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ADVANCES IN PEDIATRIC RESEARCH

Consumption of artificial food colourings by school children in the Netherlands

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Abstract

Background: There is on-going controversy as to whether food colourings can cause symptoms of attention deficit hyperactivity disorder (ADHD) in children. The aim of our study was to assess which artificial food colourings children in Amsterdam, the Netherlands, consume, and in what quantities.

Methods: A variety of products available in supermarkets and grocery shops in Amsterdam were surveyed for the presence of artificial food colourings (2012–2013). Subsequently, daily intake of artificial food colourings were assessed in a convenience sample of children (n=121, median age 7.0, range 5–12 years, 50% boys) using a three-day prospective food diary (two weekdays and one day at the weekend), and compared to the acceptable daily intake (ADI).

Results: Seventy-three of 550 (13%) products from supermarkets, groceries, and Turkish and Moroccan shops contained artificial food colourings, predominantly in sweets (33%) and (carbonated) beverages (31%). Brilliant Blue (E133), Patent Blue (E131) and Indigotine (E132) were most often encountered.

Of the 121 children surveyed, 18 (15%) consumed artificial food colourings, though only Brilliant Blue (E133), Patent Blue (E131), Indigotine (E132) and Green S (E142) were encountered. The mean intake varied from 0.02–0.96 mg/kg/day, which is below the ADI (5–15 mg/kg/day). None of the children consumed yellow, orange or red artificial food colours.

Conclusions: Intake of artificial food colourings in children in Amsterdam is well below the acceptable daily intake (ADI) and is limited to Brilliant Blue (E133), Patent Blue (E131), Indigotine (E132) and Green S (E142).

Citation: Kist-van Holthe J, Altenburg TM, Bolakhrif S, el Hamdi L, Man MW, Tu J, Chinapaw MJ (2015) Consumption of artificial food colourings by school children in the Netherlands. Adv Pediatr Res 2:5. doi:10.12715/apr.2015.2.5

Received: February 5, 2015; Accepted: February 19, 2015; Published: March 3, 2015

Competing interests: The authors have declared that no competing interests exist.

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Introduction

For nearly forty years there has been controversy over whether food colourings can cause symptoms of attention deficit hyperactivity disorder (ADHD) in children [1]. Children with ADHD have symptoms of inattention and/or hyperactivity–impulsivity, often experience problems at school and with interactions with family and friends, and have emotional disturbances. Furthermore, children with ADHD are prone to addiction and anti-social behaviour [2]. ADHD is diagnosed in approximately 5% of children in Europe and 8% of children in the United States [3, 4]. A recent meta-analysis estimated that

approximately 8% of children with ADHD may have symptoms caused by artificial food colourings [5]. However, the 24 studies included in this meta-analysis have major limitations: small samples of highly selected children, imperfect blinding and non-standardised outcome measures. There is a need for further high quality research to determine whether artificial food colourings are responsible for negatively affecting behaviour in children. Two well-designed and executed studies from the meta-analysis (performed by the same investigator group in Southampton, UK) found that artificial food colourings have a significant adverse effect on the behaviour of children with and without ADHD [6, 7]. This prompted the European Union (EU) to dictate that food ingredients labels should not only include a list of the artificial food colourings used in the product, but also to state that these additives may have an adverse effect on activity and attention in children [8]. Remarkably, based on the same studies, the United States Food and Drug Administration (FDA) concluded that the evidence linking food colourings to hyperactivity was inconclusive and insufficient to recommend warning labels for products containing artificial food colourings [9].

In the 1970s, children in the United States were estimated to consume on average 76 mg of artificial food colourings per day, with 10% consuming 121–146 mg per day [10, 11]. More recently, for nine countries in the EU, including the Netherlands, the European Food Safety Authority (FSA) calculated a much lower average intake per artificial food colouring, varying from 0.02 to 2.4 mg/kg per day [12–14]. These numbers imply a wide range and, at present, it is not known precisely which artificial food colourings, or exactly how much of them, Dutch children consume. Therefore, the aim of our study was to assess which artificial food colourings children in Amsterdam consume, and in what quantities.

Methods

General outline of the study

The study comprised two elements: first was a food product study in which the number of artificial food colourings present in products for sale at a variety of supermarkets in Amsterdam was assessed. Secondly, the daily intake of artificial food colourings by children in Amsterdam was estimated by way of a food diary study, and these results compared to the acceptable daily intake (ADI). The study was performed in Amsterdam, the Netherlands, between September 2012 and December 2013.

