The survey methodology was an open-ended 7-day record diary with weighing of the foods eaten; 331 semi-aggregated food groups were used to determine indicator foods [13] (Table 1).

Food composition databases

The national dietary surveys were combined with national food composition databases in order to quantify nutrient intakes. Thus, there was no attempt to identify foods the same way in the different participating countries; even if they have the same name, they may have a different composition.

Identification of the healthy diet

The list of indicator foods to be used for the validation of nutrient profiling schemes is derived in two steps. The first step is to identify individuals with more or less healthy diets. The second step is to list the foods contributing to healthy diets and less healthy diets.

In the first step, nutrient intakes in each country are evaluated according to the nutrient endpoints based on the Eurodiet program (Table 2) [8]. The choice of the Eurodiet was based on the fact that all five participating countries had contributed to the Eurodiet project.

The dietary goals of Eurodiet were selected depending on each country's possibility to calculate the corresponding nutrient intakes. For instance, not all countries have collected information on Body Mass Index (BMI) and therefore it was not included as a criterion. Among the Eurodiet criteria (Table 2), the dietary components chosen are: dietary fat in % of energy, saturated fatty acids in % of energy, total carbohydrates in % of energy, fruit and vegetables in g/day, dietary fiber in g/d, and sodium in g/d. Additional criteria were added for those countries where they were available: number of sugar eating occasions

Table 2 List of the Eurodiet criteria used in the determination of the "healthy eating score"

Component	Dietary goal
Fats, % of energy intake	<30
Saturated Fatty Acids, % of energy intake	<10
Total carbohydrates, % of energy intake	>55
Intake of fruit and vegetables, g/d	>400
Fiber intake, g/d	>25
Sodium intake, g/d	<6

(Ireland), BMI (Belgium and Italy), and the national goals for calcium (France).

In order to define a "healthy eating" population, it is not possible to consider only the individuals who meet all the selected Eurodiet endpoints, because their number will not be sufficient. For instance, if there are 20% of the population reaching the "total fat" endpoint and 10% of the population reaching the "sodium" endpoint and if these two criteria are independent, there would be only 2% of the population reaching both endpoints together. For a survey of 1,500 individuals, 2% represents an insufficient sub-sample of 30 persons. Therefore, it was decided to construct a healthy eating index based on the sum of scores reached for the different criteria. The score considers the ratios between the nutrient intakes observed and the nutrient goal considered. For instance in the case of total fat it is the inverse of the ratio between the dietary fat in % of energy for each individual of the surveys and the figure of 30% (The Eurodiet goal for dietary fat in % of energy). The individuals whose percentage of energy from fat is higher than 30% get a ratio lower than 1 and the higher their dietary fat in % of energy is, the lower their ratio is. For the individuals whose percentage of energy from fat was lower than 30%, the score value of the ratio is 1, the same as for the individuals with exactly 30% of energy from fat. It is thus considered that there is no nutritional benefit to reduce the dietary fat in % of energy below 30%.

A person meeting all the nutrient endpoints will be assigned the score value 6, which is the maximum value for the healthy eating index. A higher healthy eating index indicates a more favorable diet and a low healthy eating index indicates a less favorable diet. The identification of the individuals with a more or less healthy diet is possible with the analysis of the statistical distribution of the healthy eating index. It was chosen to consider as "healthy eating" individuals in the fifth quintile of the healthy eating index and as "not healthy eating" individuals in the first quintile of the healthy eating index. This statistical analysis was done separately for each country.

Association of foods to the healthy diet

The second step in the definition of the validation tool is the characterization of foods eaten by the "healthy eating" and "not healthy eating" populations. A food was defined as the most detailed food category for which a food composition profile was available in the food composition database used by the dietary survey managers. Only the 400 foods eaten in the highest quantity in grams per day for the overall adult population in each country were considered (Table 1).

In this study, it was decided to consider the difference of the food consumption between the two populations of the first and the fifth quintile of the "healthy eating" index as an indication of the association of the food consumption to the "healthy diet." In each country, the mean intake amounts of up to 400 different foods were compared between the population with a "healthy eating score" in the lowest quintile and the population with a "healthy eating score" in the highest quintile. The contribution of the food to the different nutrient intake goals of the Eurodiet criteria was not considered in order to avoid the difficulty of the choice of the different thresholds for each nutrient or indicator and in order to keep the possibility to consider the indicators of the nutritional status like the BMI in the same way.

