The Nutrient Rich Foods Index NRF9.3: The science behind nutrient density scores

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What is nutrient profiling?

Nutrient profiling is the science of ranking or classifying foods based on their nutrient composition*

Each food is assigned a unitary score that best reflects its nutrient quality

*Defined by the UK Food Standards Agency, FSA
Applications of nutrient profiling

- **Protect public health**
  Help consumers get more nutrients from the calories they consume and so promote healthier diets

- **Promote regulation**
  Provide a uniform benchmark for mandated or self-regulation by industry
  - Develop front of pack labels
  - Develop shelf labels
  - Harmonize health and nutrition claims

- **Promote innovation**
  Encourage the production and selling of more nutrient-rich foods

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Food labeling or food *guidance*?

Nutrient Rich Foods Index is a science-based, consumer-driven, guidance system
Provide “nutrition at a glance”

The Nutrition Facts Panel stresses nutrients to avoid…

…rather than the total nutrient package

It may be too complex anyway.
For effective nutrition labeling follow these steps

The Nutrient Rich Foods Index

The beginning....

Concept of a nutritious food: toward a nutrient density score1-3

Adam Drewnowski

ABSTRACT
This presentation introduces the increasingly popular nutrient density concept, a powerful tool for promoting the nation’s nutrition goals. The 2005 Dietary Guidelines for Americans recommended that consumers replace less nutritious foods in their diets with more nutrient dense options. Such dietary guidance presupposes the existence of a nutrient density standard. However, a review of the literature shows that the concept of a nutritious food is based on many different methodologies and criteria. In many cases, nutritious foods are defined by the absence of problems, while the focus is on the density of nutrients. As such, sugar, and unhealthy foods, which by the process of selection for nutrients are high in quality, are often defined as nutritious. To date, there is no consensus on the criteria used to determine the density of foods in food groups. This workshop is designed to bring together experts in nutrition and food science to discuss the need and purpose of a nutrient density index that could be used to define the density of foods and to develop a nutritional density index.
The vision:
The Nutrient Rich Foods approach makes it easy for people to build and enjoy healthier diets by getting the most nutrition from their calories.
Nutrient profiling criteria must be:

Objective
- Based on accepted nutrition science and labeling practices

Simple
- Based on published daily values and meaningful amounts of food

Balanced
- Based on nutrients to encourage and on nutrients to limit

Validated
- Against measures of a healthful diet

Transparent
- Based on published algorithms and open-source data

Consumer-driven
- Likely to guide better food choices and more healthful diets

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Select nutrients to encourage

Use simple and objective criteria

- The 2005 Dietary Guidelines seven
  - Fiber, vitamins A, C, E, Ca, K, Mg
- The Food and Drug Administration six
  - FDA defines “healthy” foods as those that contain ≥10% DV of protein, fiber, vitamins A, C, Ca, or Fe
- Additional nutrients for special population needs
  - Zn, Fe, folate, vitamins D, B₁₂
Select nutrients to encourage

