Special Article

Nutrient profiling of foods: creating a nutrient-rich food index

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Nutrient profiling of foods, described as the science of ranking foods based on their nutrient content, is fast becoming the basis for regulating nutrition labels, health claims, and marketing and advertising to children. A number of nutrient profile models have now been developed by research scientists, regulatory agencies, and by the food industry. Whereas some of these models have focused on nutrients to limit, others have emphasized nutrients known to be beneficial to health, or some combination of both. Although nutrient profile models are often tailored to specific goals, the development process ought to follow the same science-driven rules. These include the selection of index nutrients and reference amounts, the development of an appropriate algorithm for calculating nutrient density, and the validation of the chosen nutrient profile model against healthy diets. It is extremely important that nutrient profiles be validated rather than merely compared to prevailing public opinion. Regulatory agencies should act only when they are satisfied that the scientific process has been followed, that the algorithms are transparent, and that the profile model has been validated with respect to objective measures of a healthy diet.

INTRODUCTION

Nutrient profiling of foods is defined as the science of ranking foods based on their nutrient composition.[1,2] Measures of nutrient density, previously applied only to total diets,[3] are now being adapted for use with individual foods.[1,4,5] Assigning foods into categories based on their nutrient content has many potential applications, ranging from consumer education and dietary guidance[6] to nutrition labeling and the regulation of health claims.[7,8]

Helping consumers make more healthful food choices is one application of nutrient profiling. The 2005 Dietary Guidelines for Americans[9] and MyPyramid[10] both used the concept of nutrient density to promote the consumption of nutrient-rich foods across and within food groups. Selecting nutrient-dense foods and beverages in preference to discretionary calories was identified as one way to meet nutrient goals without exceeding daily energy needs.[9] The Guidelines identified lean meats, fat-free and low-fat dairy products, whole and enriched grains, legumes, and vegetables and fruit as nutrient-dense foods. However, the core concept of nutrient density was not clearly defined. Nutrient-dense foods were described in the Guidelines as those that provided "substantial" amounts of vitamins and minerals and relatively "few" calories.[9]

Nutrient profiling can also be used for regulatory purposes.[4] In 2006, the European Commission issued a proposal, which was adopted by the European Parliament, on the use of nutrient profiles in the future making of nutrition and health claims.[7,8] Only foods with favorable nutrient profiles will be permitted such claims, whereas foods with unfavorable profiles will be disqualified. Article 4 of the Commission's proposal specifically required that nutrient profiles take into account the potentially disqualifying nutrients: total fat, saturated fat, trans fat, sugar, and sodium, as well as those nutrients known to be beneficial to health.[8] Nutrient profile models also needed to consider the importance of the food in the population's diet and in the diets of children and other special groups.[8]

Multiple efforts to develop, validate, and test nutrient profile models are now underway. Interim and final

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reports issued by the Food Standards Agency (FSA) in the United Kingdom, which is the equivalent of the Food and Drug Administration (FDA) in the United States, are now available online.[2,11–14] The corresponding French agency, the Agence Française de Sécurité Sanitaire des Aliments (AFSSA), is preparing to release its own report.[8] Additional nutrient profile models have been developed in France[15,16] and in the Netherlands.[17,18] Such models are based on specific combinations of macronutrients, vitamins, and minerals and sometimes involve both nutrients and food groups.

The American Dietetic Association recently published a thoughtful practice paper on nutrient density, reviewing a number of food quality indices that have been published over the years.[19] An earlier report by Dietitians of Canada[20] likewise evaluated a number of nutrient profiles and their usefulness. Both reports pointed to gaps in the definition of nutrient-dense foods and identified future research needs. One practical question was whether the concept of nutrient density would be accepted by the consumer. Another question was whether the nutrient density approach to front-of-pack food labeling would result in healthier diets.

Parallel work on nutrient profiling has been conducted by food companies. Five companies in the United Kingdom (Danone, Kellogg's, Kraft, Nestle, and PepsiCo) and two grocery chains (Tesco and Sainsbury's) have developed their own voluntary food labeling systems. In the United States, PepsiCo, Kraft, McDonald's and the Hannaford supermarket chain have also developed their own labeling schemes.[21,22] In the Netherlands, Unilever has devised a nutrition score to help guide improvement of the nutritional quality of its product line and has screened all the foods in its portfolio.[17] Going well beyond nutrition education, the potential applications of nutrient profiling now include new product development,[17] food labeling,[7,8] health claims,[8,11] and the regulation of advertising and marketing to children.[12,13]

The creation of a nutrient profile model needs to reconcile a number of competing objectives.[1,4,23] Regulatory agencies need an algorithm that is scientifically justifiable, enforceable, objective, and transparent.[7,8] The food industry's concern has been that some profiling approaches, notably the "traffic light" system,[24] tend to separate foods into "good" and "bad", such that whole categories of foods may be penalized.[7,8] One way to deal with this issue is to create nutrient profiles that are category-specific, as opposed to an across-the-board approach.[8] The consumer requires a system that is simple, user friendly, and can signal the best options within the same food group.[19,20] All parties need to be convinced that nutrient profiling of foods will result in healthier food choices, better diets, and a measurable improvement in the public's health.

Despite such a diversity of goals, the development of nutrient profile models should follow uniform, rigorous, and science-driven rules.[4,23] These include the selection of index nutrients and reference amounts, the creation of an appropriate algorithm for calculating nutrient density, and the validation of the chosen model against some objective measure of a healthy diet. The inclusion of a convincing link to better health outcomes would be ideal. Additional studies need to link nutrient profiles of foods to other determinants of food choice—such as food preferences and food costs.[1,4,15,16] We must remember that foods are consumed for more than just sustenance and nutrition; food choices and eating habits provide opportunities for social interaction and food is a source of considerable pleasure to consumers. Finally, the usefulness of the chosen model needs to be tested among nutrition professionals and among consumer groups of different socioeconomic status.[25,26]

The European Food Safety Authority (EFSA) will review some of the nutrient profile models as early as this year. The FDA and the 2010 Dietary Guidelines Committee in the United States may eventually want to do the same. However, regulatory approval should be contingent on developing a nutrient profiling system that is science-driven, transparent, and validated with respect to healthy diets.[4,23] Describing the steps needed to develop and validate nutrient profile models is the focus of this report.

THE DEFINITION OF NUTRIENT-DENSE FOODS

Early efforts at defining nutrient density agreed that nutritious foods should provide "significant amounts of essential nutrients" but stopped short of providing actual standards or criteria.[27] Thirty years later, nutrient-dense foods were still defined as those that provided more nutrients and fewer calories.[1,28] Since nutrient-dense foods still lack a formal definition, the notion of what constitutes a "healthy" food is built, in the first instance, around food groups. There are references in the literature to nutrient-dense meats,[29] nutrient-dense milk,[30] nutrient-dense fruits and vegetables,[31] nutrient-dense nuts,[32] and nutrient-packed whole grains.[33]

However, not all foods within a given food group have the same nutritional value. Even foods within desirable food groups may contain fat, sugar, or both. The World Health Organization described all legumes, vegetables, and fruits as nutrient-dense but restricted the use of the term to lean meats, low-fat dairy products, and whole grains.[34] The 2005 Dietary Guidelines similarly described all legumes, vegetables, and fruits as nutrient-dense but restricted the term to lean meats, skinless poultry, fat-free and low-fat dairy products, and whole-grain and enriched grain products.[9] The National Cancer Institute (NCI) at one time defined all fruits and

vegetables in their natural form as healthy, but specifically excluded avocados, nuts, olives and coconuts because of their fat content.[35] As fat phobia receded, that prohibition was lifted. More recently, the USDA's MyPyramid recognized that dark-green leafy and deep-orange vegetables were especially good sources of vitamins and minerals.[10] Also recommended were fresh, frozen, canned, and dried fruits as well as fruit juices.[10] Generally excluded from the definition of nutrient-dense foods were those that contained added fat, sugar, or sodium.[9,10]

