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Original Research Article

# Cholesterol and vitamin D content of eggs in the U.S. retail market

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ABSTRACT

Nationwide sampling in the U.S. of whole large eggs, to update values in the United States Department of Agriculture (USDA) National Nutrient Database for Standard Reference (SR) (http://www.ars.usda.gov/nutrientdata), was conducted in 2000–2001 and in 2010. Retail cartons of large eggs were obtained from 12 supermarket locations using statistical sampling plans based on market share and census data. Cholesterol was analyzed at three laboratories using standard methods involving gas chromatography of the saponified total lipid extract. Vitamin $D_3$ and 25-OH-vitamin $D_3$ (2010 samples only) were analyzed by HPLC and UHPLC–MS/MS. Quality control materials were included to validate the accuracy and precision of measurements. The mean cholesterol content decreased 51 mg/100 g (12%; $p < 0.0001$), from 423 mg/100 g in 2000–2001 to 372 (range 344–405) in 2010. Over the same period, average vitamin $D_3$ increased by 60%, to 2.05 μg [80 IU]/100 g (range 0.97–12.1). Samples from 2010 contained 0.65 μg 25-OH-$D_3$/100 g (range 0.43–1.32). The disparate vitamin D (and cholesterol) content of eggs sampled from different locations may reflect industry efforts to modify poultry feed or supplements to affect the nutrient profile of eggs. Cholesterol and vitamin $D_3$ data from this work were included in SR release 23, and support food consumption surveys, food and nutrition policy, and consumer education.


## 1. Introduction

Eggs are a relatively inexpensive source of high quality protein and other nutrients. Eggs are also a primary source of dietary cholesterol. Despite conflicting evidence about the role of cholesterol intake in cardiovascular disease (CVD) risk (Vos, 2010), calls for decreasing dietary cholesterol (e.g. Houston et al., 2011; Spence et al., 2010) have prompted developments in production to yield eggs with reduced cholesterol and enhanced levels of desirable nutrients including omega-3 fatty acids, vitamin E, and vitamin D (Cherian, 2009; Elkin, 2006, 2007; Kassis et al., 2010; Naber, 1993). Commonly used practices include targeted feed composition, poultry supplements such as Hy-D® 25-hydroxyvitamin $D_3$ (DSM Nutritional Products Europe Ltd., Basel, Switzerland), or free range vs. cage environments for hens. Variability in production practices means there is greater potential variability in the composition of eggs in the current retail market.

In 2009 a study of the nutrient composition of eggs produced by controlled flocks of chickens, comparing cage vs. free range production (Anderson, 2011) was conducted. In that study the cholesterol content of whole large eggs was lower than reported in the United States Department of Agriculture (USDA) Nutrient Database for Standard Reference (SR) Release 22 (USDA, 2009). The SR22 data on eggs were based on a 2000–2001 nationwide sampling and analyses conducted by the USDA Nutrient Data Laboratory (NDL) as part of the National Food and Nutrient Analysis Program (NFNAP) (Haytowitz et al., 2007), in collaboration with the Egg Nutrition Center (ENC). Sampling and nutrient analyses for the ongoing NFNAP are conducted using statistical sampling plans, valid methods, and rigorous analytical quality control to assure the accuracy and precision of the results (Phillips et al., 2006). The data for cholesterol in eggs were reviewed in 2010 as part of the NFNAP, and a re-sampling and analysis of whole eggs was planned to update values based on potential changes in composition. Additionally, newly developed and validated methods for vitamin D would make accurate

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determination of this nutrient, including 25-OH-vitamin $D_3$ possible.

Because SR is the primary source of food composition data for many nutrient intake assessment programs, the accuracy of the resulting estimates depend on the accuracy and completeness of data in SR. It is also important to realize that changes in the average nutrient composition over time, or variability in the composition of a particular product within the food supply, may occur. Investigators must be aware of the impact of such changes on epidemiological assessments of the effect of diet on health. In fact, studies relating egg consumption or dietary cholesterol to CVD risk, such as the recent Health ABC study (Houston et al., 2011) use average nutrient concentrations from food composition databases merged with food intake records to estimate nutrient intake.

This report describes the estimation of cholesterol and vitamin D content of whole large eggs sampled in 2000–2001 and 2010 and the incorporation of the 2010 data into SR 23, with the new data for 25-OH-vitamin $D_3$ to be included in a future release of SR.

## 2. Materials and methods

### 2.1. Samples

Whole eggs were procured in November 2000/November 2001 and in March/April 2010 at 12 statistically determined supermarket locations identified for the NFNAP (Pehrsson et al., 2000; Perry et al., 2003), with the sampling plans for 2000/2001 and 2010 based on 1990 and 2000 census data, respectively. Fig. 1 shows the sampling locations in each year. Three to five cartons (one dozen eggs each) of white, large, grade A or AA eggs were obtained from each retail location. In 2010 shipment of eggs from three locations (CA1, CA2 and CO) was arranged by the ENC (Park Ridge, IL).