Then, the foods, which were eaten in statistically different amounts by the two population groups, were classified as either positively associated, i.e. consumed in higher quantities with a "healthy" diet or negatively associated (i.e., consumed in smaller quantities) with a "healthy" diet, and were, therefore considered as "indicator foods."

As food intakes are not normally distributed in a population because there are non-consumers and because the distribution of intakes among consumers is skewed, the distribution of intakes cannot be transformed to the normal scale. For this reason, a non-parametric test, the Wilcoxon Mann–Whitney test was used to compare the mean food intakes of the population corresponding to the lowest quintile of the "healthy eating" index with the mean intakes of the population of the fifth quintile.

For each country, the number of statistical tests performed equalled the number of foods included in the analysis (up to 400 foods). This is the reason why it is not possible to use a classical threshold of significance of the test like $P = 0.05$. We considered a multiple test correction like the Bonferroni approach. On this background the classical threshold of significance of the test like $P = 0.05$ was extended to include more P-values. Considering the number of tests performed, a value $P = 10^{-4}$ would theoretically be needed, but this would provide too short a list of indicator foods. Therefore in this study different intermediate P-values were considered: 0.05, 10^{-2}, and 10^{-3}.

All foods, which contribute positively or negatively to the "healthy diet" in at least one country, were considered as indicator foods. There was no consideration of the number of countries in which a food is identified as an indicator.

Table 3 Indicator foods positively or negatively associated to a "healthy diet" in selected countries at different P-levels (number and percentage)

	Indicator foods positively associated to the "healthy diet"			Indicator foods negatively associated to the "healthy diet"			All indicator foods		
	$P = 0.05$	$P = 0.01$	$P = 0.001$	$P = 0.05$	$P = 0.01$	$P = 0.001$	$P = 0.05$	$P = 0.01$	$P = 0.001$
Belgium ($n = 400$)	83 (21%)	60 (15%)	42 (10%)	68 (17%)	47 (12%)	25 (6%)	151 (38%)	107 (27%)	67 (17%)
Denmark ($n = 231$)	112 (48%)	94 (41%)	81 (35%)	39 (17%)	34 (15%)	29 (13%)	151 (65%)	128 (55%)	110 (48%)
France ($n = 400$)	78 (20%)	52 (13%)	30 (8%)	52 (13%)	38 (10%)	19 (5%)	130 (33%)	90 (23%)	49 (12%)
Ireland ($n = 403$)	93 (23%)	68 (17%)	46 (11%)	26 (6%)	15 (4%)	12 (3%)	119 (30%)	83 (21%)	58 (14%)
Italy ($n = 331$)	54 (16%)	34 (10%)	18 (5%)	68 (21%)	41 (12%)	14 (4%)	122 (37%)	75 (23%)	32 (10%)

Results

The total numbers of indicator foods associated positively or negatively to a healthy diet are shown in Table 3.

With a *P*-value of 10^{-2}, there are 128 indicator foods in Denmark (out of 231 foods tested), 90 in France (out of 400), 75 in Italy (out of 331), 107 in Belgium (out of 401) 83 in Ireland (out of 403 foods). The proportion of indicator foods among the foods tested cannot be compared between countries because the dietary survey methods and the sample sizes are different. The country with the highest number of indicator foods (Denmark) is also the country with the highest number of days ($3{,}151 \times 7 = 22{,}057$) of consumption studied in the dietary survey and so with the highest statistical power.

With a *P*-value of 10^{-3}, there are 110 indicator foods in Denmark (out of 231 foods tested), 49 in France (out of 400), 32 in Italy (out of 331), 53 in Belgium (out of 401) 58 in Ireland (out of 403 foods). Except in Denmark, the number of indicator foods is strongly decreasing when the level of significance is improved.

In all the countries except Italy ($P = 0.05$ and $P = 0.01$), there were more indicator foods positively associated with the "healthy diet" than indicator foods negatively associated with the "healthy diet" (Table 3).

