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Amounts of Artificial Food Colors in Commonly Consumed Beverages and Potential Behavioral Implications for Consumption in Children

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Abstract

Artificial food colors (AFCs) are widely used to color foods and beverages. The amount of AFCs the Food and Drug Administration has certified over the years has increased more than 5-fold since 1950 (12 mg/capita/day) to 2012 (68 mg/capita/day). In the past 38 years, there have been studies of adverse behavioral reactions such as hyperactivity in children to double-blind challenges with AFCs. Studies that used 50 mg or more of AFCs as the challenge showed a greater negative effect on more children than those which used less. The study reported here is the first to quantify the amounts of AFCs in foods (specifically in beverages) commonly consumed by children in the United States. Consumption data for all foods would be helpful in the design of more challenge studies. The data summarized here should help clinicians advise parents about AFCs and beverage consumption.

Keywords

Allura Red, artificial food dyes, attention-deficit/hyperactivity disorder, childhood behavior problems, FD&C artificial food colors, hyperactivity, sleep, tartrazine

Introduction

Artificial food colors (AFCs) are added to many foods worldwide. They are synthesized from raw materials obtained from coal tar or petroleum by-products. In 1900, 80 different dyes were used in the United States, but over the years most of these were taken off the market because of safety concerns. Currently, there are 9 AFCs allowed by the Food and Drug Administration (FDA; see Table 1). In addition to the AFCs that dissolve in water, there are also lake AFCs. These are AFCs bound to aluminum. Lakes are not soluble in water but are used to color some foods because they tint by dispersion. These types of foods include fats, gums, waxes, and oils. Lakes are sometimes used to color fruit drinks prepared from a powder mix but not in ready-to-drink beverages.

Artificial food colors are added to foods for cosmetic reasons to make products more appealing. They are used to standardize the color in products where colors may fade during production and storage. They are also added to make artificially flavored foods the appropriate colors. For example, Red #40 is used to color foods that do not contain real strawberries or cherries but instead use artificial strawberry or cherry flavors. AFCs are often added to intensify the natural color of the food because brightly colored foods attract customers, especially children. AFCs are used instead of natural dyes because they are cheaper and more stable to heat, light, and other processing exposures. Children and adolescents may consume more AFCs than adults because of their higher consumption of colored beverages, cereals, candy, and other brightly colored foods.[1]

The Joint Food and Agriculture Organization/World Health Organization Expert Committee on Food Additives sets the acceptable daily intake (ADI) for each color based on studies in animals (see Table 1). The ADI is the number of mg/kg of body weight per day that can be ingested without appreciable health risk. In the United States the FDA also sets ADIs which are slightly different from FAO/WHO values. The amount for each color was set based on toxicity studies in animals; behavioral responses of animals or children to AFC challenges were not considered.

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Table 1. Artificial Food Colors[a] Allowed in the United States by the Food and Drug Administration and Their Acceptable Daily Intakes[b].

FD&C Colors	Common Name	Type of Chemical	Shade	ADI[b] (mg/kg/d)	ADI[b] 30 kg child/d (mg)
Blue #1[b]	Brilliant Blue	Triphenylmethane	Blue	6	180
Blue #2	Indigotine	Sulfonated indigo	Dark blue	2.5	75
Green #3	Fast Green	Triphenylmethane	Blue-green	2.5	75
Yellow #5	Tartrazine	Azo	Yellow	7.5	225
Yellow #6	Sunset Yellow	Azo	Orange	3.75	112.5
Red #3	Erythrosine	Xanthene	Pink	2.5	75
Red #40	Allura Red	Azo	Red	7	210
Citrus Red #2[c]	Citrus Red	Azo	Orange		
Orange B[d]	Orange B	Pyrazolone	Orange-red		

Abbreviations: FD&C, foods, drugs, and cosmetics; ADI, acceptable daily intake.
[a]Other dyes are allowed in drugs and cosmetics but not in foods.
[b]Acceptable daily intake (ADI) is the number of mg/kg of body weight per day that can be ingested without appreciable health risk.
[c]Only used to dye orange skins.
[d]Only for use in hot dog and sausage casings but no batches have been certified for at least 10 years.

