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ORIGINAL ARTICLE

SURVEY ON FOOD DYES ADDITIVES IN FOOD PRODUCTS COMMONLY CONSUMED BY ALGERIAN CHILDREN

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ABSTRACT

Background. Children are generally attracted to colorful foods. However, some food dyes are suspected of exacerbating the activity of children and inducing other health problems that can reach reprotoxicity and carcinogenicity.

Objective. This study aims to explore the presence of dyes such as E102, E104, E110, E121, E122, E123, E124, E127, E129, E132, E133, E143 and E171 in food products widely consumed by children in Algeria notably sweets and chocolates, beverages and ice creams, yogurts and biscuits.

Material and Methods. This work was carried out on 228 products including 57 biscuits, 47 drinks and ice creams, 20 yogurts and 104 sweets and chocolates. Information mentioned on the composition label of this products were recorded to determine the presence of studied dyes.

Results. Here, we report the abundance of the yellow dyes E102 (24.1%) and E110 (18%) in the tested products. Also, apart from E121, all the other assessed dyes were found. Sweets and chocolates are the products containing the most studied dyes. The analysis of the presence of combinations of these dyes shows that 7% of analyzed foods contain 2 dyes in their composition while 20% of the products contain at least 3 dyes at the same time. Additionally, 37.5% of sweets and chocolates contain a combination of at least 3 dyes in their ingredient list.

Conclusions. In overall, except the E121, all assessed dyes were identified on the labels of food products widely consumed by children which encourage parents to be made aware of the risks associated with the ingestion of omnipresent dyes in children's diets.

Keywords: *food additives, food dyes, children, health risks, hyperactivity disorder*

INTRODUCTION

Lured by their sweet taste and flabbergasted by their smell and shape, children are obsessed with sweets in general, especially candies. This temptation is even greater if the candy is brightly coloured. In fact, the dye, influences the decision to purchase, given its psychological influence on the perception of taste [1, 2]. As a result, confectionery manufacturers "use and abuse" the use of food dyes.

Behind their cheerful and colorful appearance, food dyes hide unpleasant surprises. Their consumption is probably linked to the increase of hyperactivity disorders in children. This concerns yellow dyes E102, E104 and E110 as well as red dyes E122, E124 and E129 [3]. Apart from this study, the suspicion of a potential effect of synthetic dyes on the exacerbation of activity and disturbance of attention in children has been mentioned in 16 other scientific studies [4]. These studies had repercussions on the marketing policy for coloured sweets in Europe. Since 2010, confectionery manufacturers in this continent have had the obligation to specify the statement "may have a harmful effect on the attention of children" on the packaging of candies containing these dyes [5].

In addition to the disruption of the activity of children, food dyes would be potentially implicated in other human health concerns. In individual works it was stated that for instance, dyes E102, E110, E129 and E133 would be the cause of hypersensitivity reactions [6, 7]. On the other hand, dyes E127 and E102 would be reprotoxic. More specifically, these dyes would be

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the cause of a decrease in reproductive performance in male mice characterized by a reduction in the number of spermatozoa and an increase in abnormalities in these cells [8]. Much more serious, the dyes from petrochemical synthesis E102, E110 and E129 are contaminated with carcinogens [6, 7]. Aside from dyes E110 and E129, dyes E123, E124 and E171 are at the origin of genotoxicity characterized by the induction of DNA damage [6, 7, 9, 10]. Also, the consumption of dyes E110, E129 and E171 or dyes E121, E127, E132 and E143 was found related to the triggering of different types of tumors [6, 7, 11].

It should be emphasized that the following dyes: E121, E143 and E171 are not currently approved for use in food in the European Union (Commission Regulation (EU) No 231/2012 of 9 March 2012 laying down specifications for food additives listed in Annexes II and III to Regulation (EC) No 1333/2008 of the European Parliament and of the Council, with further ammendments).

Apart from the specific name of the dye and its E code, manufacturers in the agri-food sector in Algeria are under no legal obligations to supply any additional information on the packaging of confectioneries [12]. Therefore, our work aims to assess the presence of dyes responsible for infantile hyperactivity E102, E104 and E110 as well as other dyes likely to trigger health problems, in particular E121, E123, E127, E132, E133, E143 and E171 in food products widely consumed by children in Algeria, namely sweets and chocolates, drinks and ice creams, yogurts and biscuits.

