RIBEFOOD: A SOFTWARE TO ESTABLISH THE INTAKE OF A NUMBER OF NUTRIENTS AND CHEMICAL CONTAMINANTS THROUGH THE DIET

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Abstract
In recent years, a number of studies have shown that some foodstuffs might be a potential source of exposure to chemical pollutants, some of them with a well known potential toxicity in humans. Based on the importance of a healthy diet, we have designed a software (RIBEFOOD) that allows easily to determine the human intake of a long series of macro and micronutrients contained in widely consumed foodstuffs, and with a important nutritional value. RIBEFOOD is also able to determine the dietary intake of a number of chemical contaminants such as metals and persistent organic pollutants among others. In this paper, we present RIBEFOOD and how it may be used as an easy tool to optimize the dietary habits of any subject by increasing the intake of beneficial nutrients and by reducing those of toxic pollutants. RIBEFOOD can be useful not only for professionals (general physicians, nutritionists, endocrinologists, toxicologists, etc.), but also for the general population.

Introduction
Nowadays, most individuals know that eating certain foodstuffs is potentially good for their health. However, several areas of uncertainty remain. For example, the optimal intake of sugars, carotenoids, retinoids, etc., among other important nutrients is not firmly established yet. On the other hand, some studies have produced conflicting results, whereas certain concerns are related with the usual presence of chemical pollutants in foodstuffs.[1, 2]

Recently, in order to quantitative establish the dietary intake of chemical pollutants (health risks) versus that of omega-3 fatty acids (health benefits) through regular fish and seafood consumption, we designed a single computer program, Ribepeix (http://www.fmcs.urv.cat/portada/ribepeix/), whose main objective was to optimize the regular fish consumption. The interest raised by this program has been the basis for developing a new and more complete software, which includes also foodstuffs belonging to various food groups that are widely consumed by the population of Catalonia, Spain.

Design of RIBEFOOD
Sampling. In March-June 2006, samples of 52 widely consumed foodstuffs in Catalonia, Spain, were collected.[3] They included fish and seafood species (sardine, tuna, anchovy, mackerel, swordfish, salmon, hake, red mullet, sole, canned tuna, canned sardine, cuttlefish, squid, clam, mussel, shrimp), fruits (apple, orange, banana, pear), bread and cereals (white bread, packed sliced bread, rice, pasta), eggs, milk and dairy products (whole milk, semi-skimmed milk, cheese, yogurt), meat and meat products (hamburger, lamb, pork sausage, loin of pork, chicken breast, veal steak, ham, hot dog, salami), oils and fats (olive oil, sunflower oil, margarine, butter), pulses (lentil, beans), vegetables (green bean, lettuce, cauliflower, potato, tomato), and bakery products (croissant, cookie, fairy cake). All samples were randomly (independent of their geographical origins) purchased from local markets, big supermarkets, and grocery stores from twelve important cities of Catalonia. A total of 150 composite samples were analyzed for the levels of pollutants.

Experimental procedure. Analytical methods of metals (Cd, Hg and Pb) and organic pollutants (polychlorinated dibenzo-*p*-dioxins and furans (PCDD/Fs), polychlorinated biphenyls (PCBs), hexachlorobenzene (HCB), 16 polycyclic aromatic hydrocarbons (PAHs), polychlorinated naphthalenes (PCNs), polybrominated diphenyl ethers (PBDEs), and polychlorinated diphenyl ethers (PCDEs), including preparation of samples for analysis, extraction and clean-up, and instrumentation, were widely detailed in recent reports.[4, 5] Consumption habits for the general population of Catalonia concerning the analyzed foodstuffs were recently reported.[3] The daily intakes of metals, organic pollutants, and nutrients in each food item were calculated by multiplying the respective concentration in that item by the weight consumed by a male adult of 70 kg body weight. Total intake was obtained by summing all these products. For calculations, when a concentration was under the limit of detection (LOD), the value was assumed to be one-half of the respective LOD (ND = 1/2 LOD). All the results were subsequently introduced in RIBEFOOD, together with the average content of an important number of nutrients: protein, cholesterol, fiber, calcium (Ca), folic acid (B_9), etc.**,** values that were mainly obtained from Farran and co-workers.[6]