In the past 38 years, questions have arisen over the safety of the current AFCs for some children, especially a subpopulation of children with behavioral problems such as attention-deficit/hyperactivity disorder. The range of behavioral reactions reported also included irritability, sleep disturbance, restlessness, and aggression. To read more about this research see the following reviews: Arnold et al,[2], Stevens et al,[3] Stevens et al,[4] Kanarek,[5] Weiss,[6] and Millichap and Yee,[7] and a 2012 meta analysis by Nigg et al.[8] One thing that seems clear from the behavioral studies is that a greater proportion of children reacted to higher doses (≥50 mg) of AFCs[9-12] than to lower amounts (<50 mg).[13-19] Other important factors were age of the child (younger children were more reactive than older children) and time of evaluation (1-3 hours postchallenge were more revealing than later evaluations). Participants in these studies were thought by their parents to be reactive to AFCs and were diagnosed with "hyperkinesis," "hyperactivity," or "behavior problems," which included restlessness, irritability, and sleep problems. All studies used parent rating scales except Swanson and Kinsbourne[9] and Goyette et al,[19] who used a learning test and a visual distraction test. Challenges were either with a mixture of AFCs or Yellow #5 and/or Yellow #6. Some of the studies used a single bolus of AFCs for the challenge while others studied short-term exposure to AFCs.

Sources of Artificial Food Colors in the American Diet

In 1977, the US National Research Council prepared for FDA the results of a survey of industry on the use of food additives, including AFCs.[20] They combined use level data with estimates of food consumption to calculate intakes of each AFC by age-group. These data are presented in Table 2. The total amount of dyes certified by the FDA has increased 5-fold from 1950 (12 mg/capita/day) to 2012 (68 mg/capita/day),[21] including both adults and children. Figure 1 shows the dramatic increases in certified amounts of the total dyes, Red #40, Yellow #5, and Yellow #6 since 1950. This estimate is based on certification data collected by the FDA, which tests all batches of AFCs for safety and purity in the United States in a given year. Of course, certification amounts are not the same as consumption amounts because some unknown portion of the dyes will be thrown away and never eaten. There is no recent AFC consumption data for children or adults. These kind of data have been collected in Australia,[22] Brazil,[23,24] Kuwait,[25] and Ireland.[26] For example, a survey by Food Standards Australia and New Zealand assessed dietary exposure by children and adults aged 2 years and older to AFCs by measuring AFCs in 651samples of processed foods and beverages and food consumption data from 1995. Australia and New Zealand allow both dyes that are approved for use in the United States and several dyes not approved in the United States—Amaranth, Carmoisine, Brilliant Black, Brown HT, Green S, Ponceau 4R, and Quinoline Yellow. They reported that the range of dyes in fruit juices and fruit drinks was 0 to 60 mg/kg with a mean of 5 mg/kg and 0 to 58 mg/kg with a mean of 18 mg/kg in soft drinks. They concluded that dietary exposure for each color was well below the ADI even for high (90th percentile) consumers. This report had some limitations because it did not account

Table 2. Amounts of Artificial Food Colors Consumed in the United States by Children in 1977, Consumers Only[a,b].