MATERIAL AND METHODS

This is a cross sectional study on the presence of the dyes such as E102, E104, E110, E121, E122, E123, E124, E127, E129, E132, E133, E143 and E171 in food products widely consumed by children. in Algeria namely sweets and chocolates, drinks and ice creams, yogurts and biscuits. This work was carried out during the periods of March-April 2022 and June-September 2021 in convenience stores and supermarkets in the Djelfa region of Algeria. Indeed, the information on the packaging of 228 products (57 biscuits, 47 drinks and ice cream, 20 yogurts and 104 sweets and chocolates) concerning the name, brand, price, composition and origin were recorded. Of note, the repetition of products over the 2 years of the study was eliminated (so that each product was considered only once) before the start of the analyses.

RESULTS

Analysis of the frequency of labeling aberrations

We first analyzed the compliance of sweets/chocolates, beverages/ice creams, yogurt and biscuits labeling regarding Algerian's labeling requirements for the indication of food dyes on the packaging. In other words, we assessed if the E code or the specific name of the dye used is clearly specified in the composition formula of analyzed products. Results reveal that 73.7%, 91.5%, 95% and 82.7% of biscuits, beverages/ice creams, yogurts and sweets/chocolates respectively displayed compliant labels (Figure 1a). However, 26.3% and 17.3% of the packaging labels of biscuits and sweets/chocolates contain anomalies. Regarding biscuits, data indicate that almost 21% of them are visually colored without any indication of dye additives on their label. This also applies to almost 9% of sweets/chocolates. The other labeling aberration observed for biscuits (5.3%) and sweets/chocolates (1.9%) is the presence of the statement "Food color" on the ingredient label without any specification of the E code or the specific name of the food dye additive used (Figure 1b).

Frequency of assessed food dyes in sweets and chocolates

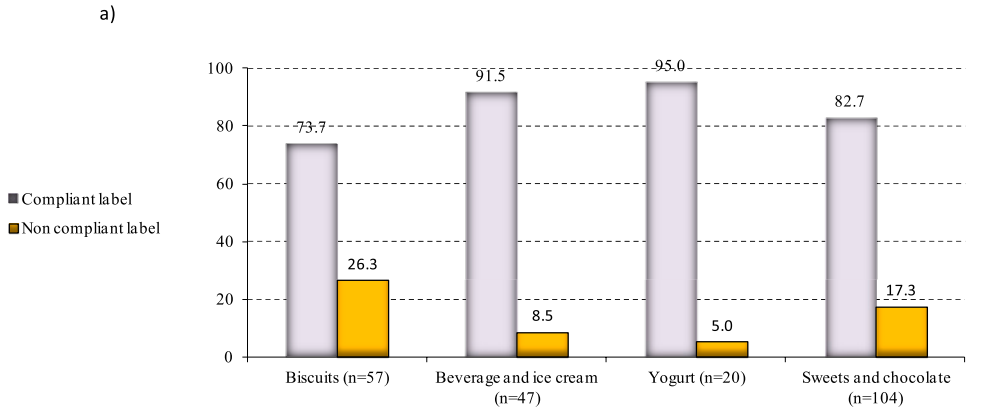
The existence of the food dyes such as E102, E104, E110, E121, E122, E123, E124, E127, E129, E132, E133, E143 and E171 have been studied in children's favorite treats; sweets and chocolates. Except the E121, results show the presence of all assessed food dyes. Indeed, the E102 is the most found dye (almost 39%). In addition, dyes E110, E124, E129, E133 and E171 were found in 28.8%, 23.1%, 17.3%, 24%, and 20.2% of sweets/chocolates respectively. In contrast, reds E122, E123, and E127 were recorded in 9.6%, 4.8%, and 5.8% of sweets/chocolates labels respectively. The results also indicate the presence of the yellow E104 (4.8%), the blue E132 (1%) and the green E143 (almost 3%) (Figure 2).

Frequency of assessed food dyes in biscuits

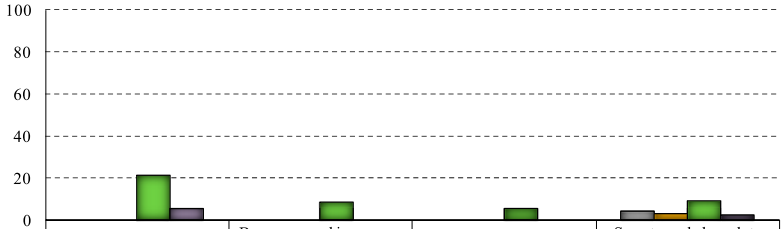
Being regularly consumed by children, biscuits were also the subject of our investigation on the presence of food dyes, in particular E102, E104, E110, E121, E122, E123, E124, E127, E129, E132, E133, E143 and E171. Our results show that red E122 (17.5%) is the most popular among the list of assessed food dyes. Also, dyes E102, E110 and E124 are each present in almost 9% of the analyzed biscuits. However, the E171 was found in 3.5% of biscuits and dyes E104, E123 and E133 were each recorded in almost 2% of biscuits (Figure 3).