Food product study

Two Research Assistants checked food and beverage products for sale in 40 supermarkets, grocery shops, and Turkish and Moroccan grocery shops in Amsterdam for the presence of artificial food colourings. Food and beverages not usually consumed by children, for example alcoholic beverages or very spicy foods, were not included in the study. Likewise, products for which the use of artificial food colourings is prohibited (e.g. bread, milk) were excluded from the study.

Food diary study

To recruit a representative sample of children aged 5–12 years, a random selection of 30 of the 194 primary schools in Amsterdam was drawn using a random selection computer program (Excel). The schoolmasters of each of the 30 schools were approached by email, with 15 then being contacted in person due to non-response to the email. Schoolteachers were asked to distribute food diaries among the children in their class to take home to their parents.

Parents were asked to prospectively record the foods and beverages consumed by their child(ren) over a three-day period (two weekdays and one day at the weekend), including the exact amount and the brand. As Amsterdam is a multicultural city the food diaries were translated into Arabic, Turkish and Chinese, and were available in hard copy as well as a digital version. The parents were asked to note the age, gender and weight of each child, and the ethnicity of both parents.

In an effort to obtain data on the exact amounts (mg/100g) of artificial food colourings used in specific products, the manufacturers were contacted by email and asked to disclose this information. Unfortunately, none chose to reveal the quantity of

artificial food colourings used in their products because the recipes were closely guarded secrets. Therefore, an estimate of the quantity of artificial food colourings in each product was calculated using the maximum allowed concentration of artificial food colourings in alcohol-free beverages (100 mg/l), and in sweets (300 mg/kg) [15].

In four cases, the weight of the child was not available so the mean weight for Dutch children in terms of age and gender was used to calculate the intake of artificial food colourings for these children in mg/kg/day [16]. The software program IBM SPSS Statistics version 20.0 (IBM Corp. Armonk, NY) was used to calculate artificial food colouring intake.

Results

A total of 550 different products from 40 supermarkets, grocery shops, and Turkish and Moroccan shops were checked for the presence of artificial food colourings. Seventy-three of 550 (13%) products contained artificial food colourings, predominantly in sweets (45 of 138 types of sweets, 33%) and (carbonated) beverages (9 of 29 types of beverages, 31%). Table 1 denotes the number of products per food category containing artificial food colourings. Table 2 shows the type and frequency of artificial food colourings encountered.

Of 1081 children from four schools who agreed to participate in the study, 121 (11%) replied and returned a food diary. Eighteen (15%) of these children consumed artificial food colourings. Table 3 shows the characteristics of these children. Because recruitment of children through schools was limited (827 diaries were distributed but only 73 diaries returned) we also distributed food diaries to children attending five after-school care facilities (115/19), two sports clubs (70/3) and children taking Chinese lessons (69/26). Table 4 denotes the estimated intake by children of artificial food colourings (mg/kg/day).

Table 1. Number of observed products per food category containing artificial food colours

Food category	Products containing artificial food colourings n/total studied (%)
Sweets	45/138 (33)
Carbonated beverages	9/29 (31)
Juices/non-carbonated beverages	6/55 (11)
Sandwich filling	6/59 (10)
Cookie, cake	1/29 (3)
Sauces	1/61 (2)
Ice cream	2/19 (11)
Cereal	1/8 (13)
Salty snacks	1/24 (4)
Milk/milk products	-/39 (-)
Ready-made food	-/28 (-)
Canned food/in glass container	-/16 (-)
Instant food mix	-/24 (-)
Soup	-/7 (-)
Miscellaneous	5/14 (1)
Total	73/550 (13.3)

Table 2. Types of artificial food colouring and frequency with which they were encountered in 73/550 (13.3%) products

Artificial food colours	Number of times encountered
E102 Tartrazine	9
E104 Chinoline Yellow	2
E110 Sunset Yellow	8
E122 Azorubine	3
E124 Ponceau 4R	3
E129 Allura Red	7
E131 Patent Blue	17
E132 Indigotine	12
E133 Brilliant Blue	41
E142 Green S	2
Total	104*

*Some of the 73 products contained more than one artificial food colouring

Table 3. Characteristics of the children (n=121)

