Exposure Estimate for FD&C Colors for the U.S. Population

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Background

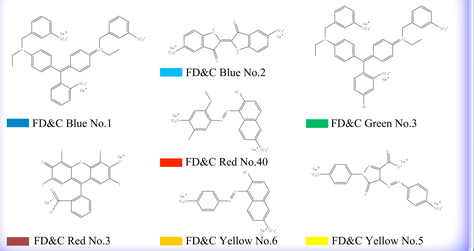
Synthetic organic dyes used as color additives in food have come under increased scrutiny both in the U.S. and internationally. Currently, there are nine of these color additives approved for use in food in the U.S. Seven of these color additives are permitted for general use in food products at levels consistent with good manufacturing practice (FD&C Blue No. 1, FD&C Blue No. 2, FD&C Green No. 3, FD&C Red No. 3, FD&C Red No. 40, FD&C Yellow No. 5, and FD&C Yellow No. 6). The other two are regulated for specific uses. Citrus Red No. 2 is listed for use only for coloring the peels of oranges not intended for processing, and Orange B is listed for use only for coloring the casings of sausages and frankfurters.

The 2007 Southampton study reported a connection between consumption of six color additives and possible adverse behavioral effects. The color additives evaluated in the Southampton study were Tartrazine (certifiable as FD&C Yellow No. 5), Sunset Yellow (certifiable as FD&C Yellow No. 6), Ponceau 4R, Carmoisine, Quinoline Yellow (certifiable as D&C Yellow No. 10), and Allura Red (certifiable as FD&C Red No. 40). In response to this study, the Center for Science in the Public Interest submitted a citizen petition in 2008 asking the Food and Drug Administration (FDA) to ban eight of the nine certified color additives (the seven FD&C color additives that are approved for general use, as well as Orange B) allowed for use in food, as well as requesting warning labels be placed on food containing these color additives until FDA makes a final decision to ban these color additives.

In response to concerns raised about these color additives, the FDA convened its Food Advisory Committee (FAC) in March 2011 to consider the available relevant data on the possible association between children's consumption of these color additives in food and hyperactivity or other behavioral effects. The FAC was tasked to advise FDA on what action, if any, was warranted to ensure the safety of these color additives. After considering the information presented by FDA, experts, and other stakeholders, the FAC concluded that a causal link between children's consumption of FD&C color additives and behavioral effects had not been established based on the available data and that additional label information (i.e., a warning label) was unnecessary to ensure the safe use of FD&C color additives. However, the FAC recommended further research, including a comprehensive exposure assessment for these color additives, especially for children.

Based on this recommendation, FDA conducted a robust exposure assessment of the FD&C colors approved for general use in food. Foods that contain FD&C colors were identified, grouped into broad food categories, and then matched with food codes from the combined 2007-2010 National Health and Nutrition Examination Survey (NHANES). The levels of FD&C color additives in over 580 foods were determined using a high performance liquid chromatography (HPLC) method developed by FDA's Office of Cosmetics and Colors (OCAC). Dietary exposures from the use of each FD&C color additive in food were estimated for the U.S. population aged 2 years or more, children aged 2-5 years, and teenage boys aged 13-18 years. This study summarizes the results of this exposure assessment.

Structures of the FD&C Colors



Exposure Assessment

Compilation and Sources of FD&C Color Additives in Foods:

Two different sources were used to determine the presence of FD&C color additives in various food products. These sources include:

- FoodEssentials LabelBase is a product label database providing access to greater than 250,000 labels containing information from the Gladson and Mintel databases. This database was used to first determine the types of foods that contain FD&C color additives.
  - Gladson Nutrition Database contains over 90% of products in most major consumer packaged goods categories. It includes information such as product images, ingredient information, nutrition information, and universal product codes (UPC).
  - Mintel Global New Products Database (GNPD) monitors product innovation and retail success in the consumer packaged goods market. It contains data similar to that in the Gladson Database for 49 countries in 32 food categories from 1996 to the present.
- Product Label Survey: Data collected from the FoodEssentials LabelBase were verified by conducting a survey of over 7300 product labels at local grocery stores in the greater Washington D.C. area from June 2012 – December 2013. Product food categories known to currently or previously contain FD&C color additives were targeted. In addition, when available, information on the use of FD&C color additives from the websites of food manufacturers and other publically available websites were used to verify the presence of FD&C color additives in various food products.