Early efforts to rank foods by their nutrient content across and within food groups[27] were based on the recommended dietary allowances (RDAs). In 1974, the Federal Trade Commission proposed limiting the use of the term "nutritious" to those foods that provide at least 10% of the US RDA per 100 kcal for protein and three other nutrients, and at least 10% RDA per serving for one of these nutrients.[27] However, only one vegetable and one milk out of a total of 135 different foods met that very stringent test. Later suggestions that "nutritious" foods ought to provide 50% of the US RDA for one nutrient; 20% for two nutrients; 15% for three nutrients; 10% for four nutrients, or 6% for each of five nutrients[36] was another attempt at a composite score. However, that rigid test also disqualified many common foods.[27]

Attempting to quantify nutritional value, Hansen et al.[37] suggested that such words as poor, fair, adequate, good, or excellent might be used to reflect gradations of nutrient density. These terms were precursors of the current FDA language guidelines for characterizing the level of nutrients in food (see Table 1). The terms "good source of" or "excellent source of" can only be used to describe protein, vitamins, minerals, dietary fiber, or potassium. Good sources of a given nutrient provide 10–19% of the daily value (DV) per reference amount, whereas excellent sources provide 20% or more. Conversely, such terms as "free", "low" or "reduced/less" apply to calories, total or saturated fat, sodium, sugars, or cholesterol. These too are based on reference amounts—or on 50 g if the reference amount is small. Recently, the FDA requested that food manufacturers refrain from using the terms "good source of" or "excellent source of" for whole grain products, since the term was reserved for nutrients as opposed to food ingredients.

An alternative approach to defining nutrient density has focused on those nutrients that are present in excess in the typical Western diet. In many cases, healthy foods were defined by low levels of nutrients to limit, rather than by the total nutrient package. For example, the National Heart Lung and Blood Institute defined healthy foods as those with low levels of fat (<12 g), saturated fat (≤4 g), cholesterol (<100 mg), and sodium (<600 mg) per serving.[38] The American Heart Association's criteria were based on the virtual absence of fat (≤3 g), saturated fat (≤1 g), and cholesterol (≤20 mg), and on low sodium content (≤480 mg) per serving.[39] Similarly, the NCI excluded from its definition of healthy foods those processed fruit and vegetables that contained sugar or fat, or those that contained >480 mg of sodium.[35]

To meet the FDA definition of "healthy" foods, the food had to contain at least 10% of the RDI or the daily reference value (DRV) per reference amount of one or more of six nutrients: protein, fiber, vitamins A and C, calcium, and iron[40]; it also had to be low in fat (<3 g), saturated fat (<1 g), cholesterol (<60 mg), and sodium (<480 mg). The addition of any beneficial nutrients had to be consistent with the FDA fortification policy. Health claims were permitted only if, prior to fortification, the

Table 1 **Nutrient content claims as defined by the Food and Drug Administration.[40]**

Term	Nutrient content per RACC
Good source of; contains; provides	Contains 10–19% of the DV. Used to describe protein, vitamins, minerals, dietary fiber, or potassium, but not carbohydrate.
Excellent source of; high; rich in;	Contains 20% or more of the DV. Used to describe protein, vitamins, minerals, dietary fiber, or potassium, but not carbohydrate.
More; added; extra; plus	Contains 10% or more of the DV. May only be used for protein, vitamins, minerals, dietary fiber, or potassium,
High potency	Describes individual vitamins or minerals that are present in food at 100% or more of the RDI per RACC.
Free; zero; no; without	Calories <5; total fat <0.5 g; saturated fat <0.5 g; trans fat <0.5 g; cholesterol <2 mg; sodium <5 mg; sugars <0.5 g (per reference amount and per labeled serving)
Low; little; few; low source of	Calories <40*; total fat <3 g*; saturated fat <1 g†; cholesterol <20 mg*; sodium <140 mg*; sugars: not defined
Reduced/less; lower; fewer	Calories >25% less; total fat >25% less; saturated fat >25% less; cholesterol >25% less; sodium >25% less; sugars >25% less‡
Light	Percent reduction for both fat and calories must be stated

* Per 50 g if reference amount is small.
† With <15% calories from saturated fat.
‡ Relative to appropriate reference food. May not be termed "low".
Abbreviations: DV, daily value; RACC, reference amount customarily consumed; RDI, reference daily intake.

food contained >10% DV per reference amount customarily consumed (RACC) of at least one of the six key nutrients. Foods were disqualified from health claims if a serving of food contained >13 g of fat, >4 g of saturated fat, >60 mg of cholesterol, or >480 mg of sodium.[40] The FDA definition thus precluded health claims for some fruit and vegetable products with added oils, salt, sauces, or syrups, and for some breakfast cereals.

The USDA defines foods of "minimum nutritional value"[41] as those that contain less than 5% of US reference daily intakes (RDI) per serving for each of eight specified nutrients: protein, calcium, iron, vitamins A and C, riboflavin, thiamin, and niacin. In the case of artificially sweetened foods, foods of minimum nutritional value provide less than 5% of the RDI for each of the eight specified nutrients per serving.[41] Unhealthful competitive foods sold to children in competition with the school lunch were generally those that contained >30% of energy from fat; >10% of energy from saturated fat; and more than 15 g of sugar per serving.[41] Different states have different policies regarding competitive foods and the restrictions vary among elementary, middle, and high schools.[41]

Industry-based nutrient profile models have also stayed close to the established FDA norms. The PepsiCo Smart Spot[21] was awarded if the product contained ≤3 g fat, ≤1 g saturated fat, zero trans fat, <60 mg of cholesterol, and <480 mg of sodium per serving. The product could not contain >25% of energy from added sugar, unless it also had at least 10% DV of fiber. In addition, Smart Spot products contained 10% or more of the DV of one or more of the following: vitamin A, vitamin C, iron, calcium, protein, or fiber.[21]

The criteria adopted by the Institute of Medicine for nutrition standards in schools were almost as stringent.[42] The key requirement was that tier 1 foods, allowed at all grade levels during the school day, provide at least one serving of desirable food groups: fruits, vegetables, whole grains, or nonfat or low-fat dairy. Tier 1 snacks had to contain <200 kcal per portion, <35% of energy from fat and <10% of energy from saturated fat, <200 mg of sodium per portion, no trans fat, and no caffeine. Total sugar was limited to 35% of energy, with some exceptions made for flavored milk and yogurt. Tier 2 competitive foods and beverages did not need to provide a whole serving of desirable foods but did need to follow equally strict standards. Tier 2 beverages were to be caffeine free, not fortified with vitamins or minerals, and limited to <5 kcal per portion.[42]

It is important to note that none of these attempts at defining nutritious foods represented a true nutrient profile model. It is only recently that the FDA has explored the feasibility of allowing health claims if a food had a favorable nutrient profile, as an alternative to current measures based on grams of nutrients per serv-ing.[43] In this new proposal, nutrient density was described as the amount of beneficial nutrients divided by dietary energy per reference amount customarily consumed (RACC). That represented a significant move toward the development of a composite nutrient density score. However, no formal metric was provided and the more nutrient-dense foods were described as those that contributed more beneficial nutrients than calories to the overall diet.[43]

More recently, the nutrient profiling approach was taken up by the regulatory agencies in the European Union.[4,7,8] As documented below, many of the existing regulatory concepts were used as components in developing new nutrient profile models. Some of the key principles of model building are detailed below.