Objectives of RIBEFOOD. To quantitative establish the dietary intake of pollutants versus that of macro and micronutrients, RIBEFOOD was designed. The main objectives of RIBEFOOD are the following: 1) To determine the intake of Cd, Hg, Pb, PCDDs, PCDFs, PCBs, PAHs, HCB, PBDEs, PCDEs, and PCNs by an individual through his/her specific usual food consumption. 2) To compare the dietary intakes of these pollutants with the tolerable/acceptable intakes, when these have been already established by international regulatory organizations. 3) To determine the dietary intake of the macro and micronutrients, and to compare the intakes of these nutrients with those generally recommended by international nutritional organizations and associations. 4) To perform potential changes in the particular dietary habits of any individual, which should allow optimizing the balance between health benefits (nutrients) and risks (chemical contaminants) derived from this specific consumption.

RIBEFOOD use. The weight, age, and sex of the user are requested in the first screen. The user must here include, for each of the selected foodstuffs, his/her weekly frequency of consumption, as well as the approximate meal size. As this can be difficult in some cases, three pictures corresponding to three different potentially consumed amounts of a specific food are included. It can be illustrative for a general user (Fig. 1).

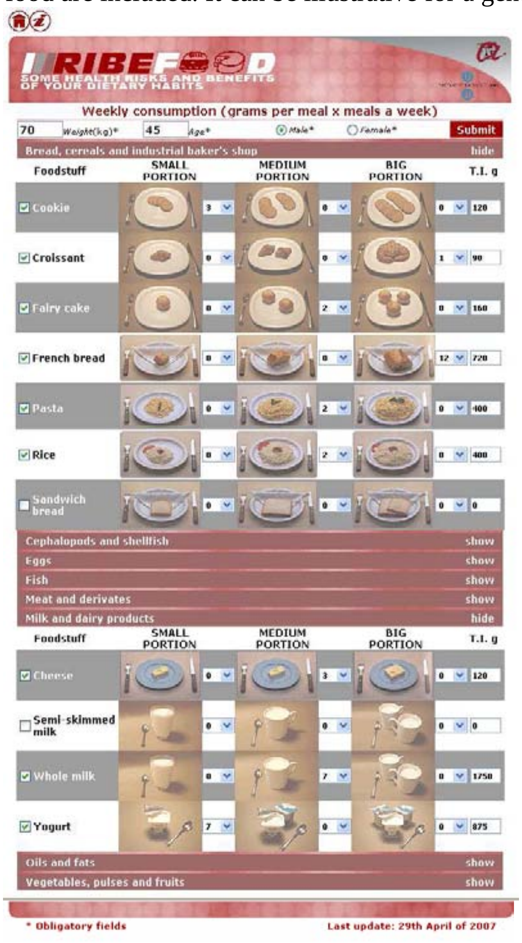
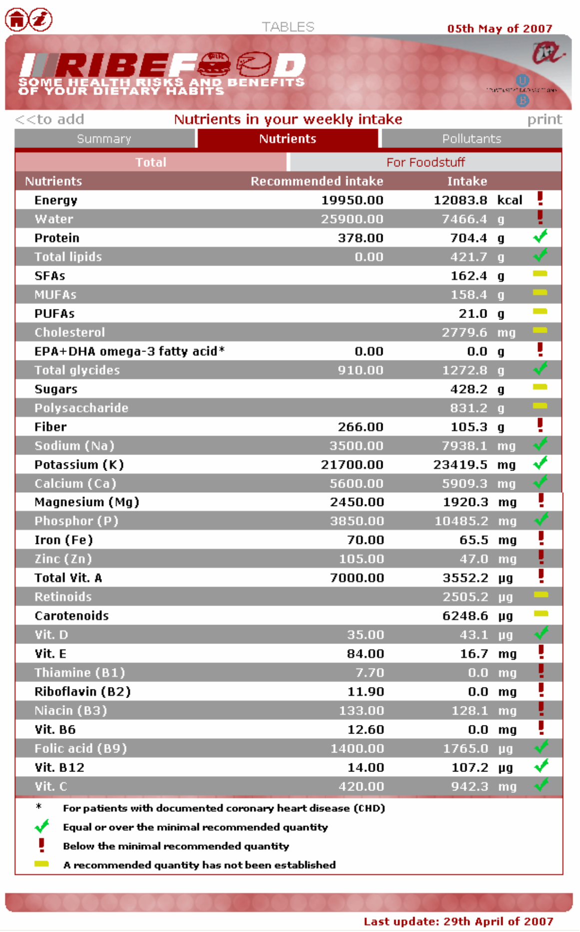