<table>
<thead>
<tr>
<th>Nutrient profile model</th>
<th>Macronutrients</th>
<th>Vitamins</th>
<th>Minerals</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR5</td>
<td>Protein, fiber</td>
<td>Vit C</td>
<td>Ca, Fe</td>
<td>AFSSA 2008</td>
</tr>
<tr>
<td>NR6</td>
<td>Protein, fiber</td>
<td>Vit A, C</td>
<td>Ca, Fe</td>
<td>Drewnowski et al 2008</td>
</tr>
<tr>
<td>NR9</td>
<td>Protein, fiber</td>
<td>Vit A, C, E</td>
<td>Ca, Fe, Mg, K</td>
<td>Drewnowski et al 2008</td>
</tr>
<tr>
<td>NR9z</td>
<td>Protein, fiber</td>
<td>Vit A, C, E</td>
<td>Ca, Fe, Zn, K</td>
<td>Drewnowski et al 2008</td>
</tr>
<tr>
<td>NR11</td>
<td>Protein, fiber</td>
<td>Vit A, C, E, B12</td>
<td>Ca, Fe, Zn, Mg, K</td>
<td>Drewnowski et al 2008</td>
</tr>
<tr>
<td>NR12</td>
<td>Protein, fiber</td>
<td>Vit A, C, E, thiamin, riboflavin, B12</td>
<td>Ca, Fe, Zn, K</td>
<td>Drewnowski et al 2008</td>
</tr>
<tr>
<td>NR14</td>
<td>Protein, fiber</td>
<td>Vit C, D, E, thiamin, riboflavin, B12, folate</td>
<td>Ca, Fe, Zn, K</td>
<td>Drewnowski et al 2008</td>
</tr>
<tr>
<td>NNR15</td>
<td>Protein, fiber, MUFA</td>
<td>Vit C, D, E, thiamin, riboflavin, B12, folate</td>
<td>Ca, Fe, Zn, K</td>
<td>Drewnowski 2009</td>
</tr>
<tr>
<td>NDS16 afssa</td>
<td>Protein, fiber, linolenic, DHA</td>
<td>Vit C, D, E, thiamin, riboflavin, B12, folate</td>
<td>Ca, Fe, Zn, Mg, K</td>
<td>Darmon et al 2006</td>
</tr>
<tr>
<td>NDS23</td>
<td>Protein, fiber, linoleic, linolenic, DHA</td>
<td>Vit A, C, D, E, thiamin, riboflavin, B6, B12, niacin, folate</td>
<td>Ca, Fe, Zn, Mg, Cu, Se, K, I, (Ph)</td>
<td>Millot et al 2007</td>
</tr>
</tbody>
</table>

Select nutrients to limit

Use simple and objective criteria

- The 2005 Dietary Guidelines six
  - Total fat, saturated fat, trans-fat, cholesterol, added sugar, sodium
- The Food and Drug Administration four
  - Foods are disqualified from health claims if they contain too much fat, saturated fat, cholesterol, or sodium
- The European Union four
  - EC lists total fat, saturated fat, trans fat, sugar and sodium
- The AFSSA three
  - Saturated fat, added sugar, sodium
Select reference daily values

Use published reference amounts

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Reference DV</th>
<th>Nutrient</th>
<th>Maximum RV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>50 g</td>
<td>Total fat</td>
<td>65 g</td>
</tr>
<tr>
<td>Fiber</td>
<td>25 g</td>
<td>Saturated fat</td>
<td>20 g</td>
</tr>
<tr>
<td>Vit A</td>
<td>5000 IU</td>
<td>Total sugars</td>
<td>125 g</td>
</tr>
<tr>
<td>Vit C</td>
<td>60 mg</td>
<td>Added sugars</td>
<td>50 g</td>
</tr>
<tr>
<td>Vit E</td>
<td>30 IU</td>
<td>Sodium</td>
<td>2,400</td>
</tr>
<tr>
<td>Calcium</td>
<td>1,000 mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>18 mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>3,500 mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>400 mg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Select the basis for calculation

Use science to decide among alternative options

- **100 grams**
  - Food labels in the EU are based on 100g amounts – so are some EU-based nutrient profiles (e.g. UK FSA)
- **100 kcal**
  - Better reflects the nutrient-to-calorie ratio – but will consumers relate?
- **Government-mandated serving size**
  - Food labels in the US are based on Reference Amounts Customarily Consumed (RACC)
RACC values and energy density are inversely linked

Best basis for NRF = 100 kcal

- Aligns closely with current Dietary Guidelines recommendations
- Correlates better with the Healthy Eating Index
- Is an accepted unit/base for defining nutrient density
- Is a standard measure for comparison for all foods
- Applies to the food packaging/labeling system both nationally and internationally
The validation process

- A formal process was used to decide among alternative algorithms
- Tested a family of NRF Indices
  - Range of positive nutrients (5-15)
  - With and without nutrients to limit (3-4)
  - Calculated per 100 kcal and per RACC
- Used diet quality measures (e.g., Healthy Eating Index- HEI-2005) and health-related variables
- Used regression analyses with dependent variables:
  - Measure of diet quality (HEI-2005)
  - Selected health outcomes (BMI, blood pressure, lipids)

