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Survey of harmful dyes in food color additives in Algeria

Djihad Bencherit [1]*, Kheira Laoues [2], Imane Karboua [2], Mohamed Lounis [2]

[1] Department of Biology, Faculty of Natural and Life Sciences, University of Ziane Achour, Djelfa, ALGERIA
[2] Department of Agro-veterinary Science, Faculty of Natural and Life Sciences, University of Ziane Achour, Djelfa, ALGERIA
***Corresponding Author:** djihadbencherit88@gmail.com

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ABSTRACT

Food colors are pervasive in our diet. However, some of them are involved in health concerns reaching carcinogenicity and reproductive toxicity. This is a survey of prepackaged color additives marketed to the simple consumer in Algeria. This exploration aimed to assess the compliance of the labeling of color additives, as well as the investigation of the presence of harmful dyes, namely E102, E110, E 121, E122, E123, E124, E127, E129, E132, E133, E143, and E171, in their composition. Our findings reveal the labeling compliance of 50.5% of analyzed coloring products and the absence of ingredient labeling for 1.6% of analyzed coloring products. While 47.8% of the products displayed different labeling flaws. Except for the dyes E121, E129, and E143, the other requested dyes have been determined. In fact, dyes E102 (39%), E110 (23%), and E171 (20%) were the most frequent. Moreover, 32.6% of all analyzed coloring products included two harmful dyes. Surprisingly, almost 3% of all assessed coloring products provided three harmful dyes simultaneously. Taken together, these results encourage further investigations of the presence of harmful dyes in our food and to establish more stringent rules governing the marketing and the use of coloring additives.

Keywords: food, color additives, harmful dyes, food labeling, health risks

INTRODUCTION

Food additives are usually defined as substance or a mixture of substances with or without a nutritive value which are deliberately added to the food in any of its production steps to improve some of its characteristics lost during processing [1-3]. Several categories of food additives, including flavoring, preservatives, stabilizers, emulsifiers, antioxidants, and food colors, can be distinguished [4-7].

Widely used in foodstuffs industry, food colors enjoy a privileged position among the other additives. Generally nonnutritive and not consumed as a food, food colors represent any substance, dye or pigment mainly added to provide, enhance, or restore color of the final product making it more attractive for the consumer. In fact, Color is considered as a food quality indicator and is instantaneously impacting the consumers mind through sight [8-10]. They are indicated by the codes from E100 to E199 in the international list of food additives. Natural or synthetic, food colors are liberally used in food products such as candies, beverages, biscuits, pastries, chips, meat, dairy products, and chocolates. Discovered and used in food since long times, food colors have known a real development in the recent years. For example, the global market for these additives which was estimated at 1.7 billion USD has reached 2.1 billion USD for the year 2019. It is also predicted to attain a total of about 3.5 billion USD in 2027 [11]. Also, food industry technological advances have brought the requirement to design these color additives in different textures (gel, powder, liquid, and paste) and with different color's shades requiring the invention of complex chemical formulas combining one or even several dyes with other categories of food additives.

Despite their economic and industrial importance, several food dyes have been associated with serious health and environmental hazards. For example, colors E102, E110, E129, and E133 were associated with hypersensitivity reactions [12, 13]. Also, E102, E110, and E129 in addition to colors E122, E124, and E104 may trigger children's hyperactivity disorder [14]. Furthermore, the consumption of colors E127 and E102 has been linked to reproductive concerns [1]. More critically, dyes E102, E110, and E129 seem to be contamined with carcinogens [12, 13]. Colors E102 and E129 as well as colors E123, E124, and E171 were implicated in DNA damages induction and genotoxicity establishment [12, 13, 15, 16]. Moreover, ingestion of colors E110, E121, E127, E129, E132, E143, and E171 proved to be connected with tumor development [12, 13, 17].

Therefore, the use and the marketing of food colors are highly legislated worldwide. Indeed, multiple countries have listed their permitted and non permitted colors and the acceptable daily intake for the authorized ones. Despite harmonization efforts, there is no global consensus regarding permitted and prohibited colors lists [18]. In Algeria, coloring additives are of common use in industrial products as well as in pastries, especially traditional cakes. Hence, a panel of food coloring products is offered to the consumer, in different textures (gel, powder, liquid, paste, etc.), in all stores marketing packaging and pastry products. However, due to their availability and technological properties, indiscriminate and the hazardous use of colors has reached an alarming level.