Fig. 1. First screen of RIBEFOOD: an example.

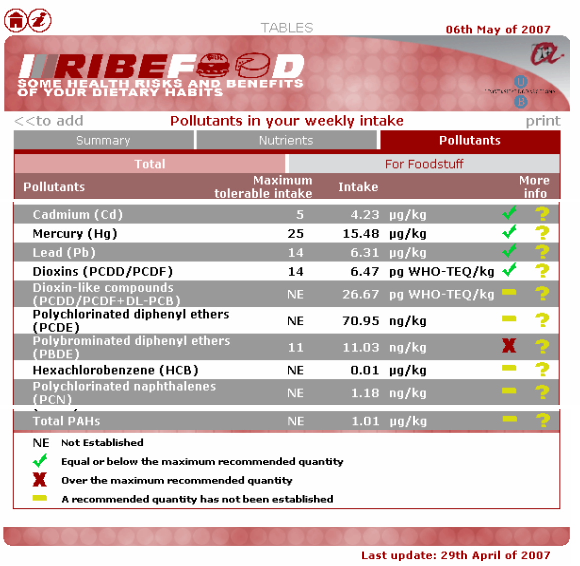
At the top of this screen (Fig. 1), clicking on the respective icons the values concerning intake of metals and organic pollutants (potential health risks), as well as the intake of the respective nutrients are immediately shown. It is important to note that an additional icon offering the possibility to go back in order to modify the consumption data is also included.



Nutrients	Recommended intake	Intake		
Energy	19950.00	12083.8	kcal	!
Water	25900.00	7466.4	g	!
Protein	378.00	704.4	g	✓
Total lipids	0.00	421.7	g	✓
SFAs		162.4	g	–
MUFAs		158.4	g	–
PUFAs		21.0	g	–
Cholesterol		2779.6	mg	–
EPA+DHA omega-3 fatty acid*	0.00	0.0	g	!
Total glycides	910.00	1272.8	g	✓
Sugars		428.2	g	–
Polysaccharide		831.2	g	–
Fiber	266.00	105.3	g	!
Sodium (Na)	3500.00	7938.1	mg	✓
Potassium (K)	21700.00	23419.5	mg	✓
Calcium (Ca)	5600.00	5909.3	mg	✓
Magnesium (Mg)	2450.00	1920.3	mg	!
Phosphor (P)	3850.00	10485.2	mg	✓
Iron (Fe)	70.00	65.5	mg	!
Zinc (Zn)	105.00	47.0	mg	!
Total Vit. A	7000.00	3552.2	µg	!
Retinoids		2505.2	µg	–
Carotenoids		6248.6	µg	–
Vit. D	35.00	43.1	µg	✓
Vit. E	84.00	16.7	mg	!
Thiamine (B1)	7.70	0.0	mg	!
Riboflavin (B2)	11.90	0.0	mg	!
Niacin (B3)	133.00	128.1	mg	!
Vit. B6	12.60	0.0	mg	!
Folic acid (B9)	1400.00	1765.0	µg	✓
Vit. B12	14.00	107.2	µg	✓
Vit. C	420.00	942.3	mg	✓

* For patients with documented coronary heart disease (CHD)
✓ Equal or over the minimal recommended quantity
! Below the minimal recommended quantity
– A recommended quantity has not been established

Fig. 2a. Nutrients screen: an example.