			Intake (mg) by Age and Percentiles				
FD&C Color	Age (Years)	No. of Children	Mean	50%	90%	95%	99%
Red #40							
	2-5	903	26.0	22.0	50.0	84.0	95.0
	6-12	1776	35.0	27.0	56.0	68.0	90.0
	13-17	1133	33.0	28.0	62.0	75.0	100
Yellow #5							
	2-5	903	13.0	11.0	23.0	28.0	37.0
	6-12	1776	15.0	13.0	25.0	29.0	37.0
	13-17	1133	15.0	13.0	27.0	31.0	41.0
Yellow #6							
	2-5	903	12.0	11.0	21.0	23.0	34.0
	6-12	1776	14.0	13.0	24.0	29.0	41.0
	13-17	1133	14.0	12.0	25.0	30.0	38.0
Blue #1							
	2-5	903	3.9	2.9	8.1	9.7	15.0
	6-12	1776	4.5	3.8	8.7	11.0	15.0
	13-17	1133	4.6	3.9	9.1	12.0	16.0
Blue #2							
	2-5	903	1.4	0.8	3.0	4.4	9.4
	6-12	1776	1.6	1.0	3.4	5.3	11.0
	13-17	1133	1.4	1.0	3.5	5.3	9.5
Green #3							
	2-5	903	NA[c]	0.6	1.8	2.3	3.3
	6-12	1776	1.1	0.4	2.3	2.7	3.5
	13-17	1133	1.2	1.0	2.5	3.0	3.0
Red #3							
	2-5	903	9.1	8.5	16.0	18.0	26.0
	6-12	1776	9.9	9.1	17.0	20.0	28.0
	13-17	1133	9.6	8.8	17.0	19.0	26.0

Abbreviations: FD&C, foods, drugs, and cosmetics; NA, not applicable.
[a]Source: *The 1977 Survey of Industry on the Use of Food Additives*. Committee on GRAS List Survey, Food and Nutrition Board, National Academy of Sciences. 1979. Available from FDA using Freedom of Information Act.
[b]Lake AFCs are not included in the data.
[c]Indecipherable from table in the 1977 report.

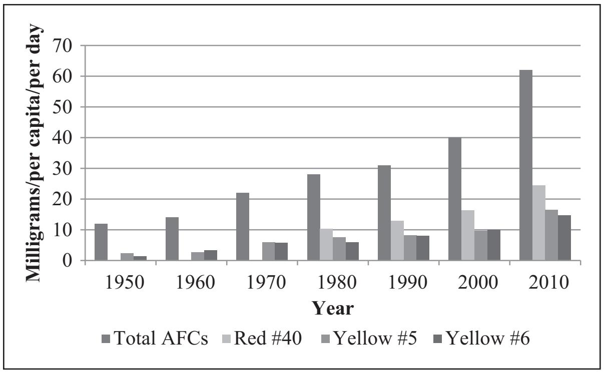

Figure 1. Trends in the amount of artificial food colors manufactured for the US market since 1950 as certified by the Food and Drug Administration for 3 common food colors and the total of all colors.

for the other 10% who consumed more AFCs. Also, a total AFCs consumption per person per day was not calculated.

Data in pounds for each color was obtained using the Freedom of Information Act from FDA and converted to milligrams, then divided by US population for a given year, then divided by 365 days. Total AFCs is the sum of all colors for a particular year.

Artificial food colors are found in many different foods, especially beverages, candy, ready-to-eat cereals, desserts, and snack foods. They are also used in toothpaste, mouthwash, and many pediatric medications. Many beverages contain AFCs and may account for a large proportion of the AFCs consumed by children.[27] These include sugar-sweetened or artificially sweetened carbonated sodas, fruit-flavored drinks and punches, fruit drink dry mixes, sports, and energy drinks. Most cola, root beer, and pepper-type products do not contain AFCs but instead use caramel color made by heating carbohydrates to a high temperature. However, caramel color seems to have its own set of problems and is rich in advanced glycation end products, which increase insulin resistance and inflammation.[28,29] A few carbonated drinks are clear and dye-free. Other beverages such as fruit drinks, sports beverages, and energy drinks commonly, but not always, contain AFCs. Most artificially sweetened beverages also contain either caramel color or AFCs. One-hundred percent fruit juices contain no AFCs. Serving sizes have dramatically increased over the years with 6.5-ounce bottles before the 1950s, 8-ounce bottles in the 1950s, 12-ounce cans beginning in 1960, 20-ounce plastic bottles in the 1990s, followed by 42-ounce bottles in 2011.[30]

How much of these beverages do children in the United States consume each day? Researchers gathered the following data to study childhood obesity so it is not known if the beverages consumed were colored with caramel coloring or AFCs. In 2011, Lasater et al[31] reported that 91% of 3583 children, aged 6 to 12 years, consumed on average 517 mL/d of sugar-sweetened beverages. Using 2007-2008 National Health and Nutrition Examination Survey data, they reported that 77% of all the children daily consumed on average 377 mL of fruit drinks and soda, 12% drank 289 mL of sports drinks, and 16% consumed 219 mL of diet drinks.

