Use Of Key Foods with an Analytical Quality Control Program

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Abstract

Objective: This presentation describes the use of the Key Foods approach to prioritize foods and nutrients for analysis, as well as its use in a quality control (QC) program. Recently released NHANES 2001-02 dietary intake data allowed an update of NDL's Key Foods list, which is used to select and prioritize foods and nutrients for the National Food and Nutrient Analysis Program (NFNAP). One component of NFNAP is a vigorous (QC) program, using locally developed control composites and certified reference materials (CRMs). Comprehensive nutrient analysis of CRMs would make the QC program cost-prohibitive; therefore, NDL employs a prioritization scheme in using CRMs. **Methods and Materials:** The list of Key Foods is developed by combining food composition data from the USDA National Nutrient Database for Standard Reference, Release 16.1 (SR16-1) and food consumption data from the National Health and Nutrition Examination Study (NHANES) 2001-02 datasets. In designing a QC program, we designate certain nutrients for a given food as "critical." These are those nutrients which are found in higher concentrations, or are important from a public health perspective, i.e., calcium in milk, or folate in hamburg/hot dog rolls. **Results:** The updated Key Foods list contains 455 foods: 9 in the 1st quartile, 23 in the 2nd, 65 in the 3rd, and 358 in the 4th quartile. For the most part, foods in the top quartile of this version of the Key Foods list are the same as the last version using NHANES 1999-2000, though the order has shifted. The 1st quartile contains commonly consumed foods, e.g., milk, eggs, orange juice, cheese, margarine, and salt, the latter because of its high usage and sodium content. Whole and 2% milk are in the 1st quartile because they have 7 nutrients in the 1st quartile for individual nutrients—these nutrients would be considered "critical" for the milks (and only sodium for salt). These nutrients would be analyzed in the CRMs, that are included in the sample stream along with the analytical samples.
Significance: The use of the Key Foods list provides NDL a cost-effective method for indicating "critical" nutrients for its QC program, as well as for prioritizing foods and nutrients for analyses.

Methods

Using recipes in the Food and Nutrient Database for Dietary Studies and dietary intake data from NHANES, intake data for foods in the USDA National Nutrient Database for Standard Reference are generated (Figure 1). The nutrients used are those identified by the 2005 Dietary Guidelines Advisory Committee as either "shortfall" nutrients or other nutrients of interest (Table 1). Individual and cumulative % intakes are calculated for each nutrient and the food items are separated into quartiles based on cumulative % intake. For the most part, foods in the top three quartiles for each nutrient are aggregated to develop an overall Key Foods list. The % contribution for each nutrient in the selected food items are used to separate them into quartiles.
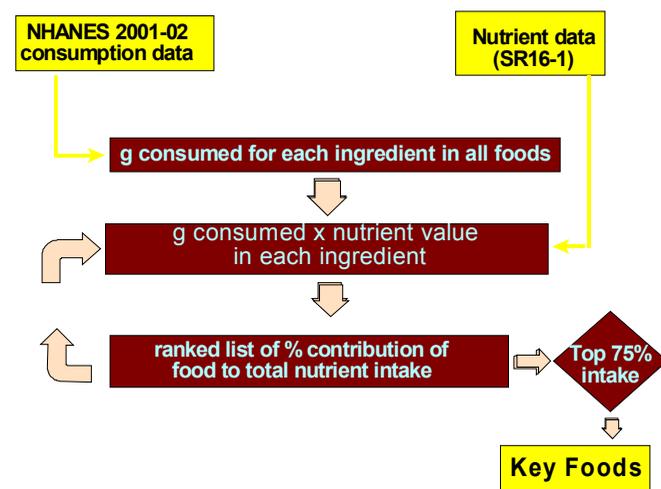
As NFNAP proceeded to analyze the food items in the Key Foods list, matrix-matched quality control materials were identified.

Table 1. List of Nutrients used in determining Key Foods

"Shortfall" nutrients*	Other nutrients of Interest
• Vitamin A	• Fat
• Vitamin C	• Energy
• Vitamin E	• Sugar
• Calcium	• Iron
• Magnesium	• Sodium
• Potassium	• Folate
• Fiber	• Vitamin B12
	• Cholesterol
	• Saturated Fatty Acids
	• Fluoride

*Dietary Guidelines Advisory Committee. 2005. Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2005. U.S. Department of Agriculture, Agricultural Research Service, Beltsville, MD.

Figure 1. Flow Chart for Key Foods Process

Results from the Key Foods Process

The updated Key Foods list contains 455 foods: 9 in the 1st quartile, 23 in the 2nd, 65 in the 3rd, and 358 in the 4th quartile. The top 10 Key Foods are given in Table 2. Some significant findings include:

• Major commodities such as milk (3 types) and eggs lead the list, both because of their high consumption and high levels of various nutrients. In the case of milk key contributors include energy, calcium, and saturated fatty acids. 2% milk replaced whole (3.5%) milk as number one contributor of a variety of nutrients.

• Carrots are among the top 10 Key Foods due to their high carotenoid levels, and salt due to high sodium levels and the ubiquitous use of salt as a flavor enhancer.

• Hamburger rolls have dropped to 10th on the list from 4th and cheese moved to 9th from 7th. Ground beef has fallen out of the top 10.