Frequency of assessed food dyes in beverages and ice creams

Depending on household eating habits, beverages and ice cream can also be consumed by children or at least made accessible to them. Therefore, the labels of these foods were also searched for food dyes (E102,



b)



	Biscuits (n=57)	Beverage and ice cream (n=47)	Yogurt (n=20)	Sweets and chocolate (n=104)
Different combinations of dyes on the same composition label preceded by the statement "according to flavor"	0.0	0.0	0.0	3.8
Presence of an incomplete "2-digit" color code or the presence of a code of another additive among dyes	0.0	0.0	0.0	2.9
Colored product without indication of dye on composition label	21.1	8.5	5.0	8.7
The statement "food color" on the composition label without specifying the name or color code	5.3	0.0	0.0	1.9

Figure 1. Analysis of the labeling compliance. a) Frequency of labeling aberrations, b) Analysis of labeling anomalies

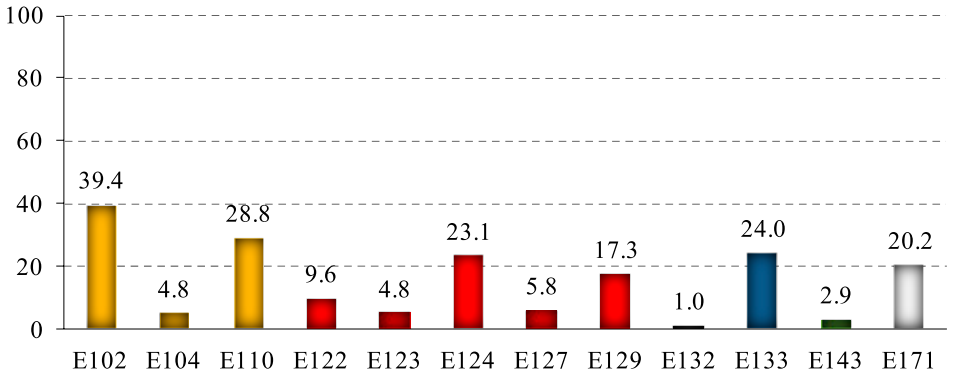


Figure 2. Frequency of assessed food dyes in sweets and chocolates

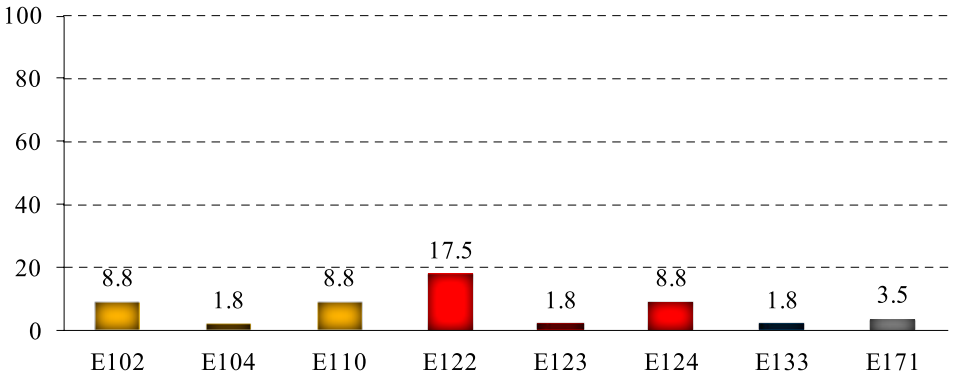


Figure 3. Frequency of assessed food dyes in biscuits

E104, E110, E121, E122, E123, E124, E127, E129, E132, E133, E143 and E171). The results report the existence of dyes E102 and E122 at an equal percentage (17%). We also note the presence of dyes E104, E110, E124, E133 and E171 in 6.4%, 10.6%, 4.3%, 8.5%, 2.1% and 6.4% of beverages and ice creams respectively. However, none of dyes E121, E123, E127, E132 and E143 were found (Figure 4).