HOW TO SELECT INDEX NUTRIENTS

Most foods contain different proportions of nutrients, some beneficial to health and others less so. The former have been referred to as the beneficial, positive, recommended, desirable, or shortfall nutrients.[1,4] The latter have been variously described as negative, restricted, less desirable, problematic, or avoidance nutrients.[1,4] Nutrient profile models can be based on 1) qualifying nutrients known to be beneficial to health, mostly vitamins and minerals; 2) disqualifying nutrients, mostly fats, sugars, and sodium; or 3) some combination of both. The content of fruits, vegetables, nuts, or whole grains in a food can also be taken into account.[14]

Table 2 provides a summary of nutrient profile models and the nutrients on which they are based. The beneficial nutrients have included, at a minimum, selected macronutrients (protein, fiber, essential fatty acids), vitamins (vitamins A and C), and minerals (calcium and iron). Some models have extended the list to include omega-3 fatty acids, B-vitamins and folate, and additional minerals, typically potassium, zinc, and magnesium. The total number of qualifying nutrients has ranged from a low of 2 to a high of 23.

The choice of qualifying nutrients was most often guided by the limiting or shortfall nutrients in the population diet (see 1 for review). For example, the 2005 Dietary Guidelines for Americans pointed to low intakes of fiber, vitamins A, C, and E, and calcium, magnesium, and potassium among US adults.[9] Low intakes of vitamins B_{12}, D, and E, folate, and iron were also identified for some subgroups.[9] The Women, Infants, and Children's Supplemental Food (WIC) program viewed protein, calcium, iron, vitamin A, and vitamin C as key, since they were most likely to be lacking in the diets of low-income women. The WIC program also tracked the intakes of folate, vitamin B_6, and zinc. Among additional nutrients of public health significance, as listed by the NCI, were

Table 2 **Summary of beneficial nutrients and nutrients to limit used to construct selected nutrient profile models.**

Score and reference	Macronutrients	Vitamins	Minerals	Nutrients to limit
Nutritional Quality Index (NQI))[37]	Protein, fiber, MUFA, carbs	Vit A, C, thiamin, riboflavin, B6, B12, niacin	Ca, Fe	Fat, saturated fat, cholesterol
Calories for Nutrient (CFN)[57]	Protein	Vit A, C, thiamin, riboflavin, niacin, B6, B12, folate	Ca, Fe, Zn, Mg	Total fat, saturated fat, cholesterol, Na
Nutritious Food Index[53]	Fiber	Vit A, C, thiamin, riboflavin, niacin, folate	Ca, Fe, Zn, Mg, K, Ph	
Ratio of recommended to restricted food components (RRR)[58]	Protein, fiber	Vit A, C	Ca, Fe	Energy, saturated fat, total sugar, cholesterol, Na
Naturally Nutrient Rich (NNR)[1,6]	Protein, fiber, MUFA	Vit A, C, D, E, thiamin, riboflavin, B12, folate	Ca, Fe, Zn, K	
Nutrient for Calorie (NFC)[6]	Protein, fiber	Vit A, C, E, B12	Ca, Fe, Zn, Mg, K, Ph	Saturated fat, Na
Nutrient Density Score NDS16[15]	Protein, fiber	Vit A, C, D, E, thiamin, riboflavin, niacin, panthotenic acid, B6, B12, folate	Ca, Fe, Mg	
Nutrient Density Score NDS23[16]	Protein, fiber, linoleic, linolenic acids, DHA	Vit A, C, D, E, thiamin, riboflavin, niacin, B6, B12, folate	Ca, Fe, Zn, Mg, K, Cu, I, Se	
Nutrient Density Score NDS5[16]	Protein, fiber	Vit C	Ca, Fe	
Nutrient Density Score NDS6	Protein, fiber	Vit A, C	Ca, Fe	
Nutrient Density Score NDS9	Protein, fiber	Vit A, C, E	Ca, Fe, Mg, K	
Limited nutrients (LIM) score[16]				Saturated fat, added sugar, Na
Limited nutrients (LIMtot) score				Total fat, total sugar, Na
Smart Spot[20]	Protein, fiber	Vit A, C	Fe	Total fat, saturated fat, trans fat, added sugar, Na
Unilever Nutrition Score[17]				Saturated fat, trans fat, sugar (total and added), Na
FSA model SSCg3d[13]	n-3 fatty acids, F + V (g)		Ca, Fe	Energy, saturated fat, added sugar, Na
FSA model WXYfm[2]	Protein, fiber, F + V + nuts (g)			Energy, saturated fat, total sugar, Na

Abbreviations: DHA, docosahexanoic acid; F + V, fruit and vegetables; MUFA, monounsaturated fatty acids.

fiber, vitamin E, and magnesium.[1] Not surprisingly, those were the nutrients that were most commonly listed in the reports in Table 2.

Table 2 also shows the standard list of nutrients to limit. As defined by the FDA, the disqualifying nutrients were total fat, saturated fat, cholesterol, and sodium.[40] As defined by the European Commission, the disqualifying nutrients were total and saturated fat, trans-fat, total sugar, and sodium.[7,8] As identified by the British FSA, the disqualifying nutrients were energy, saturated fat, total sugar, and sodium.[2] As recently formulated by the USDA's Center for Nutrition Policy and Promotion, the nutrients to limit were solid fat, added sugar, and alcohol.[44] Other definitions distinguished between total and added sugars.[17]

At this time, only those dietary compounds for which some standards of daily intake are available have been included in nutrient profiling. Whereas fiber is generally included, plant-derived phytochemicals, polyphenols, and antioxidants are not. This is probably due to a lack of data on reference amounts and incomplete nutrient composition tables. Issues can arise when data are not available for all foods for a nutrient of concern. For example, since trans fatty acid databases are quite limited, some have resorted to using an ingredient (partially hydrogenated vegetable oil) as a marker for trans fat. However, with this approach, products that may have a very limited amount of trans fat (below the labeling threshold) will be unfairly penalized.

One fundamental question is whether nutrient profile models should favor the beneficial nutrients, stress nutrients to limit, or be based on some combination of both. Table 2 shows examples of each approach. It is probably fair to say that the scores that emphasized beneficial or qualifying nutrients were intended for consumer education, whereas the scores that emphasized nutrients to limit were more concerned with food labeling and the regulation of health claims.

There are two cautions when it comes to nutrient selection. First, the concept of nutrient density should not be overly dependent on nutrients that are low (or high) in the diet of a single country. For example, high-quality protein is not a shortfall nutrient in the American diet, but a nutrient profile model without protein would have limited uses elsewhere. Although the US diet is rich in fats, essential fatty acids can still be a part of a more globally-oriented nutrient profile model. In other words, the choice of reference nutrients needs to acknowledge data on diets and health from countries other than the United States. The Naturally Nutrient Rich Score[1] was created with reference to key nutrients listed by the Food and Agriculture Organization of the United Nations,[45] whereas other scores[15,16] took into account studies on optimizing diet quality in Africa.[46]

Second, there are inherent dangers in defining nutrient density on the basis of policy goals. The FSA model WXYfm was developed to establish rules on broadcast advertising to children[2] with the intent of placing advertising restrictions on foods that were high in fat, saturated fat, sugar, or sodium. The model awarded extra points to foods that contained fruits, vegetables, or nuts.[2] The question is whether a nutrient profile model that is deliberately set up to favor the consumption of desirable food groups is driven by science – or by policy considerations?