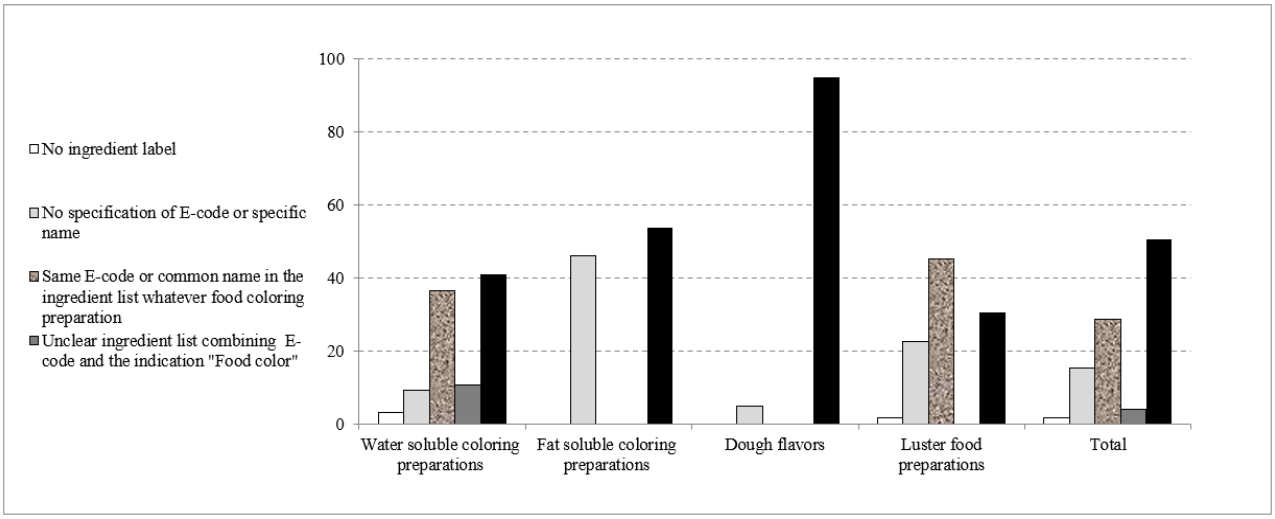

Figure 1. Conformity of food coloring products labeling (Source: Authors' own elaboration)

In this context, a survey was conducted to investigate the conformity of the labeling of color additives sold to the simple consumer as well as to explore the presence of harmful dyes especially E102, E110, E121, E122, E123, E124, E127, E129, E132, E133, E143, and E171 in the composition formula of these additives, namely water soluble color preparations, fat soluble coloring preparations, food luster preparation, and dough flavors.

METHODS

This study consists of a cross-sectional survey of food additives type food color sold in retail stores selling pastry and packaging products. It was carried out between June and September 2021. The collection of information in relation with the composition of the coloring products in question as well as the identification of harmful dyes was obtained from the labeling namely the ingredients list. In order to facilitate the understanding of this study, the term "food additive type food color" will be replaced by the mention "coloring preparation" to avoid any confusion between the terms in the following parts of this manuscript. The information mentioned on the labeling of different categories of food coloring products, namely water soluble coloring preparations (used to color conventional water-based food preparations), fat soluble coloring preparations (used to color lipid-based food preparations especially chocolate), food luster preparations (used to give shinny shading to foods: edible highlighter) and dough flavors (flavoring paste giving taste, smell, and color to food preparations) has been collected. Thus, the labeling data of 182 coloring preparations of several brands and textures (liquid, powder, and gel) were collected. Precisely, a mix of 66 water soluble coloring preparations of 11 brands, 13 fat soluble coloring preparations of three brands, 62 food luster preparations of 12 brands and 41 dough flavors of three brands were obtained.

The authorization of the store manager was obtained before recording all the information mentioned on the requested products packaging, namely the brand of the product, its category (water soluble, fat soluble, dough flavor, food luster), the texture (liquid, powder, and gel) the color given to the preparations, the composition, and the origin (local or imported). Only coloring products with packaging, labeling, and belonging to the water soluble coloring preparations, fat soluble coloring preparations, food luster preparations and dough flavors categories were included in this survey.

