USDA's National Food and Nutrient Analysis Program: A Comparison of Old and New Carotenoid Values

D.B. Haytowitz, S.E. Gebhardt, G.R. Beecher, P.R. Pehrsson, J.M. Holden,
Beltsville Human Nutrition Research Center, ARS, USDA, Beltsville, MD.

Abstract

The National Food and Nutrient Analysis Program (NFNAP) is designed to improve the quality and quantity of nutrient data in USDA food composition databases by generating nationally representative analytical data for key dietary contributors. To date, we have sampled and analyzed over 750 foods for up to 125 components. This has led to the updating and expansion of data for approximately 280 foods in the latest version (Release 16-1) of the USDA National Nutrient Database for Standard Reference. Due to public health interest in the potential role of individual carotenoids in preventing diseases (e.g. cancer and macular degeneration) values were generated for α-carotene, β-carotene, β-cryptoxanthin, lutein and lycopene. These data have made it possible to calculate vitamin A activity from the individual carotenoids and retinol, when available. As a result, a number of values have changed (Table 1).

Differences between old and new values may be due to changes in cultivars, analytical methods, sampling or other factors. The significance of these differences must be considered relative to each food's importance as a contributor of the various carotenoids.

This project supported by USDA-ARS and by NIH under contract # Y1-HV-8116-19.

Introduction

As part of the National Food and Nutrient Analysis Program, USDA has analyzed over 450 foods for individual carotenoids. These data were, in turn, used to expand upon the 1998 USDA-NCC Carotenoid Database for U.S. Foods and for the first time add data on individual carotenoids to the USDA National Nutrient Database for Standard Reference. In addition we are now calculating total vitamin A from pro-vitamin A carotenoids (α-carotene, β-carotene, and β-cryptoxanthin) plus retinol. This has resulted in a number of changes in the carotenoid and vitamin A values in USDA food composition databases (Table 1)

Methods

Food priorities for carotenoid analysis were determined using the Key Foods procedure described by Haytowitz et al (2002), where food composition and food consumption data are combined to determine key contributors of various nutrients. The NHANES 1999-2000 dataset was used for these calculations.

Analytical samples were collected in 12 locations in the U.S. and composited into either national or regional samples (Pehrsson et al. 2000) Carotenoids were determined by HPLC (Becher and Howard, 2001) or were imputed by the procedures described by Schakel et al (1998). Vitamin A (RAE) was then calculated using the new factors from the Institute of Medicine (NAS-IOM, 2001)

References

Haytowitz, D.B., Pehrsson, P.R., and Holden, J.M. 2002. The Identification of Key Foods for Food Composition Research. J. Food Comp. Anal. 15(2):183-194

Pehrsson, P.R., Haytowitz, D.B., Holden, J.M., Perry, C.R., and Beckler, D.G. 2000. USDA's National Food and Nutrient Analysis Program: Food Sampling. J. Food Comp. Anal. 13:379-389.

Schakel, S.F., Buzzard, I.M., and Gebhardt, S.E. 1998. Procedures for Estimating Nutrient Values for Food Composition Databases. J. Food Comp. Anal. 10:102-114.

NAS-IOM-Food and Nutrition Board. 2001. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium and Zinc. National Academy Press. Washington, D.C.

Table 1. Comparison of previous and current carotenoid values

Food	Carotenoid	Units	Previous	Current
Tomatoes, raw	Lycopene	mcg/100 g	3025	2573
Broccoli, cooked	Lutein	mcg/100 g	2226	1517
Lettuce, romaine	Vitamin A	mcg RAE/100 g	130	290
Eggs, whole, raw	Vitamin A	mcg RAE/100 g	191	140

Results

There were only minor changes in the Vitamin A content of fruits and milk compared to those in earlier releases (Table 2) .

The vitamin A values for raw carrots decreased significantly from 28,129 IU to 12,035 IU and cooked carrots from 24,554 IU to 17,2002 IU (Table 2). Of the top 10 contributors of vitamin A (IU), raw and cooked carrots contribute 48% (Fig. 1).

The adoption of new factors for calculating vitamin A activity in Retinol Activity Equivalents (RAEs) by the Institute of Medicine (NAS-IOM, 2001) where carotenoids are contributing half the vitamin A activity as previously, results in a further reduction in the importance of plant foods as a source of vitamin A. While raw and cooked carrots are still among the top 10 contributors of vitamin A (RAE), their contribution is lower—only 19%. Other foods, such as milk and margarine with significant amounts of retinol become more prominent sources of vitamin A in the diet (Fig. 2)

However, vegetables remain a good source of individual carotenoids. For example, fresh tomatoes contains 2573 mcg/100 g of lycopene, while cooked spinach contains 11,308 mcg/100 g of lutein+zeaxanthin (Table 1). Spinach is the major source of lutein+zeaxanthin, followed by broccoli and iceberg lettuce. Among the top 10 contributors, spinach contributes ~40% of the lutein+zeaxanthin (Fig. 3).