The aim of the study reported here was to quantify the amounts of AFCs found in beverages commonly consumed by children and adolescents.

Materials and Methods

A total of 108 beverages that listed AFCs as an ingredient were purchased from local grocery stores, superstores, pharmacies, and convenience stores. Powdered colors were obtained from Sensient Colors LLC (St. Louis, MO) and were used as standards. The standards were made up in water or 5% acetic acid solution. The 5% acetic acid solution was used for products containing lakes to release the dyes from aluminum. Dry beverage mixes were prepared in water or 5% acetic acid for those containing lakes. Beverages with intense coloration were diluted either 1:5 or 1:10 with water or 5% acetic acid to fall within the range of the standard curve. Following sample preparation, 200 µL of sample was loaded in triplicate onto a FALCON (Franklin Lakes, NJ) 96-well flat bottom assay plate, catalog number 353228.

Spectrophotometric analysis was done using a Power Wave X spectrophotometer (Bio Tek Instruments, Winooski, VT). Wavelengths used were 500 nM for Red #40, 525 nM for Red #3, 425 nM for Yellow #5, 480 nM for Yellow #6, 630 nM for Blue #1, 610 nM for Blue #2, and 625nM for Green #3. For samples containing lakes, 5% acetic acid was used as a blank, otherwise water was used. Blank absorbance values were subtracted from the sample absorbances accordingly. Results from the spectrophotometer, in mg/mL, were multiplied by 240 mL/8oz to calculate the total amount of each dye in 8 fluid ounces (fl oz).

Results

The results of the spectrophotometric analyses of 108 beverages, giving estimations of the total AFCs for 8-ounce (240 mL) servings, are found in Table 3. A total of 29 carbonated beverages were analyzed, and the amounts of total AFCs per serving ranged from 0.7 mg (Big Blue, Blue #1) to 34 mg (Faygo Redpop, Red #40). Forty-seven fruit flavored drinks or punches contained from 0.2 mg (Country Time Pink Lemonade, Red #40) to 52.3 mg (Kool-Aid Burst Cherry, Blue #1, Red #40). Analyses of 16 sports beverages found a total of dyes ranging from 1.1 (Propel Zero Sports, Blue #1, Red #40) to 22.1 mg (Powerade Orange, Yellow #6, Red #40) while there were from 0.7 (Full Throttle Blue, Blue #1, Red #40) to 18.8 mg (Full Throttle Red Berry, Blue #1, Red #40) in 16 energy drinks. Not surprisingly, Red #40 was used most commonly. Small amounts colored a few beverages pink (7 Up Cherry, 1 mg Red #40) with much larger amounts needed to produce a bright red color (Big Red, 24.3 mg Red #40 or Faygo Redpop, 34.2 mg). Red #40 with Blue #1 was also used to dye drinks a purple or grape color (Faygo Grape, 3.5 mg Blue 1, 11.6 mg Red #40). Yellow #5 colored beverages a clear, yellow shade while Yellow #6 was used to color beverages an orangey, golden color. Red #40 and Yellow #5 and/or Yellow #6, dyed beverages orange (Orange Crush, 16.6 mg Yellow #6, 17 mg Red #40). The few green beverages got their color from Yellow #5 and Blue #1 (Tum-E Yummy Green, Blue #1 0.2 mg, 5.8 mg Yellow #5). No beverage listed Green #3 or Red #3 on its label. Blue #2 was not used in any of the samples because in solution it rapidly fades when exposed to acids, alkali, and sugars.[32] Some products were dyed with both Yellow #5 and Yellow #6 (Tang, 24.6 mg Yellow #5, 18.2 mg Yellow #6). Since the wavelengths for these 2 yellow dyes overlap, only one color was selected (the larger concentration of the two) to calculate the total AFCs. The choice of 240 mL to represent one serving was conservative—many carbonated beverages come in 12-fl oz cans and bottles or even larger plastic bottles while sports and energy drinks come in 16 fl oz or more plastic bottles or aluminum cans.