RESULTS

Conformity of Food Coloring Products Labeling

First of all, we have assessed the compliance of the food coloring products labeling with Algerian's labeling requirements. Hence, we investigated the ingredient label of each product and checked the presence, the clarity and the appropriateness of the details specified on the ingredient list regarding food colors code. In overall, 50.5% of analyzed products displayed a compliant label. This applies to ingredient lists of 95.1% of dough flavors, 53.6% of fat soluble coloring preparations, 40.9% of water soluble coloring preparations and 30.6% of food luster preparations. However, 3% of water soluble coloring preparations and 1.6% of food luster preparations were sold without ingredient label. Furthermore, almost half (46.2%) of fat soluble coloring preparations were sold without specification of either the food color's e-code or the specific name on their ingredient label. Equally, the ingredient list of 22.6%, 9.1%, and 4.9% of the investigated food luster preparations, water soluble coloring preparations, and dough flavors respectively contained the same labeling gaps. We also recorded that certain food coloring products brand displayed the same color e-code or common name in the ingredient list whatever the food coloring product. This concerns 45.2% of food luster preparations and 36.4% of water soluble coloring preparations. Otherwise, about 11% of the examined water soluble coloring preparations provided an unclear ingredient list combining a color e-code and the indication "food color" (**Figure 1**).

Assesement of the Occurrence of Harmful Food Dyes in Coloring Preparations

The frequency of harmful food colors, namely yellow colors E102 and E110, red colors E 121, E122, E123, E124, E127, and E129, blue colors E132 and E133, the green color E143 and the white color E171, were evaluated in coloring preparations. Of

Table 1. List of harmful food colors frequencies recorded in coloring preparations

Food color	Frequency
E102	39%
E110	23%
E121	0%
E122	10%
E123	2%
E124	13%
E127	1%
E129	0%
E132	7%
E133	5%
E143	0%
E171	20%

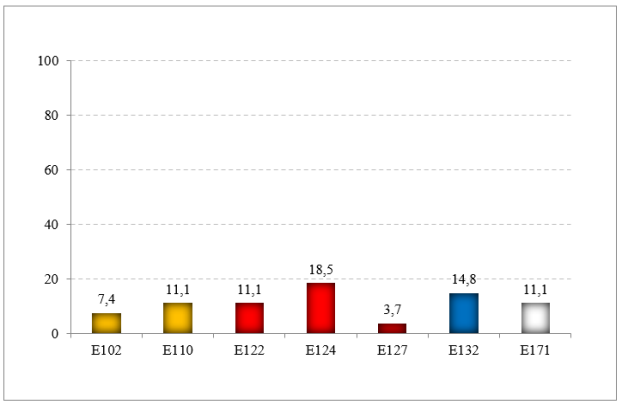

Figure 2. Frequency of harmful food colors in water soluble coloring preparations (Source: Authors' own elaboration)

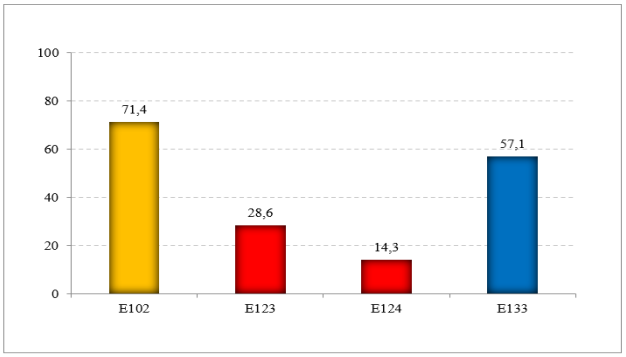

Figure 3. Frequency of harmful food colors in fat soluble coloring preparations (Source: Authors' own elaboration)

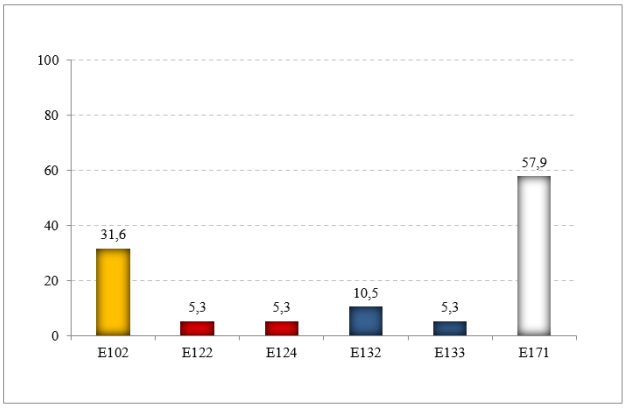

Figure 4. Frequency of harmful food colors in food luster preparations (Source: Authors' own elaboration)