SHOULD INDEX NUTRIENTS BE FOOD-GROUP SPECIFIC?

Different food groups make different nutrient contributions to the total diet. The fruit group is a major contributor of vitamin C, whereas the vegetable group is a major contributor of fiber, vitamins A and B_6, potassium, and copper.[47] Grains are major contributors of carbohydrate, thiamin, folate, iron, and magnesium, whereas the meat group provides protein, vitamin B_6, niacin, and zinc. The milk group is a major contributor of riboflavin, vitamin B_{12}, calcium, and phosphorus, whereas fats and oils provide linoleic, alpha-linolenic acids, and vitamin E. In addition, each basic food group is a substantial contributor of many other nutrients.[47]

One important question is whether nutrient profiling should be across-the-board or food-group specific. In other words, should the calculations of nutrient density be based on different nutrients for each food group? One concern, voiced by the food industry, has been that some across-the-board scores, particularly those based on negative nutrients,[24] may lead to whole categories of foods failing the nutrient profile test. Industry groups as well as some regulatory agencies are therefore said to prefer nutrient profile models that apply different criteria to different groups or categories of foods.[7,8] According to the French Nutrition Institute,[8] the category-by-category approach was favored by the April 2006 workshop of the European branch of the International Life Sciences Institute[7] and may be adopted by the French regulatory agency AFSSA.

However, nutrient profiles that are food-group specific beg the question of what exactly constitutes a food group. The assignment of foods into categories is culture dependent and can vary widely across countries. As of now, the Dutch use 14 food categories, the Swedes and the Danes have 26, and the Eurofoods system uses 33 food groups.[8] Our recent study in France used 7 major and 25 minor food groups.[16] Harmonizing cultural differences, defining food groups, and selecting appropriate nutrient profiles for each food category or food group are among priority topics for further research.

Several models listed in Table 2 use across-the-board scores that make for easy comparisons both within and across food groups. The calories for nutrient; the naturally nutrient rich (NNR), and the RRR scores are across-the-board scores. The FSA model WXYfm[2] is a mixture of both approaches: though nutrient based, it did take fruits, vegetables, and nuts into account. The recent two scores created by Maillot et al.[16] can be adapted to consider the importance of the food group in the population's diet—as specified in Article 4 of the European Commission's proposal. The Unilever score used different sugar and sodium benchmarks for different food groups and can be considered to be food-category specific.[17]

HOW TO SELECT THE BASIS FOR CALCULATIONS

Nutrient density of foods was initially defined as the ratio of the food's nutrient content and its energy level[37]. Hansen's Nutritional Quality Index (NQI) was calculated as the ratio of the percent recommended dietary allowances (RDA) to calories contained in the same amount of food.[37] Nutrient density calculations can be based on 100 kcal, 100 g, or on some government-mandated serving size of a given food.[1] All three methods were mentioned by the European Commission.[7,8] However, no uniform, government-mandated standards for serving size exist in the European Union at this time. As a result, model profiles developed in the European Union are typically based on 100 g or 100 kcal of food. In the United States, definitions for reference amounts customarily consumed (RACC values) for each food are provided by the FDA and can be used to calculate nutrient profiles. However, given that the existing RACC values are based on older food intake data, it is reasonable to expect that these values will be updated at some time in the future.[48]

Hansen et al.[37,49] insisted early on that valid comparisons could only be made on a standard per-calorie basis. The resulting nutrient density ratio would then be independent of serving size, an important consideration when the serving sizes are nonexistent or unclear.[1] Darmon et al.[15] made a useful distinction between nutrient adequacy scores and nutrient density scores. Nutrient adequacy scores were calculated based on a standard weight (100 g) of food, whereas nutrient density scores were based on 100 kcal of food. Dividing the nutrient adequacy score by the energy density of the food yielded a measure of nutrient density.[15,16]

Models based on 100 g food weight may penalize "unhealthy" foods that are generally consumed in small amounts and may need special volume adjustment for beverages. Furthermore, consumers may react more favorably to nutrition information that does take into account the regular serving size. For this reason, tests of nutrient profile models ought to compare results obtained when the scores are calculated per 100 kcal, 100 g, or per RACC.

HOW TO SELECT REFERENCE DAILY VALUES

The FDA has established RDIs for a number of vitamins and minerals that are essential in human nutrition.[50] Summarized in Table 3, these values are largely based on dietary reference intakes published by the Institute of Medicine.[51,52] The FDA has also developed a set of reference daily values for macronutrients, again for labeling purposes.

Whereas norms exist for most vitamins and minerals, there are no established values for either dietary sugars or fats. The values listed in Table 3 for linoleic and

Table 3 **Daily values used in calculation of nutrient profiles.**

Nutrient or food component	Daily values based on 2000 kcal/d
Protein	50 g
Fiber	25 g
Linoleic acid	9 g
Linolenic acid	1.8 g
DHA	0.11 g
Vitamin A	5,000 international units
Vitamin C	60 mg
Vitamin D	400 international units (10 μg)
Vitamin E	30 international units (20 mg)
Vitamin K	80 μg
Thiamin	1.5 mg
Riboflavin	1.7 mg
Niacin	20 mg
Vitamin B_6	2.0 mg
Vitamin B_{12}	6 μg
Folate	400 μg
Pantothenic acid	10 mg
Calcium	1,000 mg
Iron	18 mg
Magnesium	400 mg
Zinc	15 mg
Phosphorus	1,000 mg
Selenium	70 μg
Copper	2.0 mg
Potassium	3,500 mg
Iodine	150 μg
Fat	65 g
Saturated fat	20 g (10% energy of 2000 kcal diet)
Monounsaturated fat	20 g (10% energy of 2000 kcal diet)
Cholesterol	300 mg
Sugar, total	125 g/50 g*
Sugar, added	50 g (10% energy of 2000 kcal diet)
Sodium	2,400 mg

* 125 g from IOM report; 50 g from WHO report.

linolenic acids and for docosahexaenoic acid, which were used to construct the nutrient density score (NDS) for 23 nutrients, NDS23,[16] were therefore based on French dietary recommendations. Values for undesirable nutrients were based on maximum recommended values or MRVs. The value for monounsaturated fats was based on approximately 10% of dietary intake calculated based on 2,000 kcal diet. The value for added sugars was based on approximately 10% of a 2000 kcal/d diet, or 50 g/d. The value for sodium was 2,400 mg/d.

Judging from past studies, there has been some flexibility in how those norms were applied to nutrient profiling. The use of cutoff points and other benchmarks has not always been uniform. Gazibarich and Ricci[53] took the highest value of the RDI range for sodium, the midpoint of the range for niacin, and the lowest values for iron and potassium—all for the population group with the highest RDI. The Unilever score applied different benchmarks for sugar and sodium depending on food group because of food technology constraints and optimal hedonic values.[17]

Our preferred approach is to link reference amounts to those used in food labels. If the purpose of nutrient profiling is to help consumers select healthier foods, then communications of recommended levels of nutrients must follow a recognized standard.

HOW TO DEVELOP NUTRIENT PROFILE MODELS

The construction of a profiling algorithm can be approached in a number of ways—the simplest is to select only the nutrients found on the food label and build the score strictly according to the FDA criteria.