Food categories of the indicator foods

The indicator foods associated to a "healthy diet" mainly belong to the "fruit and vegetable" (as expected given the Eurodiet criteria), "bread and breakfast cereals," "milk products," and "potatoes, pasta, rice, and pulses" food categories (Table 4). There are more fruits and vegetables associated to the "healthy diet" in Italy and, to a lesser extent, in France.

The indicator foods associated negatively to a "healthy diet" mainly belong to the "meat and meat products," "fats," "cake and pastries," "cheeses," and "potatoes, pasta, rice, and pulses" food categories (Table 5). The significance level of $P = 0.05$ was used in the tables 4 and 5 in order to get enough indicator foods to study their repartition in different food groups.

Table 4 Foods in various categories positively associated to the "healthy diet" (number and %) ($P = 0.05$)

Food category	Belgium	Denmark	France	Italy	Ireland
Alcoholic beverages	0	2 (2%)	0	1 (2%)	4 (5%)
Warm beverages	5 (6%)	3 (3%)	0	0	1 (1%)
Non-alcoholic cold beverages	5 (6%)	5 (4%)	4 (5%)	0	1 (1%)
Ice creams	0	1 (1%)	1 (1%)	0	1 (1%)
Water	1 (1%)	2 (2%)	0	1 (2%)	1 (1%)
Fruit and vegetables	32 (39%)	43 (38%)	40 (52%)	33 (61%)	40 (43%)
Pastries, cakes, sweetened snacks	3 (4%)	6 (6%)	4 (5%)	0	5 (6%)
Oils and fats	5 (6%)	1 (1%)	1 (1%)	1 (2%)	2 (2%)
Milk and dairy products (inc. cheese)	11 (13%)	9 (8%)	7 (9%)	3 (5%)	7 (8%)
Bread and rolls, breakfast cereals	5 (6%)	15 (13%)	7 (9%)	3 (5%)	7 (8%)
Pizzas	0	0	0	0	0
Eggs and egg products	0	0	0	0	0
Fishes and seafood	1 (1%)	7 (7%)	5 (8%)	1 (2%)	6 (6%)
Potatoes, rice, pastas, and pulses	5 (6%)	5 (4%)	4 (5%)	10 (18%)	6 (6%)
Sandwiches	0	0	0	0	0
Sauces	1 (1%)	2 (2%)	1 (1%)	0	0
Sugar, confectioneries, and other sugar products	4 (5%)	5 (4%)	1 (1%)	1 (2%)	3 (3%)
Meat and meat products	5 (6%)	5 (4%)	1 (1%)	1 (2%)	3 (3%)
Total	83 (100%)	112 (100%)	78 (100%)	54 (100%)	93 (100%)

Table 5 Foods in various categories negatively associated to the "healthy diet"(number and %) ($P = 0.05$)

Food category	Belgium	Denmark	France	Italy	Ireland
Alcoholic beverages	6 (9%)	1 (3%)	0	5 (8%)	2 (9%)
Warm beverages	4 (6%)	1 (3%)	0	0	0
Non-alcoholic cold beverages	1 (1%)	1 (3%)	0	1 (1%)	1 (4%)
Ice creams	0	0	0	1 (1%)	0
Water	0	0	0	1 (1%)	0
Fruit and vegetables	0	0	0	4 (6%)	0
Pastries, cakes, sweetened snacks	6 (9%)	2 (5%)	9 (17%)	5 (8%)	3 (12%)
Oils and fats	7 (10%)	6 (14%)	1 (2%)	4 (6%)	2 (8%)
Milk and dairy products (inc. cheese)	8 (12%)	4 (11%)	6 (11%)	7 (10%)	1 (4%)
Bread and rolls, breakfast cereals	5 (7%)	1 (3%)	0	3 (5%)	1 (4%)
Pizzas	0	0	1 (2%)	0	0
Eggs and egg products	1 (1%)	1 (3%)	0	0	0
Fishes and seafood	2 (3%)	0	1 (2%)	3 (5%)	0
Potatoes, rice, pastas, and pulses	4 (6%)	2 (5%)	5 (9%)	10 (15%)	2 (9%)
Sandwiches	0	0	1 (2%)	0	0
Sauces	4 (6%)	4 (11%)	1 (2%)	3 (5%)	1 (4%)
Sugar, confectioneries, and other sugar products	1 (1%)	0	2 (5%)	3 (5%)	0
Meat and meat products	19 (28%)	15 (39%)	25 (48%)	16 (24%)	12 (46%)
Total	68 (100%)	39 (100%)	52 (100%)	68 (100%)	26 (100%)

In four countries, the criteria used to define the "healthy eating population" were modified to include additional items (Table 6). In most of the cases, the indicator foods of this sensitivity analysis were already classified the same way in the main analysis.