note, only coloring preparations with compliant labeling (92 coloring products) were considered for the various analyzes in the rest of the manuscript. This represents 27 water soluble coloring preparations, seven fat soluble coloring preparations, 39 dough flavors and 19 food luster preparations. Generally, data indicate that E102 (39%), E110 (23%), and E171 (20%) are the most frequent. Red dyes E122, E123, E124, and E127 were identified in 10%, 2%, 13%, and 1% of the coloring products, respectively. Furthermore, blue dyes E132 and E133 were observed in 7% and 5% of the analyzed coloring products. However, the E121, E129, and E143 have not been registered in any coloring product (**Table 1**).

Investigation on the Occurrence of Harmful Food Dyes in Water Soluble Coloring Preparations

Food colors causing health concerns, indicated above, were assessed in water soluble coloring preparations. As illustrated in **Figure 2**, data revealed that E124 (18.5%) and E132 (14.8%) were the most observed among the investigated harmful food colors. In addition, each of the colors E110, E122, and E171 were detected in equal frequency of 11.1% of the analyzed water soluble coloring preparations. Also, dyes E102 and E127 were recorded in 7.4% and 3.7% of the water soluble coloring preparations. However, none of the dyes E121, E123, E129, E133, and E143 were recorded in any of the analyzed coloring preparations.

Investigation on the Frequency of Harmful Food Dyes in Fat Soluble Coloring Preparations

In the same way for water soluble coloring preparations, harmful food colors have also been searched in composition label of fat soluble coloring preparations. Only, food colors E102, E133, E124, and E123 were found. Colors E102 and E133 were the most widespread with a frequency of 71.4% and 57.1% respectively. Colors E123 and E124 were identified in 28.6% and 14.3% of the examined fat soluble coloring preparations (**Figure 3**).

Investigation on the Occurrence of Harmful Food Dyes in Food Luster Preparations

The assessment of harmful food dyes (E102, E110, E121, E122, E123, E124, E127, E129, E132, E133, E143, and E171) were also performed in food luster preparations. More than half (57.9%) of the examined food luster preparations contained the E171. About 31.6% of luster products contained the E102 while the E132 were identified in 10.5% of luster preparations. Dyes E133, E124, and E122 were identified each in 5.3% of the analyzed luster preparations respectively. However, dyes E110, E121, E123, E127, E129, and E143 were not identified (**Figure 4**).

Assessment of Harmful Food Dyes in Dough Flavors

Considering the coloring strength of dough flavors, we also studied the presence of harmful food colors in their composition. The results (**Figure 5**) reveals that yellow colors E102 and E110 were identified each in almost half of dough flavors. Indeed, the E102 color were found in 59% of dough flavors. Also, the E110 were identified in 46.2% of examined dough flavors. In the other hand, each of the red colors E124 and E122 were present in 12.8% of the assessed dough flavors. Moreover, 10.3% of dough flavors contained the E171 color. Dyes E121, E123, E127, E129, E132, E133, and E143 were absent in all assessed dough flavors.

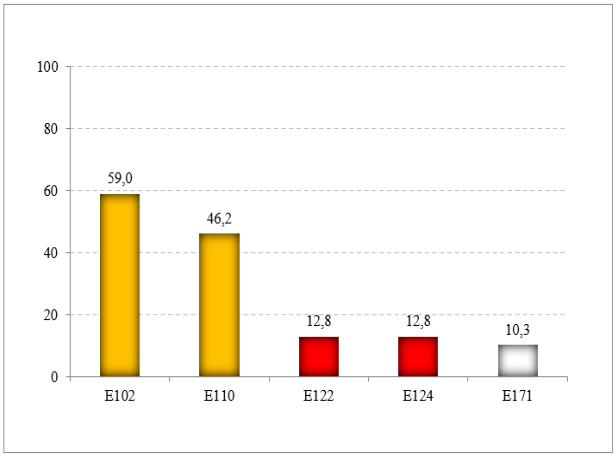

Figure 5. Frequency of harmful food colors in dough flavors (Source: Authors' own elaboration)