For example, foods that are good sources of a particular nutrient (10–20% DV) would get one point per nutrient, whereas foods that are excellent sources (>20% DV) would get two points per nutrient. The number of positive nutrients can be arbitrarily capped at two or three. Points may also be taken away if the food contains excessive amounts of nutrients to limit. Alternatively, foods containing excessive amounts of even a single nutrient to limit would be assigned into the bottom category. The summary score, split into tertiles, would then be used as the basis for ranking foods by their nutrient content. However, that would be an obvious and trivial application of existing FDA regulations and not a particularly interesting score.

Some examples of nutrient profile algorithms, past and present, are summarized in Table 4. Hansen's Nutritional Quality Index[37] was an early profiling method, calculated as a nutrient-to-energy ratio. Initially named the index of food quality in 1973,[54,55] it was later renamed an index of nutritional quality (INQ),[56] and finally the nutritional quality index (NQI).[37] The NQI can also be expressed as the ratio between the amount of a nutrient in a portion that meets energy needs (i.e. 2,000 kcal) and the recommended allowance for that nutrient (US RDA), also based on 2,000 kcal. The NQI was a nutrient-by-nutrient profile, based on 18 nutrients, but it was not a composite index of nutrient quality of food.[1]

The calories for nutrient score was an early composite measure.[55] Initially developed using nine nutrients, it was later expanded to 13. To compute the calories for nutrient score, percent DVs for each nutrient were calculated based on 100 g of food. The average percent DV was calculated by summing all the 13 DVs, and dividing by 13. The energy density of the food (ED = kcal/g) was then divided by the mean percent DV.[57]

The Australian Nutritious Food Index[53] was based on both desirable and less desirable food components. It was calculated as the mean ratio of the amounts present in a portion of food relative to the recommended intakes. This was a weighted score, with greater weights given to nutrients of public health significance. The maximum percent DV of the desirable nutrients was capped at 100%; no cap was applied to the less desirable nutrients.[53]

The Ratio of Recommended to Restricted (RRR) food components was computed by dividing mean percent DVs for six positive nutrients by mean %DV for four negative nutrients and energy.[58] This too was a ratio score, and one that was based only on those nutrients present on the food label.

The Naturally Nutrient Rich score,[1,6] was an unweighted mean of percent DVs for 15 positive nutrients, including fiber. Although the score did not directly consider the foods' content of fat, sugar, or salt, the fact that it calculated per calorie meant that the more energy-dense foods with a high sugar and fat content received lower scores. The calculations capped percent DVs, so that the contribution of any single nutrient would not contribute disproportionately to the total score.

The French nutrient adequacy and nutrient density profiles[15,16] were based on unweighted arithmetic means of percentage RDAs for a variable number of qualifying nutrients. The authors first calculated nutrient adequacy scores based on the French recommended daily values for adults, based on a 2,000 kcal/day diet. Only the nutrients naturally present in foods were used for calculating score values. The SAIN16 and SAIN23 scores were based on 16 and 23 nutrients, respectively, and on 100 g of food. The NDS16 and NDS23 scores were arrived at by dividing SAIN scores by the energy density of food. In this way the NDSs were unweighted arithmetic means of percent DVs for a variable number of qualifying nutrients.[15] Whereas the SAIN scores were based on 100 g, the NDSs were based on 100 kcal.[16]

The LIM model[16] was based on three disqualifying nutrients, calculated for 100 g food to avoid bias against energy-dense foods. Reference amounts were based on

Table 4 **Summary of algorithms for selected nutrient profiling methods.**

Score and reference	Algorithm	Amount	Comment
Nutritional Quality Index (NQI)[37]	$NQI = (N/RDA_n)/(kcal/1{,}000)$	1,000 kcal	Calculated separately for each nutrient (N), so not a total score.
Calories for Nutrient (CFN)[57]	$CFN = ED/\Sigma_{1-3}(\%DV)/13$	100 g	A caloric penalty approach. Energy density (ED) divided by mean of percent DVs for 13 nutrients, based on 100 g of food.
Nutritious Food Index (NFI)[53]	$NFI = \Sigma(wDFC/RDI + wLDFC/RDI)$	Serving	Sum of weighted (w) desirable (DFC) and less desirable (LDFC) food components; each divided by RDI.
Ratio of recommended to restricted (RRR)[58]	$RRR = \Sigma(Nutrient_{recommended}/6)/\Sigma(Nutrient_{restricted}/5)$	Serving	A ratio score based on nutrients listed on the food label
Naturally Nutrient Rich, (NNR)[1,6]	$NNR = \Sigma_{1-15}((Nutrient/DV) \times 100)/15$	2,000 kcal	Unweighted arithmetic mean of % DVs for 15 nutrients. DVs based on 2000 kcal and capped at 2000%DV.
Nutrient Adequacy Ratio (NAR) SAIN16,[15] SAIN23[16]	$NAR_n = \Sigma_{1-n}((Nutrient/DV) \times 100)/n$	100 g	NAR based on nutrients (n) and 100 g of food.
Nutrient Density Score, NDS16,[15] NDS23[16]	$NDS_n = (NAR_n/ED) \times 100$	100 kcal	NDS calculated by dividing NAR by energy density (ED)
Limited nutrients score (LIM)[16]	$LIM = \Sigma_{1-3}((Nutrient/MRV)/3 \times 100/Q$	100 g	Based on maximum recommended values (MRV) for 3 negative nutrients and 100 g
Nutrient Rich Food, NRFn[15]	$NRFn = (\Sigma_{1-n}((Nutrient/DV) \times 100)/n)/ED$	100 kcal	Unweighted arithmetic mean of %DVs for n nutrients.
Nutrient for Calorie (NFC)[1,6]	$NFC = \Sigma_{1-11}(\%DV)/11 - \Sigma_{1-3}(\%DV)/3$		Sum of 11 positive nutrients minus sum of 3 negative nutrients
Nutrient Rich Food NRFn.3	$NRFn$—LIM	RACC	Calculated by subtracting LIM from NRFn. Calculations based on RACC
FSA-SSCf3d[14] and WXYfm[2]	Point system: see references		Total score = C (negative nutrients)—A (positive nutrients) unless C>11. Complex score for nut, vegetable and fruit content.

maximum recommended values (MRVs) for the nutrients to limit in the French population, i.e., 10% of energy intake each for added sugar and saturated fat, and 6 g/day of salt. Based on a 2,000 kcal/day diet, these amounts convert to 20 g saturated fat and 50 g of added sugar.

The Unilever score,[17] which was used to evaluate the entire Unilever portfolio of beverages and foods, was based on the following four disqualifying nutrients: saturated fat, trans-fat, sugar, and sodium. Each of the four nutrients was split into three categories according to rather complex international criteria and domestic dietary recommendations for the Netherlands. The nutrient content benchmarks for sugar and sodium were adjusted by product category because of sensory, technological, or manufacturing considerations. Most of the company products were scored using generic benchmarks, whereas the rest were scored using category-specific benchmarks.

The British FSA nutrient profile model WXYfm was based on four disqualifying and three qualifying nutrients, also calculated per 100 g. The food content of fruits, vegetables, and nuts was derived using another complex formula. The sum of desirable components was subtracted from the sum of undesirable components to yield the final score, unless the sum of the undesirable components exceeded 11, in which case it remained the final score.[2] The final score had reverse polarity, with numbers below zero denoting the more nutritious foods. Conversely, the sum of negative nutrients actually added to a large positive, but undesirable, score. A food was classified as less healthy if it scored four points or more; a drink was so classified if it

scored one point or more. Healthier foods and healthy drinks had to have a score of 0 points or less.