### Healthy Eating Index - 2005

<table>
<thead>
<tr>
<th>Component</th>
<th>Points</th>
<th>Std. for max. score</th>
<th>Std. for min. score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fruit (includes 100% juice)</td>
<td>5</td>
<td>≥0.8 cup equiv. per 1,000 kcal</td>
<td>No Fruit</td>
</tr>
<tr>
<td>Whole Fruit (not juice)</td>
<td>5</td>
<td>≥0.4 cup equiv. per 1,000 kcal</td>
<td>No Whole Fruit</td>
</tr>
<tr>
<td>Total Vegetables</td>
<td>5</td>
<td>≥1.1 cup equiv. per 1,000 kcal</td>
<td>No vegetables</td>
</tr>
<tr>
<td>Dark Green and Orange Vegetables and Legumes</td>
<td>5</td>
<td>≥0.4 cup equiv. per 1,000 kcal</td>
<td>No Dark Green or Orange Vegetables and Legumes</td>
</tr>
<tr>
<td>Total Grains</td>
<td>5</td>
<td>≥3.0 oz equiv. per 1,000 kcal</td>
<td>No Grains</td>
</tr>
<tr>
<td>Whole Grains</td>
<td>5</td>
<td>≥1.5 oz equiv. per 1,000 kcal</td>
<td>No Whole Grains</td>
</tr>
<tr>
<td>Milk</td>
<td>10</td>
<td>≥1.3 cup equiv. per 1,000 kcal</td>
<td>No Milk</td>
</tr>
<tr>
<td>Meat and Beans</td>
<td>10</td>
<td>≥2.5 oz equiv. per 1,000 kcal</td>
<td>No Meat or Beans</td>
</tr>
<tr>
<td>Oils</td>
<td>10</td>
<td>≥12 grams per 1,000 kcal</td>
<td>No Oil</td>
</tr>
<tr>
<td>Saturated Fat</td>
<td>10</td>
<td>≤7% of energy</td>
<td>≥15% of energy</td>
</tr>
<tr>
<td>Sodium</td>
<td>10</td>
<td>≤0.7 gram per 1,000 kcal</td>
<td>≥2.0 g per 1,000 kcal</td>
</tr>
<tr>
<td>Calories from Solid Fat, Alcohol, and Added Sugar (SoFAAS)</td>
<td>20</td>
<td>≤20% of energy</td>
<td>≥50% of energy</td>
</tr>
</tbody>
</table>
The NRFn.3 indices and HEI

The NRF9.3 algorithm

\[
NRF9.3 = \sum_{i=9} (\%DV/100\text{kcal}) - \sum_{i=3} (\%DV/100\text{kcal})
\]

9 nutrients to encourage
- Protein
- Fiber
- Vitamin A
- Iron
- Calcium
- Vitamin C
- Potassium
- Magnesium
- Vitamin E

3 nutrients to limit
- Saturated Fat
- Added Sugars
- Sodium
NRF9.3 Index components

- Based on 9 nutrients to encourage, 3 nutrients to limit
- Includes nutrients with a DRI (except added sugars)
- Created with open-source, transparent databases
- Based on established, authoritative sources
- Based on 100 kcal basis
- Uses “unweighted” scores
- Based reference amount on FDA’s Daily Value
- Capped nutrient contributions to 100% DV
- Validated against USDA’s Healthy Eating Index
- Is a scientifically valid definition of nutrient density

Regulatory agencies recommend the same science-driven process

- European Food Safety Authority Scheme 2007
Question 1: How does the NRF9.3 index perform?

Use open source USDA data sets

- Nutrient composition data: FNDDS 1.0 USDA 4500 foods
- Nutrient density
- Energy density Kcal/100g
- Energy Cost $/1000 kcal
- Price data: CNPP price database

What are the most nutrient rich foods?
What are the most affordable nutrient rich foods?
Nutrient Density (NR9.3 per 100 kcal) and Energy Density (kcal/100g)

Data from USDA FNDDS 1.0

For Fruits and Vegetables:
- french fries
- dried fruit
- fruit
- vegetables

For Grains:
- cake
- cookies
- oatmeal
- Fortified cereals
Nutrient Density (NR9.3_{100kcal}) and Energy Density (kcal/100g)

Data from USDA FNDDS 1.0

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Nutrient Density (NR9.3_{100kcal}) and Energy Density (kcal/100g)

Data from USDA FNDDS 1.0
Nutrient Density (NR9.3\textsubscript{100\text{cal}}) and Energy Density (kcal/100g)