Association of Harmful Food Dyes in Analyzed Food Coloring Preparations

Among all of tested coloring preparations, 43.5% contained 1 harmful color. This applies respectively to 68.4%, 44.4%, 42.9%, and 30.8% of food luster preparations, water soluble coloring preparations, fat soluble coloring preparations and dough flavors examined in this study. Furthermore, 32.6% of all analyzed coloring products included two harmful dyes simultaneously. In fact, about half of dough flavors or fat soluble coloring preparations (51.3% and 57.1%, respectively) contained two harmful dyes. Association of two harmful colors was also found in the ingredient list of 11.1% of water soluble coloring preparations and 15.8% of food luster preparations. Surprisingly, almost 3% of all assessed coloring products provided three harmful colors simultaneously. This accords to 2.6% of dough flavors, 5.3% of food luster preparations and 3.7% of water soluble coloring preparations (**Figure 6**).

DISCUSSION

The first part of this work focused on the assessment of the coloring products labeling conformity with the Algerian labeling guidelines. Indeed, the Algerian executive decree No. 12-214 define Algeria's labeling requirements necessitating the indication of the specific (non-generic) name and/or the e-code of each food additive on the food label [19].

Among the analyzed coloring preparations, about 48% had labeling loopholes. In fact, almost 15% of coloring preparations had a food label specifying only the color's common name (without specific name or e-code). This applies to 46.2% of fat soluble coloring preparations, 22.6% of food luster preparations, 9.1% of water soluble coloring preparations and 4.9% of dough flavors. This result should be taken with a little hindsight for dough flavors. Indeed, this labeling problem in flavoring pastes can be a real labeling error as it can be explained by the absence of dyes in the chemical formulation of these preparations, given that the flavors in question, vanilla, and lemon, are not necessarily associated with a color. This survey also revealed that certain brands of food coloring stick the same composition label on the coloring preparations packaging, regardless of the color conferred by the coloring preparation. This concerns about 29% of the tested preparations.

Among the flaws also detected was the presence of a composition label with incomplete or even obsolete information in about 4% of the products. In other words, 3.8% of the reparations analyzed presented a composition associating a coloring code for certain component and just the indication "dye" for others. It is also important to mention that some tested coloring preparations (about 2%) were unlabeled (without ingredient label). Algerian legal texts also require mentioning of the maximum limit of use of each food additive, *inter alia*, food colors [20]. Such information seems completely non-existent on the packaging of all assessed coloring preparations. These findings encourage to ensure strengthening surveillance measures on the food labeling in particular coloring agents.

If all food additives, in particular dyes, existing in foods must be specified in the composition label, that's due to their potential to induce health concerns. In Algeria, 54 food colorants are authorized [21]. Among these dyes, several can be harmful to health. Although there is no consensus on the blacklist of dyes to be banned from our diet, some colors make unanimous consent among scientists because of their dangerousness, in particular yellows E102, E110, reds E121, E122, E123, E124, E127, and E129, blues E132, and E133, the green E143 and the white E171. In this investigation, we tried to look for the presence of these dyes in food coloring preparations. Our results reveal that E102 (39%), E110 (23%), and E171 (20%) colors are the most found. The E102, tartrazine, was found in 39% of coloring preparations. This synthetic dye would be very dangerous for health. It would be responsible for children's hyperactivity disorder, contaminated by carcinogens and even induces genotoxic hazards [12-14]. Among the tested coloring preparations, E102 was found in 71.4% of fat soluble coloring preparations, 59% of dough flavors, 31.6% of food luster preparations and 7.4% of water soluble coloring preparations. In addition to the human's harmful effects cited above, tartrazine would also have a reproductive toxicity consisting of reduced reproductive performance, reduction of sperm account and an increase in sperm abnormalities [1].

The second dangerous yellow food color is E110, sunset yellow. It was found in 23% of assessed coloring preparations. This dye was found in almost half (46.2%) of dough flavors and in 11.1% of water soluble coloring preparations. However, none of the examined fat soluble coloring preparations or food luster preparations contained the E110. Like E102, the sunset yellow (E110) would be contaminated with carcinogens, responsible for hypersensitivity reactions and involved in children's hyperactivity. Moreover, the E110 could be carcinogenic given its ability to induce adrenal and testicular tumors [12, 13].