Frequency of assessed food dyes in yogurts

Considering their importance in children's diets, yogurts were also included in our survey of food colorings. The same list of food dyes (E102, E104, E110, E121, E122, E123, E124, E127, E129, E132, E133, E143 and E171) assessed in the above foodstuffs was explored in yogurts. The E129 dye was the most common (15%) among the assessed food dyes. Furthermore, dyes E133 and E110 were each recorded in 10% of analyzed yogurts. However, dyes E102, E122 and E124 were found at an equal percentage of 5%. None of the dyes E104, E121, E123, E127, E132, E143 and E171 have been registered (Figure 5).

Frequency of assessed food dyes combinations

Finally, we tried to determine, among the products studied, the percentage of products containing 0, 1, 2 or 3 or more assessed food dyes. Some of the analyzed products do not contain any assessed food dyes. This corresponds to almost 54% of biscuits, almost 55% of beverages/ice creams, 60% of yogurts and almost 30% of the sweets/chocolates category. On the other hand, about 42% of biscuits, 25.5% of beverages/ice creams, 30% of yogurts and about 21% of sweets/chocolates contain studied food dyes in their manufacturing formula. More interestingly, about 11% of biscuits and 10% of yogurts contain combinations of 2 assessed food dyes. This is also true for 8% of sweets/chocolates. Surprisingly, 37.5% of sweets/chocolates contain at least 3 studied food dyes in their ingredient list. This kind of combination was also reported in 8.5% of beverages/ice creams and in 3% of biscuits (Figure 6).

DISCUSSION

The manufacture and marketing of food products containing food additives, in particular dyes, is governed, in Algeria, by executive decree no. 12-214 requiring the inclusion of the specific name and/or the E code of the used food dye on the product label [12]. The assessment of the application of these labeling guidelines in food products commonly consumed by children showed that 83.3% of the labels of analyzed products are compliant. This is representative of 73.7% of biscuits, 91.5% of beverages and ice creams, 95% of yogurts and 82.7% of sweets and chocolates. On the other hand, 16.7% of the tested product labels