Table 3. Amounts of Artificial Food Colors (AFCs) in Milligrams in 108 Beverages per Serving (240 mL ≈ 8 Fluid Ounces).

	No. Tested	Predominate AFCs	Lowest Amount of Total AFCs (mg)		Highest Amount of Total AFCs (mg)		Median (mg)
Carbonated soft drinks							
Red, strawberry, cherry, pink	10	Red #40	7 Up Diet Cherry	0.9	Faygo Redpop	34.2	11.3
Orange	9	Red #40, Yellow #5	Nihi Peach	1.9	Orange Crush	33.6	24.9
Yellow, lemon, citrus	4	Yellow #5	Generic Citrus	1.2	Faygo Moon Mist	6.8	3.8
Blue, purple, grape	6	Red #40, Blue #1	Big Blue	0.7	Faygo Grape	15.1	11.7
Fruit juice drinks and punches							
Red, strawberry, cherry, pink	19	Red #40	Country Time Pink Lemonade	0.2	Kool-Aid Burst Cherry	52.3	15.5
Orange	11	Yellow #5 and #6, Red #40	Kool-Aid Jammer Peach-Mango	2.4	Sunny D Orange Strawberry	41.5	9.9
Yellow, lemon, citrus	6	Yellow #5	Sunny D Tangerine-Strawberry	1.3	Sunny D Citrus Punch	26.6	4.5
Blue, purple, grape	9	Blue #1, Red #40	Tum-E Yummy Glue	0.3	Little Hug Grape	15.4	4.7
Green, lime	2	Yellow #5, Blue #1	Tum-E Yummy Green	6.0	Hawaiian Punch Green	19.0	12.5
Sports drinks							
Red, strawberry, cherry	4	Red #40	Gatorade Fruit Punch[a]	13.2	Powerade Fruit Punch	17.4	17.4
Orange	2	Yellow #5,# 6, Red #40	Gatorade Orange[a]	3.2	Powerade Orange	22.1	12.7
Yellow, lemon, citrus	3	Yellow #5	Gatorade Lemon Lime[a]	3.4	All-Sport Lemon Lime	6.1	3.8
Blue, purple, grape	6	Blue 1	Propel Zero Sport	1.1	Gatorade Blueberry Pomegranate[a]	2.6	2.3
Green	1	Blue #1, Yellow #5	Powerade Sour Melon	11.1	Powerade Sour Melon	11.1	11.1
Energy drinks							
Red, strawberry, cherry	6	Red #40	AMP Cherry Energy Burst	2.3	Full Throttle Red Berry	18.8	8.2
Orange	1	Yellow #5	HyDrive Energy Orange	6.7	HyDrive Energy Orange	6.7	6.7
Yellow, lemon, citrus	3	Yellow #5	Full Throttle Citrus	5.4	NOS Original	7.6	7.3
Blue, purple, grape	6	Blue #1, Red #40	Full Throttle Blue	0.7	AMP Grape	8.2	1.7

[a]Low calorie.