Source of FD&C Color Additive Use Levels in Foods:

- Analytical Data: Based on the label survey, over 580 representative products were chosen for analysis by a contract laboratory for FD&C color additives using a peer-reviewed HPLC method developed by FDA's OCAC with a limit of detection of 1 mg/kg. Prior to analysis, all products were prepared as they would be consumed. Results of the level of each FD&C color additive present in a given food product were provided in mg/kg.

Methods for Estimating Exposure to FD&C Color Additives

Dietary exposure estimates for FD&C color additives from their use in food were performed using food consumption data from the 2007-2010 NHANES. Three population groups were chosen for the exposure estimate:

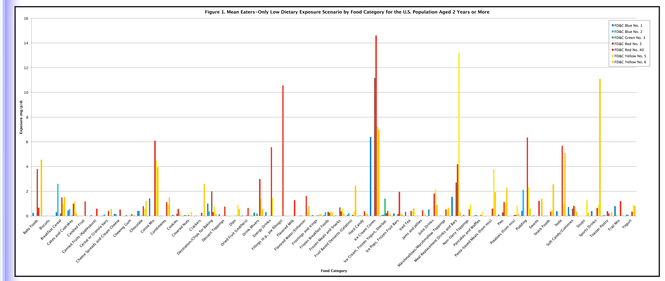
- U.S. population aged 2 years or more
- Children aged 2-5 years
- Teenage boys aged 13-18 years

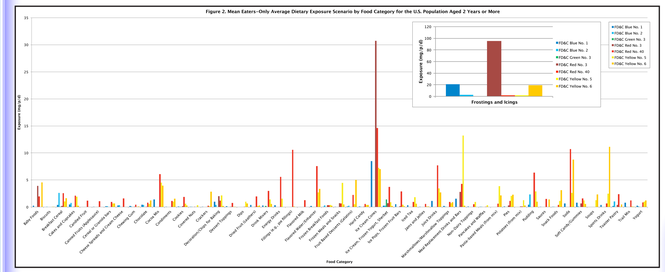
All dietary exposures were estimated on an "eaters-only" basis, meaning that the estimate represents the dietary exposure to FD&C color additives from the consumption of foods containing FD&C color additives by the individuals in the population who consumed one or more of those foods over the survey period. Dietary exposures were estimated at the mean and the 90th percentile, where the 90th percentile represents those individuals who are the "high intake" consumers of a given food.

The exposure estimate was performed as follows:

- Foods that contain FD&C color additives were identified based on label information. These foods were then grouped into over 50 broad food categories.
- Over 300 food codes from the NHANES survey were assigned across these food categories for each of the seven FD&C color additives.
- For each NHANES food code identified as containing a particular FD&C color additive, a use level for that FD&C color additive, which was based on the results of the analytical data, was assigned to that food code. If a given FD&C color additive was not found to be present in food products represented by a given NHANES food code, then that food code was not included in the exposure estimate for that FD&C color additive.
- For each FD&C color additive, three different exposure scenarios were performed:
  - Low Exposure Scenario: The lowest analytical value for a given FD&C color additive was assigned to each food code. This represents the lowest exposure to a given FD&C color additive.
  - Average Exposure Scenario: The analytical results were averaged for a given food code. For those food codes where only one product was represented by a given food code, the same FD&C level was used for all three scenarios.
  - High Exposure Scenario: The highest analytical value for a given FD&C color additive was assigned to each food code. This represents the highest exposure to a given FD&C color additive.
- For each population group, the following exposures to each FD&C color additive were estimated:
  - Each individual food category
  - Cumulative exposure that takes into account all the foods included in the individual food categories