Like E102 and E110, E171, also called titanium dioxide, is a pigment of natural origin that gives food an immaculate white color. Its nanoparticles NPs would be the cause of a series of health problems including gastrotoxicity, hepatotoxicity as well as the alteration of the intestinal flora and especially genotoxicity and carcinogenicity [15, 17, 22]. This dye has been banned in France since 2020 and throughout the European Union EU from January 2022 [15, 23]. Our results reveal its presence in 20% of analyzed coloring preparations. More precisely, this coloring was found in 57.9% of food luster and in 11.1% of water soluble coloring preparations as well as in almost 10% of dough flavors. However, none of the fat soluble coloring preparations analyzed contained this dye.

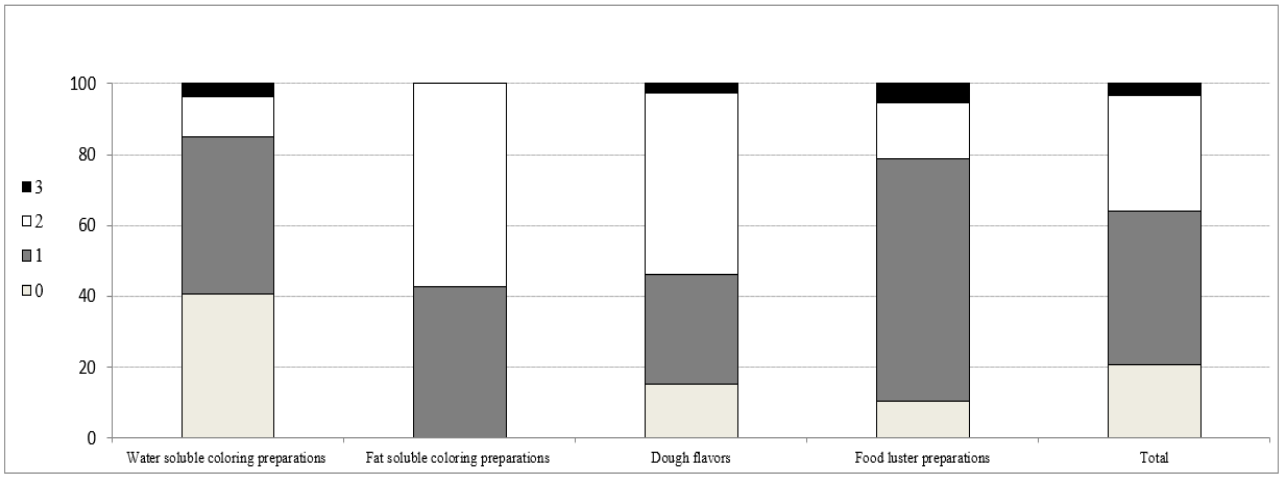

Figure 6. Frequency of harmful food colors association in food coloring preparations (Source: Authors' own elaboration)

Red dyes E121, E122, E123, E124, E127, and E129 also entail health risks. Indeed, reds E121, E127, and E129 are potential carcinogens. E123 and E124 would be genotoxic and E122, E124, and E129 could induce children's hyperactivity disorder [12, 13]. The results of this survey reveal the absence of E121 in all analyzed coloring products. This result could be explained by the fact that this dye is prohibited in Algeria. Also, all the products examined are free of E129. This could be justified by the sampling limitation. However, dyes E122 and E124 were identified in 10% and 13% of coloring products respectively. For each of these colorants, about 13% of dough flavors contain it. These two colorants are also present each in 5.3% of food luster preparations. Also, the E122 was recorded in almost 11% of the water soluble coloring preparations while the E124 was revealed in 18.5% of the water soluble coloring preparations and 14.3% of the fat soluble coloring preparations. One of the confirmed genotoxic red dyes is E123. the latter would be responsible for DNA damage in colon cells and in lung cells [1, 12, 13, 16]. The E123 was recorded in 2% of coloring preparations. This dye was found only in fat soluble coloring preparations (about 29%). In addition, the red E127 was present in 1% of coloring preparations. More specifically, E127 was identified in 3.7% of water soluble coloring preparations. Although it is authorized in Algeria, this dye is prohibited in the United States in cosmetics and externally applied drugs. Indeed, this dye is classified as potentially carcinogenic since it triggers thyroid tumors. It would also have reproductive toxicity [12, 13].