The nutrient-rich food (NRF) scores, also based on the beneficial nutrients and the nutrients to limit, have two components. The nutrient density component is based on a variable number of beneficial nutrients. The limiting nutrients (LIM) component is based on three nutrients only: saturated fat, added sugar, and sodium. The simplest algorithm subtracts the three-item LIM score from the nutrient density component to yield the Nutrient Rich Food (NRFn.3) score, where n stands for the number of beneficial nutrients selected. NRF scores were calculated per 100 g, per 100 kcal, or per RACC.[16]

In summary, existing models and scores already illustrate a variety of approaches. They use positive or negative nutrients or some combination of both; they are based on different reference amounts, and they employ across-the-board and category-specific benchmarks. Most are continuous scores, providing a measure of discrimination among different foods.

HOW TO APPROACH THE PROFILING ALGORITHM

There are a number of technical issues that need to be addressed when creating the profile algorithm. These may include, but are not limited to, colinearity, weighting, and capping.

Some nutrients are highly correlated with each other. For example, energy and fat content of foods tend to be correlated, as are saturated fat and cholesterol. A score that includes energy, total fat, saturated fat, trans-fat, and cholesterol is a score that discriminates among foods based purely on their fat content. Similarly, a score that emphasizes fat and sugar may turn out to be no more than a transform of energy density, with nutrient content of foods playing a relatively minor role. On the other hand, a score based on a large number of vitamins, minerals, trace elements, and other micronutrients may have little discriminating power, especially if all nutrients are treated as equally important and all scores tend towards the mean. Selecting the optimal number of nutrients, based on some objective criteria, is one priority for future research.

Most of the scores cited in Table 3 were unweighted scores, whereby each nutrient was assigned the same importance. However, there are instances in the literature of weighted nutrient density scores, where some key nutrients were assigned higher weights.[53,59] Weighting can be based on the biological quality of nutrients in the food source, their bioavailability, and the distribution of the nutrients in the food supply. For example, animal proteins are generally of higher quality than plant proteins. Calcium in milk is more bioavailable than calcium in spinach, whereas heme iron in meat is more bioavailable

than the iron in plant-based products.[60] Similarly, whereas some nutrients are widely distributed, others are restricted to a limited number of food sources or are found in sufficient quantities in a small number of foods. For example, vitamin C is limited to vegetables and fruit and relatively few foods contain vitamin E and vitamin B$_{12}$. A weighting system that favors non-ubiquitous nutrients could be based on the distribution and the relative rarity of the nutrients in the food supply.

Certain foods are excellent sources of a single nutrient, present in large amounts, but do not contain a broad range of key nutrients. One solution to this problem is to cap percent DVs at some arbitrary limit (e.g. 100%DV) before calculating the final score.[1,27] In this way, the contribution of any one nutrient does not contribute unduly to the overall nutrient profile.

The polarity of the score is another consideration. The calories for nutrient[57] and the FSA-WXYfm[2] models both employ reverse-polarity scores with lower scores denoting healthier foods. This approach will need to be tested with consumer groups. Finally, the score can be a continuous measure, normalized to a 10- or 100-point scale, or foods can be assigned into categories, based on fixed scores or on n-tile splits of the food supply. These practical issues represent another area of future research.

HOW TO VALIDATE A NUTRIENT PROFILE

Ranking foods by their nutrient content is supposed to be a science and not an exercise in consensus building. Nutrient profile models therefore need to be validated against some objective measure of diet quality. In the continuing absence of such measures, many past studies have correlated different scores with each other, or compared the generated food rankings against expert opinion. The main criterion for such comparisons was whether the list of foods looked "right" to the expert eye.

In the United Kingdom, over 700 nutrition professionals were asked to rate an arbitrary list of 120 foods for perceived nutritional value, using a six-point category scale.[61,62] Their responses were then correlated with nutrient density scores for the same 120 foods, obtained using a variety of profiling methods. In France, 12 nutrition experts rated an arbitrary list of 125 foods from most healthy to least healthy, using five-point category scales.[63] The expert panel, which included 10 nutrition scientists and two dietitians, was not provided with extensive nutrition information. The panel's opinions reflected not only knowledge and expertise, but also personal and cultural points of view.[63]

Such exercises are not to be confused with a true validation of nutrient profile models. Efforts at developing acceptable techniques have identified a number of options. Early reports suggested that one approach for

validating nutrient profiles may be based on identifying healthy diets and then looking for correlations with indicator foods.[7,8] Another possibility would be to go further and look for correlations between the consumption of index foods and selected health outcomes. More sophisticated validation methods need to be developed, in which a "goodness of fit" test can help discriminate between one nutrient profile model and another.

It may be necessary to link nutrient profiles of individual to global measures of diet quality such as the Healthy Eating Index.[64,65] Previous studies have linked the consumption of specific foods to diet quality measure[66,67] and similar techniques could be adapted to nutrient profiling. Other studies examined link glycemic load and healthful eating habits.[68] The key issue is to be able to link a food-based scoring system with objective and independent measures of a healthy diet. A model that calculates goodness of fit might then become the standard for comparing one nutrient profile model against another. Developing validation techniques is an essential component of nutrient profiling and ought to be the highest research priority.

HOW NUTRIENT PROFILE MODELS BEHAVE

It is instructive to track how different nutrient profile models behave when applied to different foods that are broadly representative of the population diet. We compared the performance of different models when applied to the same list of 378 caloric foods and beverages. This list was far from arbitrary. The 378 foods and beverages were the component foods of the food frequency questionnaire, which was developed by the Fred Hutchinson Cancer Research Center[69] and used in numerous epidemiologic studies on diets and health. Foods are selected for inclusion in such instruments if they meet three sets of criteria. First, the food must be frequently consumed by large numbers of people; second, it needs to contain nutrients of interest, and third, consumption of the food needs to vary from person to person, such that it is most predictive of a healthier diet.[70] The present list excluded diet beverages and tap water, but included fortified cereals and formula diet products.

The 378 foods were then coded into 74 different food categories, following USDA food codes. The categories ranged from 1 to 30 foods, with cooked vegetables ($n = 30$) and fresh fruit ($n = 25$) being the most numerous. This approach provided for greater stability of data, yet the number of food groups was sufficiently large to permit discrimination among the different items.

The nutrient profile models illustrated here were the Nutrient Rich models NRF5 and NRF15; the LIM model, and the FSA WXYfm model (adapted). The NRF5 model was the simplest nutrient-to-calories ratio, based on only five positive nutrients: protein, fiber, vitamin C, calcium, and iron, analogous to the French NDS5 score.[16] The NRF15 model was based on a larger number of beneficial nutrients. The LIM score was based on saturated fat, added sugar, and sodium calculated per 100 g of food.[16] The FSA model WXYfm[2] was based on a combination of beneficial nutrients, energy and the nutrients to limit.