The eggs were shipped in their original cartons, by overnight express, on refrigerated cold packs to the Food Analysis Laboratory Control Center (FALCC) at Virginia Tech (Trainer et al., 2010) where they were composited, homogenized and subsampled for analysis. Eggs were inspected for integrity immediately upon receipt. Any damaged eggs were discarded. The eggs were stored refrigerated ($4 \pm 3$ °C) and composited prior to their labeled sell-by date (within 1–21 days of receipt) as described below (except in three cases where the samples were composited no more than 9 days past the sell-by date).

Eggs were composited as follows. In 2010, 12 single-city and 6 random city-pair composites were prepared. For the single-location composites, 9–12 eggs (450–700 g) from each location were used. For the 6 city-pair composites 9–12 eggs from each outlet were combined (total of 900–1300 g). In 2000–2001, 11 single-city composites, four regional composites of samples from three (triad) or four locations, and a national composite of samples from all locations were prepared using an equal number of eggs from each outlet (total of 800–1400 g per composite).

For each composite, eggs were homogenized in a stainless steel bowl using a hand blender (CSB-1C, Cuisinart®, Stamford, CT). Subsamples were dispensed, while maintaining homogeneity of the mixture, into 1-oz clear straight sided glass jars with Teflon®-lined lids (GLC-07098, Qorpak®, Bridgeville, PA). Each subsample was sealed under nitrogen and stored at −60 °C prior to analysis.

### 2.2. Control composites

An egg control composite (Egg CC) was prepared in October 2008. Two cartons of eggs (1.5 dozen each) labeled as vitamin D enriched, were purchased locally (Kroger, Blacksburg, VA) and stored refrigerated ($4 \pm 3$ °C) until composited two days after purchase. Samples were homogenized as described above and subsamples were dispensed into 2-oz clear straight sided glass jars (GLC-08640, Qorpak®, Bridgeville, PA), sealed under nitrogen, and stored at −60 °C prior to analysis.

A pork and egg control composite (Pork/Egg CC) was prepared as follows. Two cartons of eggs (1.5 dozen each) labeled as vitamin D-enriched, and five packages (16 oz each) of pork bratwursts were purchased locally (Kroger, Blacksburg, VA). The samples were stored refrigerated ($4 \pm 3$ °C) and composited one day after receipt. Eggs were separated and only the yolks were included in the composite. Bratwursts were cut into pieces of ~1.25 cm. The cut bratwursts, egg yolks, and distilled deionized water (4.5:14.5:1, w/w/w) were homogenized in a 6 L industrial food processor (Robot Coupe® Blixer BX6V, Robot Coupe USA, Inc., Jackson, MS). The homogenized material was gradually added to a stainless steel bowl containing liquid nitrogen. After all of the material was sufficiently frozen, it was re-homogenized in a second 6 L industrial food processor, yielding a fine powder. Subsamples were dispensed into 1-oz clear straight sided glass jars with Teflon®-lined lids (GLC-07098, Qorpak®, Bridgeville, PA), sealed under residual nitrogen, and stored at −60 °C prior to analysis or shipment.

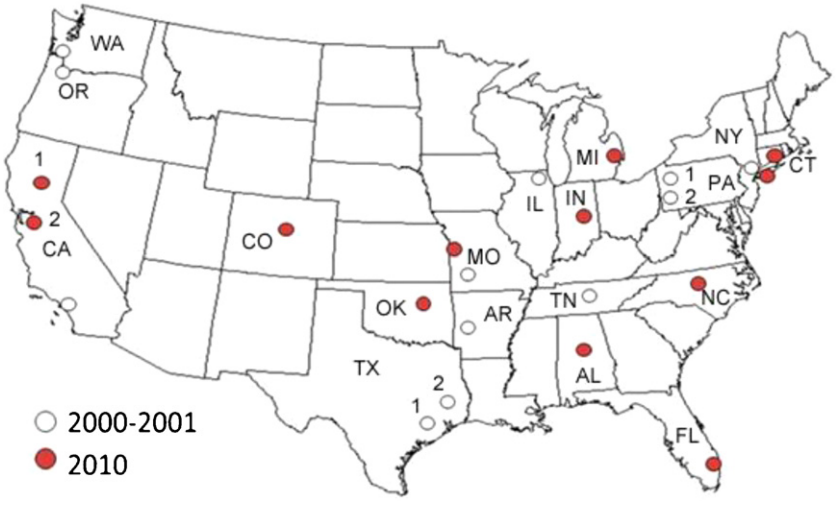


**Fig. 1.** Sampling locations in 2000–2001 and 2010. AL = Alabama; AR = Arkansas; CA = California; CO = Colorado; CT = Connecticut; FL = Florida; IL = Illinois; IN = Indiana; MI = Michigan; MO = Missouri; NC = North Carolina; NY = New York; OK = Oklahoma; OR = Oregon; PA = Pennsylvania; TN = Tennessee; TX = Texas; WA = Washington.