Discussion

The concentrations of AFCs per unit volume reported in Table 3 are similar to amounts that were reported several decades ago. In 1968, the Certified Color Industry published a list of processed foods in which certified colors were used.[33] The report showed that beverages (liquid and powdered) contained a wide range of concentrations from 5 to 200 ppm (1.2 mg/240 mL to 48 mg/240 mL). These results are similar to Table 3 in which the range is 0.2 to 52.3 mg/240 mL. In 1980, the *CRC Handbook of Food Additives* reported colors and concentrations in carbonated beverages for various flavors: strawberry and cherry, 14.4 to 24 mg/mL; orange, 12 to 18 mg/240 mL, lemon; grape, 4.8 to 18 mg/240 mL.[27] These too are in ranges similar to those in Table 3. Although carbonated drink consumption has declined since 2000 (53.0 gallons/person/year in 2000 to 44.6 gallons/person/year in 2011), there have been increases in the number of different beverages available, serving sizes, and consumption of fruit juice drinks (3.7 gallons/person/year in 2000 to 4.7 gallons/person/year 2011).[34] Although Gatorade had been formulated in 1965 for athletes, sports beverages generally entered the market in the early 1990s and energy drinks a decade later. Their sales continue to increase each year.[34] For example, sports drink have increased from 2.2 gallons/person/year in 2000 to 4.3 gallons/person/year in 2011. Sales of energy drinks were up 16.6% in 2011 compared with 2010.

According to *Beverage Digest Fact Book 2012*, a statistical yearbook of nonalcoholic beverages, in 2011 the average American consumed an estimated 44.6 gallons of carbonated beverages drinks, 4.7 gallons of fruit juice drinks, 4.3 gallons sports beverages, and 2.4 gallons of powdered drinks.[34] Although not every brand of the 108 beverages analyzed for this study was listed in the *Beverage Digest Fact Book*, of the 29 brands of carbonated beverages, intake in millions of cases (1 case = 192 fl oz) sold in 2011 in the United States ranged from 5.1 million cases (Diet 7 Up Cherry) to 623.8 million cases (Mountain Dew). Of the 47 fruit-flavored drinks, volume ranged from 0.3 million cases (Crystal Light Pink Lemonade) to 20.5 million cases (Hawaiian Punch). Of the 16 sports beverages, sales ranged from 12.1 million cases (All-Sport beverages) to 561.0 million cases (Gatorade). Sales of energy drinks ranged from 1.2 million cases (HyDrive beverages) to 13.5 million cases (AMP beverages).

Estimating the amounts of AFCs in beverages and foods that children consume is important for designing new challenge studies. Combining the data in Table 3 with the beverage intake data, it is possible that, depending on the beverage choice and the serving size, the amounts of AFCs consumed in beverages could range from less than a milligram to 90 mg or more. For example, if a child drank 2 cans (720 mL) of a bright red or orange beverage he or she could consume more than 90 mg of AFCs in just these beverages without considering AFCs in the rest of the diet. On the other hand, if a child consumes the equivalent of 2 cans of a slightly colored beverage, he or she would consume only a couple of milligrams of AFCs.

The early behavioral studies that used only 26 to 27 mg of mixed dyes were not representative of what many children were consuming. (See Table 2, which lists the amounts of different AFCs consumed in the United States by children in 1977. These data were compiled by the joint efforts of food manufacturers and the Food and Nutrition Board of the National Academy of Sciences.) In these older studies, the children were challenged with even lower amounts of each dye. For example, only 10, 7, and 6 mg of Red #40, Yellow #5, and Yellow #6, respectively, were given in the 27-mg challenge mixture. Of the 10 red carbonated beverages listed in Table 3, in a 240-mL serving, 6 exceeded 10 mg of Red #40 and in 9 orange sodas all but one contained more than 7 and 6 mg of Yellow #5 and Yellow #6, respectively. Swanson and Kinsbourne[9] reported that 17 of 20 children reacted to a challenge of 100 to 150 mg of an AFC mix as assessed by a learning task. Pollock and Warner[10] reported reactions to a 125-mg mix of AFC in 8 of 19 children based on a parents' standard rating scale. Rowe and Rowe[11] reported a dose–response effect of Yellow #5 of 1 to 50 mg in 34 hyperactive children. Studies using 50 or more milligrams of dyes were often criticized and dismissed as containing too much color. Williams et al[13] commented about their study in which only 3 of 26 children responded to the AFC challenge, "It is relatively certain that the amount of artificial colors in a commercial food would be a fraction of the amount in the challenge cookies [26 mg]." Clearly, that was not true in 1978 or now.