Figure 1 shows the relation between food scores based on the NRF5 model profiles and energy density of foods. NRF5 scores are plotted on a logarithmic scale. First, there was an obvious inverse relationship between energy density and nutrient density of foods, which had
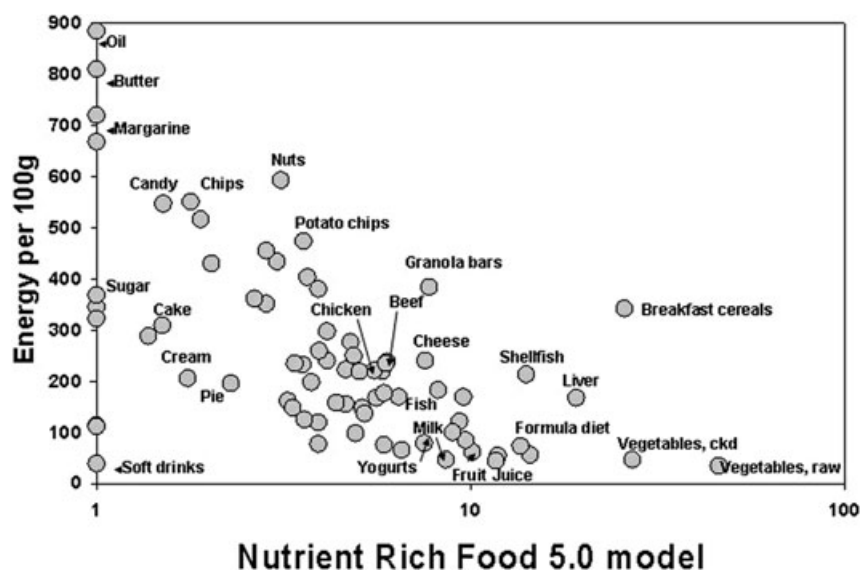
Figure 1 Relation between the Nutrient Rich Food NRF5 model and energy density of foods (kcal/100 g). NRF5 scores plotted on a logarithmic scale.

also been observed with the NNR and NDS23 models.[1,15,16] However, the NRF5 model was not completely dependent on energy density—both energy-dense oils and energy-dilute sweetened beverages scored low. Since the model was based on beneficial nutrients, there was good discrimination at the top end of the scale. As might be expected, vegetables, fruit, juices, milk, yogurt, cheese, beef, and chicken were all awarded relatively high scores. Fortified breakfast cereals, liquid formula diets, and granola bars also scored high, reflecting their high nutrient-to-energy ratios.

The other NRF models in the same family have provided similar results, as previously reported in other studies.[1,15,16] As more nutrients were added to the model, the relation with energy density weakened. Ongoing studies have tested a family of Nutrient Rich models with respect to energy density and energy cost. One example of how such models behave is provided in Figure 2. The Nutrient Rich Foods model NRF15 was calculated as the arithmetic mean of percent daily values for 15 beneficial nutrients. Figure 2 shows the relation between NRF15 scores, plotted along a logarithmic scale and energy density of foods.

Because of their high water content, lean meats and low-fat dairy products are foods with relatively low energy density. The various NRF scores accurately ranked milk products according to their fat content.[1] Skim and low-fat milk scored higher than whole milk, whereas plain yogurt had a higher score than did frozen yogurt or ice cream.[1] In the meat category, lean cuts of beef and lean ground beef scored higher than regular ground beef, which in turn scored higher than fried chicken.[1]

Figure 3 shows the relation between the LIM score, based on saturated fat, added sugar, and sodium and the energy density of foods. The LIM score discriminated foods that contained sugar and saturated fat from those that did not.

Figure 4 shows the relation between the adapted FSA WXYfm model and energy density of foods. The adaptation involved simplifying the complex methods used to calculate the percent of fruits or vegetables in ketchup, fruit pies, soups, or mixed dishes with beans. However, the number of foods so affected was limited and the modification should not have affected the observed relations among food groups. The healthiest foods were beans, vegetables, fruit, and potatoes, including mashed and fried as a consequence of focusing on protein and fiber.

The FSA WXYfm model showed a high correlation with energy density. Given that the model profile was largely based on energy, saturated fat, and sugar, this was not surprising. One consequence was that low-energy-density soft drinks got more favorable scores than did beef or shellfish. Similarly, the saturated fat criterion meant that cheese got lower scores than either popcorn or nachos. The score performed as designed, providing much discrimination at the top end among candy, cookies, cake, and snacks. Grains, in particular, tended to score poorly and nutrients in fortified cereals were not taken into account. The model tended to penalize those foods that were dry.[71]

As a result, there was a high degree of correlation between the FSA WXYfm model and the LIM score. This relation is summarized in Figure 5. Rather than reflect the
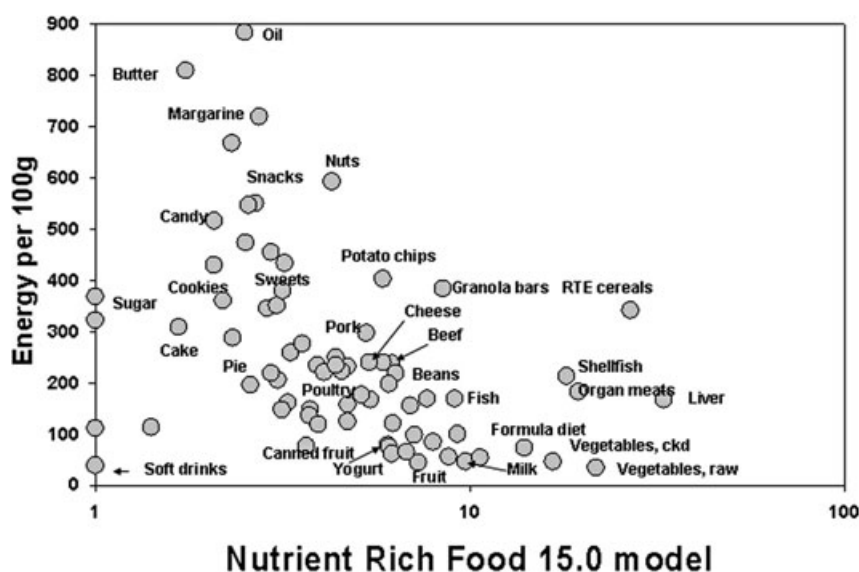
Figure 2 **Relation between the Nutrient Rich Food NRF15 model and energy density of foods (kcal/100 g).** NRF15 scores plotted on a logarithmic scale.
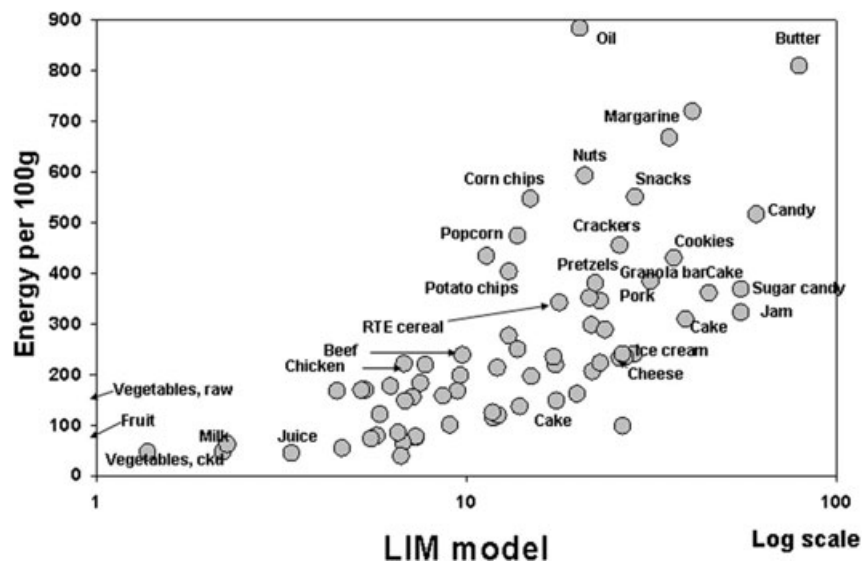
Figure 3 **Relation between the LIM model and energy density of foods (kcal/100 g).** LIM scores plotted on a logarithmic scale.

total nutrient package, the FSA score was heavily linked to the energy density of foods.