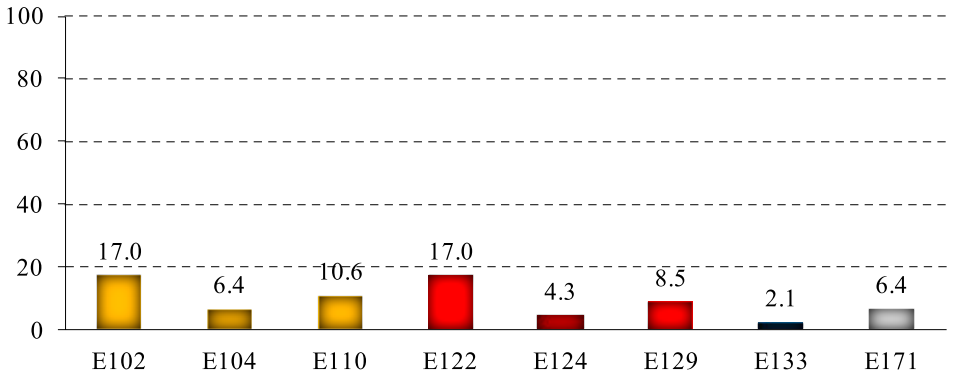


Figure 4. Frequency of assessed food dyes in beverages and ice creams

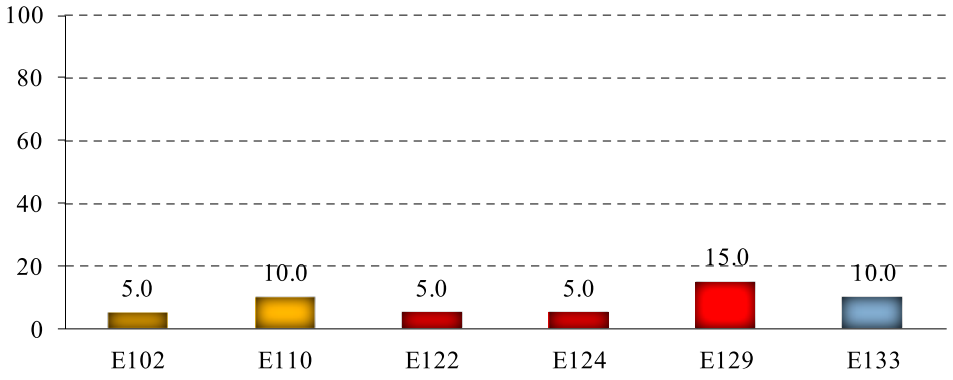
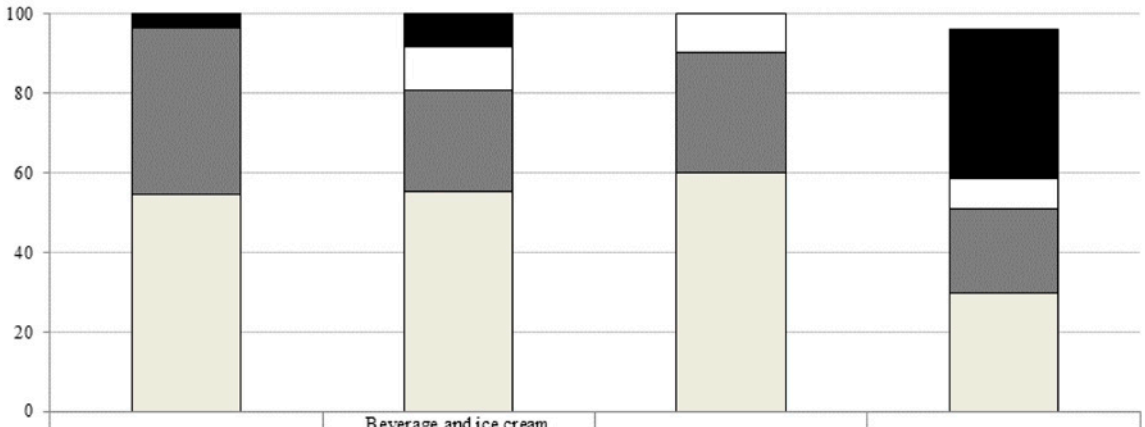


Figure 5. Frequency of assessed food dyes in yogurts



	Biscuits (n=57)	Beverage and ice cream (n=47)	Yogurt (n=20)	Sweets and chocolate (n=104)
3 or more	3.5	8.5	0.0	37.5
2	0.0	10.6	10.0	7.7
1	42.1	25.5	30.0	21.2
0	54.4	55.3	60.0	29.8

Figure 6. Frequency of assessed food dyes associations

(26.3% of biscuits, 8.3% of beverages and ice creams, 5% of yogurts, 17.3% of sweets and chocolates) proved to be non-compliant with Algerian labeling rules. These products had various labeling flaws, namely the absence of indication of the dye additive on the label despite the colorful appearance of the product, the presence of the statement "Food color" on the label without any specification of the dye additive specific name or its E code, display of an incomplete "2 digits" E code or indication of another food additive E code among food dyes as well as the inscription of several food dyes combinations on the same ingredient label preceded by the wording "according to flavor". In fact, the absence of indication of the coloring additive on the label despite the colorful appearance of the product cannot be considered as a real labeling problem given that these foods are made from fruit puree. In other situations, this aberration sometimes reflects another concern to be taken into consideration consisting of the use of the new flavoring technology called "flavoring paste" giving the product, in addition to the flavor, the taste and the dye. The problem with this concept of flavoring pastes is that these latter are made from food dyes without being able to detect them on the composition formula of the products containing these flavoring dough [13].

Also, the problem of the presence of an E code belonging to another family of food additives among the dyes could be explained by the fact that certain food additives have a coloring power despite their belonging to other categories of food additives (the case of egg yolk powder).

Apart from labeling loopholes, the closer analysis of the presence of dyes in products widely consumed by children in Algeria reveals that about 56% of the analyzed products are colored by dyes covered by our study. The yellow dyes E102 (24.1%) and E110 (18%) are the most popular among the studied food dyes. Indeed, the E102 is suspected of being responsible for the exacerbation of children's activity, contaminated by carcinogens, inducer of hypersensitivity reaction and reprotoxic [3, 6-8]. It was found in 34.9% of sweets and chocolates, in 17% of beverages and ice creams, in almost 9% of biscuits and in 5% of yogurts. Like the E102, the E110 is responsible for the increase in infantile hyperactivity disorders, the appearance of allergies, contaminated by a carcinogen in addition to its potential tumorigenic power for adrenal and testicular tissues [3, 6, 7]. This dye was also abundantly found in sweets and chocolates (almost 29%), in beverages and ice creams (almost 11%), in yogurts (10%) and in biscuits (almost 9%). These results are consistent with research carried out in Sri Lanka in 2019 and in India in 2013 [1, 14]. Specifically, Dilrukshi et al. 2019 [1] study showed that E102 (41%) and E110 (22%) were the most popular in confectionary and beverages in Sri Lanka. The predominance of E102 was also reported by dixit et al in 2013 in sweets and savories in India [14]. Even if the study carried out by Asif Ahmed et al the previous year in Saudi Arabia indicated the predominance of the dyes E133 (54.1%) and E128 (58.3%) among the food dyes of synthetic origin in the food products consumed by school going children in Saudi Arabia, this work showed that E102 and E110 existed in 42.3% and 39.1% of the products explored (chocolate, ice cream, juice and drinks, candy, jelly and gums), respectively [15].