Age (years) median, range	7.0 (5–12)	
Gender* n (%)	Male	Female
	60 (50)	57 (47)
Ethnicity	Mother n (%)	Father n (%)
Dutch	60 (49.6)	59 (48.8)
Moroccan	18 (14.9)	16 (13.2)
Chinese	21 (17.4)	25 (20.7)
Other	6 (5.0)	5 (4.1)
Missing value	16 (13.2)	16 (13.2)

*4 missing

Table 4. Estimated intake of artificial food colouring by children (n=18, mg/kg/day)

n	E 131	E 132	E 133	E 142	Total intake
1			0.39	0.96	1.35
2	0.06				0.06
3				0.38	0.38
4			0.01		0.01
5	0.23		0.11		0.34
6				0.28	0.28
7		0.02			0.02
8		0.02	0.005		0.025
9				0.29	0.29
10			0.43		0.43
11	0.19				0.19
12		0.02			0.02
13			0.02		0.02
14			0.01		0.01
15		0.04			0.04
16		0.09			0.09
17	0.11		0.11		0.22
18		0.14			0.14
Mean intake	0.15	0.06	0.13	0.48	
Max. intake	0.23	0.14	0.43	0.96	
Acceptable daily intake [15]	5.0	5.0	6.0	5.0	

Discussion

Artificial food colourings were found in a small percentage (13%) of 550 varied products from supermarkets and grocery shops, predominantly sweets (33%) and (carbonated) beverages (31%). Brilliant Blue (E133), Patent Blue (E131) and Indigotine (E132) were most often encountered. Interestingly, the six artificial food colourings used in the Southampton trials (Tartrazine, E102; Chinoline Yellow, E104; Sunset Yellow, E110; Carmosine, E122; Ponceau Red, E124; and Allura Red, E129) were rarely used in food products in the Netherlands [6, 7]. In the Netherlands, yellow, orange and red foods and beverages mostly contain natural food colourings. This suggests that manufacturers have taken measures to evade the use of artificial yellow, orange and red colours in food products after a change in EU legislation required products containing artificial food colourings to display a warning label about possible adverse effects on activity and attention in children [8]. The effects of blue and green artificial food colourings were not studied in the Southampton trials [6, 7], but these are the artificial colourings most consumed by children in the Netherlands.

In agreement with the findings of our study, a German study found that three artificial food colourings (Sunset Yellow, E110; Ponceau Red, E124; and/or Allura Red, E129) were encountered in less than 15% of more than 2500 food items including sweets and beverages [17].

It is noteworthy that the consumption of artificial food colourings in our sample was considerably lower than the ADI [15]. Although in Germany children consume different colours, the mean intake of artificial food colourings (0.16–0.50 mg/kg/day) was comparable to that found in our study [17]. In an Irish food survey 13–34% of 1035 children consumed one or more of the six artificial food colourings used in the Southampton studies [6, 7, 18]. Mean intake of the artificial food colourings (0.39–2.77 mg/day) among consumers was also well below the ADI for children [18]. In Kuwait on the other hand, four (Tartrazine, E102; Sunset Yellow, E110; Carmoisine, E122; and Allura Red, E129) out of nine food colourings exceeded the ADIs in children by factors of 2–8 [19]. In the United States a wide range of

artificial food colourings are currently used in food and beverages in widely varying amounts but no recent data on their intake in children exist [20]. For Australian children, dietary exposure to individual added colours was also below the ADI, even for high (90th percentile) consumers [21]. However, if artificial food colourings cause symptoms of ADHD in a sensitive subgroup of children, then these children should avoid such additives, and artificial colourings should no longer be used in food and beverages.

A weakness of the present study is its small sample size, and potential selection bias due to low response rates. It is possible that parents interested in healthy food may have been more inclined to participate in the study and return the food diary. This may have caused an underestimation of the consumption of artificial food colourings. Furthermore, the artificial food colouring contents were not analysed in foods, but were based on a calculation of the maximum allowable concentrations of food and drinks. It was also assumed that children's weights were correctly declared, but in some cases this might not have been true and misclassification and underestimation of true artificial food colouring intake might have occurred.

A strength of our study is the combination of product research and the three-day prospective food diary survey to estimate artificial food colouring intake by children in Amsterdam.

Conclusions

Intake of artificial food colourings by children in Amsterdam is considerably lower than the acceptable daily intake (ADI) and is limited to Brilliant Blue (E133), Patent Blue (E131), Indigotine (E132) and Green S (E142).

Acknowledgments

We would like to thank all children and their parents for participating in the study.

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