HOW TO APPLY NUTRIENT PROFILES IN CONSUMER RESEARCH

The development of nutrient profile models should not proceed independent of consumer research. Nutritional quality of foods is one reason why consumers select healthy diets. However, their choices are also influenced by food costs,[15,16] as well as by taste and eating pleasure.[1,4] If consumers are to use nutrient profiling to make better

food choices, those factors also need to be taken into account.

Some of these considerations may be lost in the single-minded pursuit of optimal nutrition. For example, the Unilever score,[17] developed to evaluate and improve the nutrient quality of beverages and foods, was based on the foods' content of saturated fat, trans fat, sugar, and sodium. As reported, foods meeting global dietary recommendations were skim milk, apple, boiled potato, diet soft drink, and leaf tea, making for a nutritionally sound but joyless diet. Boiled egg and clear vegetable soup were in the gray area, whereas full-fat milk, cream of asparagus
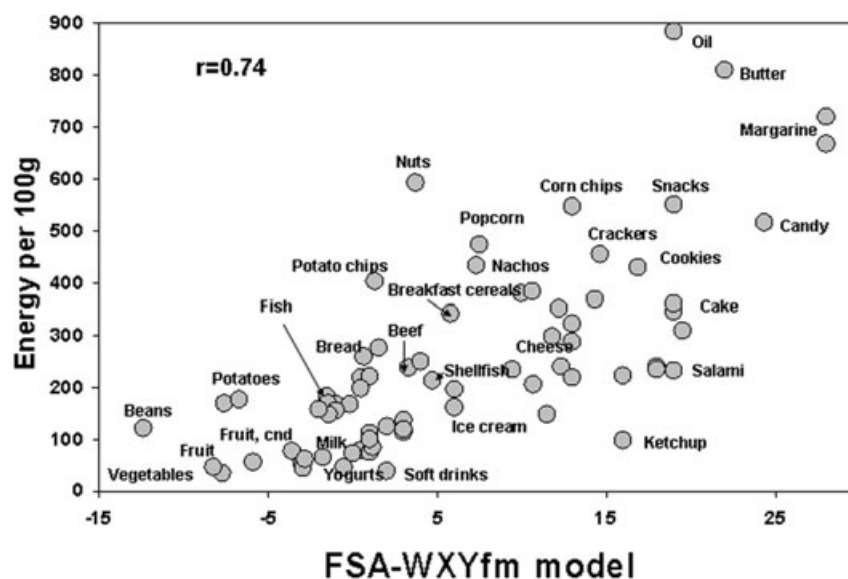

Figure 4 **Relation between the FSA WXYfm model and energy density of foods (kcal/100 g).**
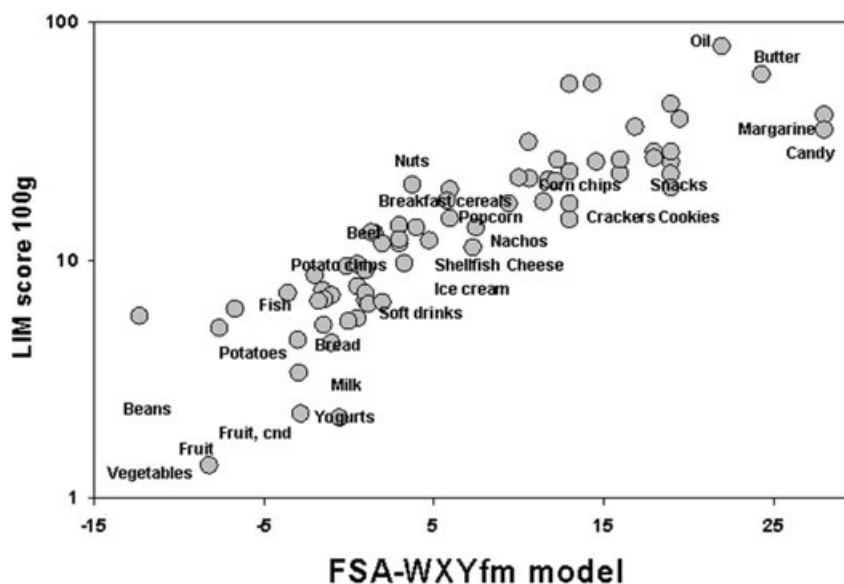
Figure 5 **Relation between the FSA WXYfm model and the LIM model.** LIM scores plotted on a logarithmic scale.

soup, brown bread, beef stew, ravioli, and ice cream failed to meet any recommendations at all.

The Institute of Medicine's report on nutrition standards in schools[42] listed whole fruit, raisins, carrot sticks, whole-grain, low-sugar cereals, some multigrain tortilla chips, some granola bars, and nonfat yogurt among tier 1 foods. Lunch entrée items that met the criteria were a turkey sandwich and a fruit salad with yogurt, accompanied by plain water, skim or 1 percent milk, soy beverages, and 100 percent fruit or vegetable juice, the latter not to exceed a 4-oz serving.[42] Among tier 2 items were single servings of baked potato chips, low-sodium whole-wheat crackers, graham crackers, pretzels, caffeine-free diet soda, and seltzer water. Taste and enjoyment were clearly not a major consideration. It should not come as a surprise if there is opposition to those measures from both children and their parents.

The feasibility of the nutrient density approach needs to be tested. One criterion is whether consumers exposed to this new information will alter eating behaviors and improve diet quality. This will require a pilot effort at communication and some interventions at point of sale. The development and validation of nutrition education materials under the USDA MyPyramid Nutrition Education and Promotion Agreement is under way.

Another question is whether this approach is economically sound. Foods that are low in energy density and nutrient-dense may be more costly per calorie.[15,20] However, many such foods have a very favorable nutrient-to-price ratio, delivering optimum nutrients per calorie at an affordable cost.[15] Future studies should examine how the concept of nutrient density fits in with the structure of food prices and diet costs.

CONCLUSIONS AND RECOMMENDATIONS

Nutrient profiling can have multiple applications. Assigning foods into categories based on their nutrient composition will permit consumers to identify and select nutrient-dense foods, while permitting some flexibility where discretionary calories are concerned.[1,4] The nutrient density approach has further implications for nutritional policy making, nutrition labels, health claims, and marketing and advertising to children. Nutrient profiling can also be used to monitor and improve the nutrient-to-calorie ratio in the food portfolio of major companies.[17]

The European Commission's proposal to establish nutrient profiles as the basis for regulating nutrition and health claims[7,8] has led to enormous international interest in this area. The EU initiative will require rapid development of a food profiling system to determine which foods will qualify for or be disqualified from making a nutrition or health claim. There is no time to lose, since the European Food Safety Authority is expected to make a decision by 9 January 2009. The present recommendation is for the EFSA to favor simplicity, transparency, and good science.

Specific recommendations are as follows. 1) The index nutrients need to be relevant to dietary needs and, preferably, limited in number. Good nutrient composition databases will be indispensable for this research. 2) The reference daily values ought to be based on an authoritative source and linked to food labeling. 3) The algorithm ought to be both simple and transparent. Public health has no need for profiling models that are patented or proprietary. 4) The chosen models must be validated against independent measures of a healthy diet

and, ideally, against health outcomes. 5) The models chosen need to be weighed against food cost and food enjoyment. Finally, consumer research is an integral part of this process. As noted by Buss,[72] the ultimate test is whether nutrient profile models will communicate nutrition information in a way that is both useful and valuable to the consumer.

Acknowledgments

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