Summary

USDA now provides values for individual carotenoids for over 3,000 foods used in the nutrient database for NHANES. New data on the carotenoid content of foods has resulted in more accurate and representative estimates on the vitamin A content of foods for the following reasons:

Better Sampling Design

- Old data were often based on limited sampling, including samples from single sources and experimental plots.
- New values are based on a national probability proportional to size (population), stratified random sampling plan

Better Analytical Methods

- Old data were often based on the AOAC method for vitamin A where all carotenoids were measured as β-carotene
- New vitamin A values (IU and RAE) are calculated from individual carotenoids analyzed by HPLC with the use of appropriate factors.

Data are released on the Nutrient Data Laboratory Web site:
http://www.nal.usda.gov/fnic/foodcomp

Table 2. Comparison of vitamin A values in SR15 and SR16-1

	SR15	SR16-1							
Long_Desc	Vitamin A (IU)	Vitamin A (IU)	Vitamin A (RAE)	Retinol (mcg)	β-Carotene (mcg)	α-Carotene (mcg)	β-crypto-xanthin	Lycopene (mcg)	Lutein+ Zeaxanthin (mcg)
Carrot juice, canned	10946	19124	956	0	9303	4342	0	2	333
Carrots, cooked, boiled, drained, without salt	24554	17202	860	0	8332	3776	202	0	687
Carrots, raw	28129	12036	602	0	5774	2817	78	2	207
Cheese food, pasteurized process, american	913	761	201	196	65	0	0	0	0
Broccoli, boiled	1388	1967	98	0	1180	0	0	0	1517
Chicory greens, raw	4000	5717	286	0	3430	0	0	0	10300
Egg, whole, raw, fresh	635	487	140	139	10	0	9	0	331
Egg, yolk, raw, fresh	1945	1442	381	371	88	38	33	0	1094
Ice creams, vanilla	389	422	118	116	19	0	0	0	0
Lettuce, iceberg	330	322	16	0	192	2	0	0	352
Margarine, regular, stick, composite, 80% fat, with salt	3571	3577	819	768	610	0	0	0	0
Melons, cantaloupe, raw	3224	3382	169	0	2020	16	1	0	26
Milk, lowfat, fluid, 1% milkfat, with added vitamin A	205	196	58	58	2	0	0	0	0
Milk, nonfat, fluid, with added vitamin A (fat free or skim)	204	204	61	61	0	0	0	0	0
Milk, reduced fat, fluid, 2% milkfat, with added vitamin A	205	189	55	55	3	0	0	0	0
Milk, whole, 3.25% milkfat	126	102	28	28	5	0	0	0	0
Orange juice, canned, unsweetened	175	175	9	0	29	5	148	0	115
Spinach, boiled	8190	10841	524	0	6288	0	0	0	11308
Spinach, canned, drained soilds	8776	9801	490	0	5881	0	0	0	10575
Spinach, frozen, chopped or leaf, boiled	7784	12061	603	0	7237	0	0	0	15690
Spinach, raw	6715	9377	469	0	5626	0	0	0	12198
Sweetpotato, cooked, boiled, without skin	17054	15770	788	0	9444	36	0	0	0
Tomatoes, red, ripe, raw, year round average	623	833	42	0	449	101	0	2573	123

Figure 1. Percent contribution of the top 10 food Items for vitamin A (IU) intake using SR16-1 data

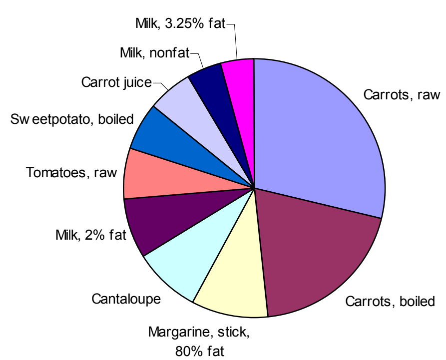

Figure 2. Percent contribution of the top 10 food Items for vitamin A (RAE) intake using SR16-1 data

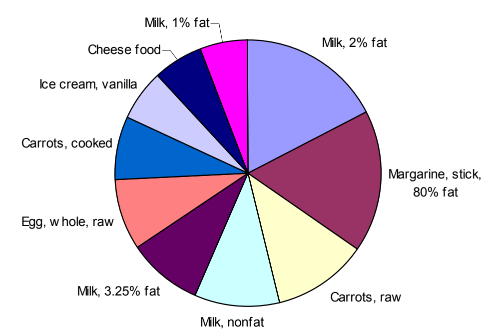

Figure 3. Percent contribution of the top 10 food Items of lutein+zeaxanthin (mcg) intake using SR16-1 data