In addition, the survey on the dyes used in the sweets sold in Muscat (Oman) showed that E133 was present in 13% of the analyzed candies [16]. In the present study, this dye was also found in 13% of studied products (sweets and chocolates 24%, yogurts

10%, beverages and ice creams 2.1%, biscuits 1.8%). Also, among the most popular food dyes in studies of dyes used in sweets sold in Oman and in children's consumed food products in Saudi Arabia are E129 (43.8% of Muscat candies and 33.9% of children's consumed food products in Sausi Arabia) and E171 (26% of Muscat candies) [15, 16]. Here, we report the presence of each of these 2 dyes in 11% of the tested products. If we focus on the results of this study, we see that sweets and chocolates are the most colorful products among the different products included in this study with a predominance of dyes E102 (39.4%), E110 (28.8%), E133 (24%), E124 (23.1%), E171 (20.2%). If it is trendy to discuss about the ability of food dyes E102, E110 and E124 to increase hyperactivity disorders in children, we must never forget that these dyes have been associated with other physiological disorders, in particular genotoxicity (E102 and E124), tumorigenicity (E110) and reprotoxicity (E102) [6-8, 10]. Like E102 and E110, E133 is involved in hypersensitivity reactions. Its ability to inhibit the development of nerve cells should also not be overlooked, especially when it comes to products consumed by growing children [6, 7]. In addition, E171 was also found to be present in almost a fifth of assessed sweets and chocolates. Prohibited, since 2020, in France and throughout the European Union, since 2022, this so-called "food color" is responsible for gastrotoxicity, hepatotoxicity, an alteration of the intestinal flora, the appearance of oxidative stress, genotoxicity and is carcinogenic [6, 7, 9, 11, 17].

On the other hand, we also note the absence of the dye E121 in all the products covered by this study which could be explained by the fact that it is forbidden to use in Algeria [18, 19]. However, all other food dyes assessed in present survey are authorized by the Algerian low [12].

Before finishing, it is important to point out that the study of the frequency of combinations of dyes shows that 7% of the studied products contain a combination of 2 assessed dyes and 20% of the products contain at least 3 dyes. This result is all the more interesting knowing that the food categories containing the most combinations of dyes are sweets and chocolates, enough to leave any parent "speechless". Under the slogan "the aims justify means" manufacturers use and abuse of coloring additives without any hindsight on their misdeeds or at least their cocktail effect with the other additives present in the food. Given their psychological influence on the purchase decision and the perception of taste, the choice of coloring additives in the food industry is often motivated by the desire to obtain the most "enticing" confectionery or more generally food without any consideration of the repercussions on health. Inevitable in the food industry, these results encourage us to increase our vigilance towards food additives particularly food dyes which are ubiquitous in our meals and in those of our children especially since 37.5% of the sweets and chocolates studied contain a combination of at least 3 assessed dyes. In overall, it is extremely important to raise parents as well as children aware of the dangers associated with dyes contained in confectionery products and to instill in them a culture of reading food labels.

From legal standpoint, it would be very interesting to update the list of authorized dyes.

CONCLUSIONS

Overall, except the E121, the dyes such as E102, E104, E110, E121, E122, E123, E124, E127, E129, E132, E133, E143 and E171 have been identified in food products widely consumed by children without any particular statement on the label. Dyes E102 (almost 24%) and E110 (18%) are the most popular among tested food products. These dyes are present by 2 (7%) or even by 3 (20%). Sweets and chocolates are the food categories containing the most combinations by 3 assessed dyes (37.5%) which could be unfavourable for children health.

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Conflict of interest

The authors declare no conflict of interest.

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