Table 2. Top 10 Key Foods and 1st Quartile components based on NHANES 2001-02 consumption data and SR16-1

Description	Components in 1st quartile	Rank in 1999-2000 Key Foods List
Milk, 2% fat	Energy, Ca, Mg, K, B12, Saturated FA	2
Egg, whole	Fe, α-tocopherol, Cholesterol	3
Milk, whole (3.5% fat)	Fat, energy, Ca, Mg, K, B12, Saturated FA	1
Orange juice, canned	Fe, Mg, K, Vitamin C, Folate	8
Carrots, raw	Vitamin A (IU and RAE), β-carotene	11
Salt	Sodium	9
Milk, fat free or skim	Mg, K, Vitamin A (RAE), vitamin B12	13
Margarine, stick, 80% fat	Fat, energy, Vitamin A (IU and RAE),α-tocopherol, Saturated FA	5
Cheese food, pasteurized process, American	Fat, Saturated FA	7
Rolls, hamburg or hotdog	Energy, fiber, Fe, Mg, Folate	4

Results from the NFNAP QC Program

To provide QC materials for NFNAP, 20 Certified Materiels (CRMs) were selected from NIST and other certifying authorities. To supplement the CRMs, 20 control composites (CC) were also developed (Table 3)

• CRMs are not available to exactly match the matrix of each food analyzed
• Blind QC controls are included with each food for each nutrient
  • If nutrient is deemed "critical", the best possible CRM is used
  • If nutrient is not deemed "critical", a CC is used
• CCs are formulated as part of NFNAP
  • CC are designed to be used with a variety of similar matrices to limit number needed
  • Consensus values for the nutrients are developed after multiple analyses
  • Laboratory performance with CRMs are compared to CC results (example Tables 4 & 5)

Table 3. Quality Control Materials used in NFNAP

Certified Materials (CRMs)	Prepared Control Composites (CC)
Baby Food (NIST 2383)	Beef Baby Food
Baking Chocolate (NIST 2384)	Vegetable I & II
Beef-Pork Fat Blend (BCR 163)	Mixed Food I & II
Cereal (AACC VMA 399)	Bread I & II
Chocolate Confectionary (LGC 7016)	Starchy Vegetable
Coconut Oil (NIST 1563)	Snack Food
Fish Tissue (NIST 1946)	Salad Dressing I & II
Freeze Dried Typical Diet (NIST 1548a)	Cheese I & II
Infant Formula (NIST 1846)	Margarine
Lyophilized Brussels Sprouts (BCR 431)	Vegetable Oil
Lyophilized Mixed Vegetables (BCR 485)	Pasta/Rice
Meat Homogenate (NIST 1546)	Tomato
Milk Powder (BCR 421)	Orange Juice
Non-fat Milk Powder (NIST 1549)	Cake
Peanut Butter (NIST 2387)	Peanut Butter I & II
Rice Flour (NIST 1568a)	Soda
Sweet Digestive Biscuit (LGC 7103)	Chocolate Milk
Total Diet (NIST 1544)	Milk Chocolate
Water (NIST 1640)	Snack Food I & II
Wheat Flour (NIST 1567a)	Juice/cola

Table 4. Results from several labs compared to certified levels in a CRM (NIST 1546 – Meat Homogenate)

Nutrient	Certificate value	Lab A	Lab B	Lab C
Protein	14.9 (13.9 – 15.9)*	14.9 ± 0.9, 9 ‡	14.8 ± 0.2, 3	14.5 ± 1.4, 4
Fat	21.0 (19.6 – 22.4)	21.3 ± 1.7, 14	19.1 ± 1.4, 4¨	20.8 ± 4.7, 4
Riboflavin	0.200 (0.141 – 0.259)	0.178± 0.045, 8	------------------	------------------
Cholesterol	75 .0 (67.8 – 82.2)	75.4 ± 4.4, 14	------------------	------------------

Table 5. Results from several labs for a NFNAP Control Composite – Beef Baby Food

Nutrient	Lab A	Lab B	Lab C	Lab D	Lab E
Protein	12.7 ± 0.6, 15 ‡	12.3 ± 0.2, 5	12.3 ± 0.7, 4	12.3, 1	12.8 ± 0.7, 4
Fat	7.3 ± 0.4, 21	7.4 ± 0.3, 8	7.3 , 2	7.0, 2	7.0 ± 0.6, 8
Riboflavin	0.116 ± 0.023, 17	0.118 ± 0.029, 3	0.157 ± 0.019, 4	------------	0.118 ± 0.020, 8
Cholesterol	41.4 ± 1.8, 21	42.3 ± 6.3, 5	-------------	44.4, 1	44.2 ± 2.6, 8

¨Mean (range)
‡ Mean ‡ SD, N

Conclusion

• The use of the Key Foods process continues to provide a cost effective mechanism for selecting and prioritizing foods and nutrients for analysis. As new food composition and new food consumption data become available, the Key Foods list is updated.

• The food items in the top quartiles of the Key Foods list stay essentially the same, though the relative ranking may shift.

• It is essential to have a rigorous QC program as part of any analytical work. The accuracy and precision of the analytical program is enhanced by the use of both CRMs and CC. The use of the Key Foods list provides one way to decide on the type and nature of QC materials.