Based on 2 studies in the United Kingdom,[35,36] in July 2010 the European Union began to require warning labels on foods that contained AFCs stating that the product might cause hyperactive and inattentive behavior in some children. Unfortunately, these 2 studies challenged children with a mixture of AFCs plus sodium benzoate, a preservative. Therefore, they could not conclude whether the changes in behavior were due to the dyes, the sodium benzoate, or the combination. In the United States, the Center for Science in the Public Interest petitioned FDA to require warnings on food labels or a ban of AFCs. The FDA committee, after a 2-day meeting of listening to experts, did not find enough evidence to ban or require warning labels. The vote, however, was close, 8 to 6. They concluded that current evidence did not establish a causal relationship between consumption of AFCs and hyperactivity in most children although they did acknowledge for the first time that dyes adversely affected a subset of sensitive children. However, 93% of the committee recommended that more studies are warranted, including a "robust intake estimate."[37]

Important questions about the role of AFCs in childhood behavioral problems remain. Do AFCs cause behavioral changes in a subset of a general population of children with and without attention-deficit/hyperactivity disorder as suggested by Bateman et al[35] and McCann et al?[36] If so, which AFCs are responsible for behavioral changes? Although Red #40 is the most widely used AFC certified by the FDA, does it produce behavioral changes in children? Is there any synergistic action of a mixture of AFCs? How much AFCs should be used for future challenge studies in the United States? To answer the last question, measurement of AFCs in artificially colored foods commonly consumed by children should be undertaken followed by a study of how much of these beverages and foods American children consume each day by obtaining food frequency records and calculating the amount of dyes in the selected foods and beverages per child. These data can be used to choose reasonable amounts of AFCs in future challenge studies.

Clinical Suggestions

Parents who wish to try a dye-free diet should be encouraged to read ingredients lists on all products they purchase. Any beverage that has a color with a number (ie, an AFC) should be avoided—for example, Red #40 or Yellow #5. However, not all beverages are dyed. Among carbonated sodas Sprite, 7 Up, Squirt, and Sierra Mist are clear and do not contain dyes. Some brands of fruit drinks and sports drinks have flavors that are dyed with AFCs while other flavors are not. For example, Powerade White Cherry has no dye but all the other Powerades are colored with AFCs. Snapple Green Tea, Sweet Tea and Peach are uncolored but Very Cherry and Grape Punch have Red #40. All natural Snapple beverages have either vegetable-based dyes or no dyes. Of the energy drinks, Monster Energy has no AFCs, but Red Bull lists "colors" with no further explanation. Rockstar Lemonade has no AFCs, Rockstar Energy Drink has caramel coloring, but Rockstar Blue contains Blue #1 as does Rockstar Fruit Punch (Red #40 and Blue #1). Most of the beverage powders like Kool-Aid and Wylers have AFCs, but Crystal Light Pure uses turmeric for color and no AFCs. Crystal Light Natural Lemonade has Yellow #5 so the term "natural" does not necessarily mean no AFCs. There are many pure, 100% fruit juices available such as Juicy Juice, Ocean Spray, Minute Maid, and Welch's. Of course, parents should be reminded that all sugar-sweetened beverages can be a major source of unwanted calories for children and can promote dental decay, and even pure fruit juices are high in natural sugars and calories. Furthermore, in 2011 the American Academy of Pediatrics stated that children should not consume energy drinks and rarely need sports drinks.[38]

Conclusion

Most sweetened and artificially sweetened carbonated beverages, fruit drinks and punches, sports drinks, and energy drinks are dyed with either caramel color or AFCs in widely varying amounts. Many of these beverages are consumed daily by children in the United States. Estimating average intake of AFCs in the total diet would greatly benefit the design of challenge studies to test the effects of AFCs on behavior.

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