Discussion

This study is a first attempt to derive a reference list of indicator foods positively or negatively associated with a healthy diet from the analysis of dietary surveys. The study shows that it is possible to derive a reference list of indicator foods from different national dietary surveys in Europe. The choice of the nutritional endpoints chosen among the Eurodiet dietary goals has an influence on the list of indicator foods due to the causative nature of, for example, increased meat consumption on overall intakes of saturated fat.

The healthy eating index is a simple sum of scores based on the ratios between the actual nutrient intakes and the nutritional endpoints. It could be refined by introducing weight factors to account for the idea that the same numerical difference between an intake and the desirable endpoint does not necessarily have the same public health consequence for each nutrient, for instance for saturated fat and for sodium. Ideally, these weight factors should be based on a quantitative analysis of the health impact of not reaching an endpoint and should use the same metric, for instance Quality Adjusted Life Years (QALYs) or Disability Adjusted Life Years (DALYs).

The choice of lowest and top quintiles of the proposed "healthy eating score" to define the "healthy" and "unhealthy" eating population for each country means implicitly that we consider the healthy diets in a relative and not absolute manner. The proportion of "healthy eating" individuals in each country is the same with our methodology. This methodological choice may explain some overlaps and differences between countries in the lists of indicator foods contributing or not to the "healthy diet." This choice may not always be appropriate and a future improvement of the method could be the use of the same numerical threshold of the healthy eating index in each country.

With our approach, indicator foods were selected from a list of most commonly eaten foods in each country. It was difficult to define precisely what an individual food is and what a food group is. Some dietary surveys use very detailed information up to the branded product. Other surveys use a list of generic foods. Results may differ according to the level of details used in the different dietary methods to define a food.

Indicator foods are identified by comparing the mean food intake of a food by the "healthy eating" population and the mean intake of the same food by the "not healthy eating" population. Other criteria could be used to define indicator foods like the contribution of the food to the intake of different nutrients. The result of this alternative approach would be that foods that do not contribute significantly to total nutrient intakes would not be considered as indicator foods. This could improve the consistency of the definition of indicator foods, by preventing that a food like jam which is regularly consumed together with another food like bread, which contributes to a "healthy diet," could be considered as a positive indicator food. But the difficulty of this approach is to define objectively thresholds of the minimum contribution to intake for the different

Table 6 Results of the sensitivity analysis for additional criteria (for Belgium, Ireland, France). Number of foods classified.

Criteria	Foods preferably consumed in a healthy diet	Foods less consumed in a healthy diet
No. of sugar eating occasions, Ireland ($P = 10^{-2}$)	62	19
BMI criteria for Italy ($P = 10^{-2}$)	51	64
BMI criteria for Belgium ($P = 10^{-2}$)	63	38
Five national criteria (fiber > = 15 g/d, starch in %energy > = 25%, calcium > = 800 mg, saturated fat < = 50% total fat, salt < = 8 g/d) in France, $P = 0.05$	30	4

nutrients and for criteria like total fat in % of energy or saturated fat in % of energy.

The comparison of the indicator foods identified in the present study with those of the validation study in UK based on expert opinions [12] shows some coherence (fruit and vegetables, whole grain cereal products, low-fat dairy products as positive indicator foods, fatty meat products considered as negative indicator foods) but also some discrepancies. In the future, it would be useful to try to develop a validation method that could take into account both expert opinions and contribution of foods to the diet.

For the future, there is a need to improve the methodology used in the present study to establish a "gold standard" for the validation of nutrient profiling systems. The robustness of the results could be improved by increasing the number of dietary surveys used and thus the total cumulative size of the survey samples. The list of the criteria used to define the "healthy diet" could be extended with the addition of biomarkers of exposure (for instance urinary sodium instead of calculated sodium intake) and indicators of the nutritional status.