Data from USDA FNDDS 1.0

Dairy ▲ Meat △ Eggs ○ Beans ◇ Grains □ Fruits ▲ Vegetables ○ Fats ◇ Sugars

Question 2:

What happens when indices are based on nutrients to limit only?
Scores based on what not to eat

Contrast positive and negative approaches

<table>
<thead>
<tr>
<th>Nutrient profile model</th>
<th>Nutrients/Foods to encourage</th>
<th>Nutrients to limit</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIM</td>
<td>Sat fat, added sugar, Na</td>
<td></td>
<td>Mailiot 2007</td>
</tr>
<tr>
<td>Unilever</td>
<td>Sat fat, trans fat, sugar (total + added), Na</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kellogg</td>
<td>Energy, sat fat, trans fat, total sugar, Na (cholesterol)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WXYfm</td>
<td>Protein, fiber, fruit, veg, nuts</td>
<td>Energy, sat fat, total sugar, Na</td>
<td></td>
</tr>
<tr>
<td>Keystone</td>
<td>&gt;10%DV of fiber, Ca, K, Mg, Vits A, C, or E, Fruit, Veg, whole grain, low fat dairy</td>
<td>Total fat, sat fat, trans fat, cholesterol, added sugar, Na</td>
<td>website</td>
</tr>
</tbody>
</table>

A balanced score includes nutrition but need not exclude taste, cost, or convenience

Nutrient Rich Foods 9.3 | Protein, fiber, Vits A, C, E, Ca, Fe, Mg, K | Sat fat, added sugar, Na | Drewnowski 2008


WXYfm model mostly reflects ED

![Energy density (kcal/100g) vs FSA Ofcom Total Score](image)

R² = 0.57
WXYfm plotted against LIM score

![Graph showing the relationship between WXYfm and LIM score for various food items. The graph includes points for different foods such as shellfish, fish, potatoes, corn chips, milk, snacks, cheese, beef, oil, candy, beans, potato chips, breakfast cereals, yogurts, nuts, margarine, butter, fruit, vegetables, fruit, ice cream, bread, cookies, crackers, soft drinks, popcorn, and nachos. The plotted points are scattered across a linear regression line, indicating a positive correlation.]
Question 3:
What do consumers want?

100 point scale – too much information?

Data from USDA FNDDS 1.0
Quintiles show that high scoring foods are high in nutrients and low in calories.

Best Grouping: 5 Categories

- Consumer research identified 5-point scales as a better choice than 10 or 100 categories
- Results in 5 statistically distinct groups
- Is best predictor of Healthy Eating Index scores
- Scoring system based on the nutrient content of foods in the USDA FNDDS and MyPyramid servings databases
Individual Foods

Grains Group

1. Rye
2. Whole Wheat
3. Corn
4. Barley
5. Oats

Vegetables Group

1. Broccoli
2. Carrots
3. Spinach
4. Sweet Potato
5. Sweet Corn

Fruits Group

1. Apple
2. Banana
3. Orange
4. Avocado
5. Mango

Milk Group

1. Skim Milk
2. 1% Milk
3. 2% Milk
4. Whole Milk
5. Dairy Beverages

Meat & Beans Group

1. Chicken
2. Fish
3. Pork
4. Beef
5. Beans

Confidential Information
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Question 3: What about cost?

Energy density (kcal/100g) and energy cost ($/1000 kcal)

Data from USDA FNDDS 1.0 and CNPP prices database

Log scale!
NRF9.3 score and ED by food group
size of circle = calories per dollar

What drives food purchases?

Consumer

Food Behavior

Taste

Cost

Convenience

Health

Access

Cooking skills

Time

Money
The Nutrient Rich Foods Index is:

- **Objective** - based on 2005 Dietary Guidelines; 2005 MyPyramid and other expert panel data
- **Simple** – based on FDA percent Daily Values and FDA serving sizes and on USDA nutrient data sets
- **Balanced** – based on nutrients to encourage and on nutrients to limit
- **Validated** – against 2005 Healthy Eating Index (HEI)
- **Transparent** – algorithms published in peer-review journals
- **Consumer-driven** – research on helping consumers to build healthier diets is in progress