Pollutants	Maximum tolerable intake	Intake			More info
Cadmium (Cd)	5	4.23	µg/kg	✓	?
Mercury (Hg)	25	15.48	µg/kg	✓	?
Lead (Pb)	14	6.31	µg/kg	✓	?
Dioxins (PCDD/PCDF)	14	6.47	pg WHO-TEQ/kg	✓	?
Dioxin-like compounds (PCDD/PCDF+DL-PCB)	NE	26.67	pg WHO-TEQ/kg	–	?
Polychlorinated diphenyl ethers (PCDE)	NE	70.95	ng/kg	–	?
Polybrominated diphenyl ethers (PBDE)	11	11.03	ng/kg	X	?
Hexachlorobenzene (HCB)	NE	0.01	µg/kg	–	?
Polychlorinated naphthalenes (PCN)	NE	1.18	ng/kg	–	?
Total PAHs	NE	1.01	µg/kg	–	?

NE Not Established
✓ Equal or below the maximum recommended quantity
X Over the maximum recommended quantity
– A recommended quantity has not been established

Fig. 2b. Pollutants screen: an example.

Examples corresponding to a specific intake are shown in Figures 2a (nutrients) and 2b (pollutants), respectively. Data are based on the respective body weight, the weekly consumption, and the meal size. The tolerable/admissible intake concerning each pollutant is also shown for those contaminants for which information is available. For those pollutants in which a red symbol appears, the tolerable weekly intake is being surpassed. Finally, clicking on the "?" symbol concerning each contaminant, a brief summary of information about this pollutant can be found. This can be especially important for those individuals who are not very familiarized with the chemistry, environmental distribution, and toxicity of certain contaminants.

According to the results concerning intake of nutrients and chemical pollutants of a particular food consumption habit, an individual can then decide to optimize the balance between the potential health risks (pollutants) and benefits (nutrients) derived from his/her particular dietary habits. There are some screens where the most and the less polluted foodstuffs are detailed, as well as the food items included in RIBEFOOD with the highest and lowest contents of the respective nutrients. With this information, the user can modify the consumption habits in order to reduce the potential risks by exposure to chemical contaminants and to increase the intake of the most beneficial macro and micronutrients. All the screens can be printed for making easier to visualize the results of changing the food consumption habits.

Conclusions

RIBEFOOD includes only those food items most consumed in Catalonia, Spain. However, foodstuffs were purchased independently on the geographical origin, and the contents of the nutrients are average values taken from the literature. Therefore, due to the simplicity of the program, it can be easily adapted to any region or country. Obviously, to analyze (or to know) the concentrations of the pollutants in the foodstuffs most consumed in the respective region/country is quite essential. RIBEFOOD can be also easily adapted to the dietary habits of each region or country. Food preferences of consumers based on economic, social, and ethnic background, and the availability in different regions/countries and in different economic strata, are information that can be available to specific geographical areas.

A limitation of the usefulness of RIBEFOOD is the lack of reported information concerning human health risks of substances such as PBDEs, PCDEs, or PCNs. It is especially relevant for PCNs and PCDEs, which could act as dioxin-like compounds adding their risks to those of PCDD/Fs and dioxin-like PCBs. Consequently, to determine these potential adverse effects is basic to establish the potentially best recommendations on the consumption of specific foodstuffs, frequency of consumption, and average meal size. Another potential limitation of the use of RIBEFOOD is that results for the chemical contaminants are only valid for single pollutants in single-species diets. Although calculating consumption limits for multiple contaminant situations and for multiple diets is theoretically possible, it would mean a tremendous complexity. Data interpretation is hard and complicated, and it would surpass the objectives of this software. Anyhow, we expect that RIBEFOOD, adapted to specific regional/national characteristics, will be useful not only for those professionals involved in nutritional health issues, but also for the general population.

Acknowledgements

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