The number of surveys that identify a food as an indicator food could be a criterion of the reliability of its classification. This approach requires that the identification of indicator foods is done in the same way in the different countries. One problem that should be overcome is the classification of foods, because individual foods of the same translated name are not always exactly the same in the different EU countries (for instance breads, sausages, cheeses, fruit juices). Their description and composition should be used to match them.

The addition of the contribution to nutrient intake as a criterion of selection of an indicator food could help to avoid the artificial identification as indicator of foods whose consumption is correlated with the intake of other indicator foods. It might also help to explain why the consumption of foods of a same category can be associated in this study with positive and negative eating habits.

Conclusion

The study shows that it is possible to define indicator foods for the validation of nutrient profiles by identifying such foods from different national dietary surveys in Europe, which are positively or negatively associated with a healthy eating pattern. The study also shows a need to improve the harmonization of dietary surveys (including food description and categorization) and food composition databases across Europe in order to make comparisons reliable. The validation of nutrient profiles using these indicator foods may be done in a second step by comparing the status of these foods (positively associated to healthy eating pattern or not) and their classification according to a nutrient profiling scheme. This comparison will be done for three different nutrient profiling schemes in a following article.

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References

1. Azaïs-Braesco V, Goffi C, Labouze E (2006) Nutrient profiling: comparison and critical analysis of existing systems. Public Health Nutr 9(5):613–622
2. Deutsche Gesellschaft für Ernährung, Östereichische Gesellschaft für Ernährung, Schweizerische Gesellschaft für Ernährungsforschung, Schweizerische Vereinigung für Ernährung (D-A-CH) (2000) Referenzwerte für die Nährstoffzufuhr. Umschau Baus Verlagsgesellschaft, Frankfurt a. M
3. Devriese S, Huybrechts I, Moreau M, Van Oyen H (2006) Enquête de consommation alimentaire belge 1–2004. Institut Scientifique de Santé Publique. Rapport D/2006/2505/16
4. EFCOSUM group (2001) European food consumption survey method, final report. TNO report V3766
5. European Parliament (2006) Position of the European Parliament adopted at second reading on 16 may 2006 with a view to the adoption of Regulation (EC) N° …/2006 of the European Parliament and of the Council on nutrition and health claims made on foods
6. Institute of Medicine (2000) Dietary reference intakes: applications in dietary assessment. The National Academies Press, Washington DC
7. Irish Universities Nutrition Alliance (IUNA) (2001) North/South Ireland food consumption survey, summary report. Food Safety Promotion Board, Dublin
8. Kafatos A, Codrington CA (1999) Nutrition and diet for healthy lifestyles in Europe: the "Eurodiet" project. Public Health Nutr 2(3A):327–328
9. Lachat C, Van Camp J, De Henauw S, Matthys C, Larondelle Y, Remaut-De Winter AM, Kolsteren P (2005) A concise overview of national nutrition action plans in the European Union Member States. Public Health Nutr 8(3):266–274
10. Lyhne N, Christensen T, Groth MV, Biltoft-Jensen A, Hartkopp H, Hinsch H, Matthiessen J, Møller A, Saxholt E, Trolle E (2005) Dietary habits in Denmark 2000–2002 (in Danish). Publ # 11, The Danish Institute for Food and Veterinary Research, Søborg
11. O'Neill M (2004) Traffic lights for food? How nutrient profiling can help make healthy choices become easy choices. National Consumer Council, June 2004
12. Rayner M, Scarborough P, Stockley L, Boxer A (2005) Nutrient profiles; Further refinement and testing of model SSCg3d. Final report [online], http://www.food.gov.uk/multimedia/pdfs/npreportsept05.pdf/ (accssed 30 October 2007)
13. Turrini A, Leclerc C, D'Amicis A (1999) Patterns of food nutrient intales in Italy and their application to the development of food-based dietary guidelines. Br J Nutr 81(Suppl2):S82–S89
14. Volatier JL (2000) Enquête Individuelle et Nationale sur les Consommations Alimentaires INCA (in French). Editions Lavoisier TEC&DOC, Paris, 158 p
15. World Health Organisation regional office for Europe (WHO-Europe) (2002) Food and health in Europe, a new basis for action. WHO regional office for Europe, Copenhagen, 31 pp