Results





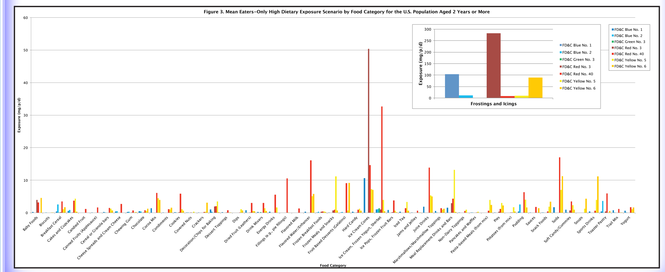


Table 1. Cumulative Exposure to FD&C Color Additives (mg/p/d) for the U.S. Population Aged 2+ Years or More

Color	% Eaters	Low Exposure Scenario		Average Exposure Scenario		High Exposure Scenario	
		Mean	90th Percentile	Mean	90th Percentile	Mean	90th Percentile
FD&C Blue No. 1	92	0.9	2.2	1.3	3.0	2.3	4.9
FD&C Blue No. 2	69	0.6	1.3	0.7	1.6	1.1	3.3
FD&C Green No. 3	15	1.3	2.6	1.3	2.6	1.3	2.6
FD&C Red No. 3	54	1.3	3.4	2.3	3.6	3.5	3.8
FD&C Red No. 40	94	4.2	11.4	9.2	22.1	20.8	52.4
FD&C Yellow No. 5	94	2.7	6.7	4.7	11.2	8.5	20.4
FD&C Yellow No. 6	91	4.4	11.5	6.4	15.9	8.3	20.5

Table 2. Cumulative Exposure to FD&C Color Additives (mg/p/d) for the Children Aged 2-5 Years

Color	% Eaters	Low Exposure Scenario		Average Exposure Scenario		High Exposure Scenario	
		Mean	90th Percentile	Mean	90th Percentile	Mean	90th Percentile
FD&C Blue No. 1	96	0.7	1.2	1.2	2.3	2.2	4.1
FD&C Blue No. 2	78	0.5	0.8	0.6	1.1	0.9	2.6
FD&C Green No. 3	14	0.8	1.6	0.8	1.6	0.8	1.6
FD&C Red No. 3	62	0.8	1.2	1.9	1.5	3.4	1.8
FD&C Red No. 40	97	2.6	5.6	6.8	16.3	15.3	38.3
FD&C Yellow No. 5	98	2.3	5.8	3.5	8.3	5.6	12.8
FD&C Yellow No. 6	97	2.5	6.5	4.2	9.8	6.2	14.0

Table 3. Cumulative Exposure to FD&C Color Additives (mg/p/d) for the Teenage Boys Aged 13-18 Years

Color	% Eaters	Low Exposure Scenario		Average Exposure Scenario		High Exposure Scenario	
		Mean	90th Percentile	Mean	90th Percentile	Mean	90th Percentile
FD&C Blue No. 1	93	1.0	2.2	1.6	3.4	2.8	6.3
FD&C Blue No. 2	72	0.6	1.1	0.8	1.7	1.5	4.0
FD&C Green No. 3	14	1.7	3.8	1.7	3.8	1.7	3.8
FD&C Red No. 3	53	0.9	2.3	1.6	2.4	2.6	3.0
FD&C Red No. 40	95	5.9	14.1	12.9	29.7	28.7	70.1
FD&C Yellow No. 5	93	3.3	8.1	6.2	14.1	11.8	26.1
FD&C Yellow No. 6	94	8.4	22.3	11.2	26.4	13.9	34.5

Conclusions and Future Work

- Exposure was estimated for each FD&C color additive for the U.S. Population aged 2 years or more, children aged 2-5 years, and teenage boys aged 13-18 years.
- For all populations considered and for all three exposure scenarios, the highest exposures were estimated for FD&C Red No. 40, FD&C Yellow No. 5, and FD&C Yellow No. 6.
- In order to better represent chronic exposure to FD&C color additives, exposure will also be estimated using 14-day food consumption data.
- FDA is reassessing the safety studies conducted on FD&C color additives that are available in its files. However, all exposure estimates for these color additives are well below the acceptable intake levels that have been established by FDA.
- FDA will determine if additional safety studies are needed.