Blue dyes E132 and E133 were also identified in 7% and 5% of the coloring preparations. In fact, E132 was found in approximately 15% of water soluble coloring preparations and in 10.5% of food luster preparations. On the other hand, E133 was identified in 57.1% of fat soluble coloring preparations and in 5.3% of food luster preparations. These two dyes, authorized in Algeria as in the European Union and in the United States, could be the cause of health problems ranging from hypersensitivity reactions and problems of development of nerve cells for E133 to the potential induction of brain and bladder tumors for E132 [12, 13].

Although it is banned in the European Union and the United States, the use of the green dye E143 has been permitted in Algeria since 2012. This dye would be potentially carcinogenic considering its ability to induce bladder cancer. Our results indicate its absence in all analyzed coloring products [12, 13].

These results prompt to provides the awakening about the misuse of these dyes in Algeria while underlining that they are sometimes sold by weight in stores, notably for white and red colors, without ingredient labeling and just a price tag indicating the common name of the dye.

In overall, our findings show that the most frequent dyes were the artificial yellow dyes E102 (39%) and E110 (23%). This is similar to the rates found in 2 studies carried out on food products in Oman (E102=18%, E110=29.3%) and Saudi Arabia (E102=42.3%, E110=39.1%) [24, 25]. In addition, a survey performed in Canada in 2019 recorded the presence of E110 in 11% of the examined products. This study revealed also the E102 in approximately 25% of the examined food products while being the most found dye among the requested dyes [26]. The E102 was also the most common dye in an Indian study performed in 2013 [27]. Simultaneously, this survey also showed the presence of the E171 in 20% of the coloring products. This dye was also found in 26% of the candies analyzed in a study carried out in Oman in 2021 [24].

Regarding red dyes, our results for dyes E122, E123, and E127 are comparable to other surveys. Indeed, E122 was found in 10% of coloring preparations. This is comparable to the percentage recorded for this dye in the sweets sold in Masqat (5%) according to a survey last year [24]. Also, E123 and E127 were found at almost a similar percentage (E123=2%, E127=1%) in coloring preparations. This is similar to the result recorded in a report published in 2019 by the Canadian Food Inspection Agency showing a percentage of 3% for each of these colors. However, this survey realized by the Canadian authorities in 2019 as well as the study achieved in Oman in 2021 recorded the presence of E129 in 25% and approximately 44% of the assessed products respectively [24, 26]. During our investigation, we did not identify any coloring preparations containing this dye. This difference in observations was also noticed for the E133. If the latter was identified in 5% of the examined coloring preparations, it was recorded in 15% of the analyzed food products in the Canadian survey, in 54.1% of the products examined in the Saudi study and in 46% of the Omani survey [24, 25, 26]. Finally, it is important to mention that these comparisons should always be taken with a grain of salt given the difference in the nature of the sampling.

The flagship result of this survey was the determination of the frequency of coloring preparations containing only one or association of two or three harmful colors. Overall, almost half

(43.5%) of the studied samples contained only one harmful dye. However, more than 30% of tested coloring preparations consisted of a mixture of two undesirable dyes. This represents exactly 57.1% of fat soluble coloring preparations, 51.3% of dough flavors, 11.1% of water soluble coloring preparations and 15.8% of food luster preparations. Interestingly, about half of the studied fat soluble coloring preparations contained two harmful dyes. This result should be taken carefully considering the reduced number of samples in general, in particular the conform ones (limitation of sampling due to the specificity of this category of coloring preparations and their shortage in stores given their cost). In other hand, almost 51% of dough flavors consisted also a mixture of two harmful dyes which could be very worrying since they are products of complex chemical composition further supplemented with two harmful dyes. Additionally, about 3% of assessed coloring preparations were surprisingly made from a mixture of three harmful dyes. This corresponds to approximately 4% of water soluble coloring preparations, 3% of dough flavors and 5% of food luster preparations. The idea of designing a presumed “food preparation” containing simultaneously two and sometimes three unsafe dyes in association with other components could be explained by the commitment to obtain a tricky color, a shinny shading or even a sublime glitter effect on foods. Nevertheless, these outcomes are frightening insofar as it can be very dangerous for health to ingest a combination of several harmful dyes for health without neglecting the “cocktail” effect with the other constituents of such preparations.

CONCLUSION

To summarize, dyes directly related to health concerns including yellows E102 and E110, reds E122, E123, E124, and E127, blues E132 and E133 and the white E171 have been identified in coloring preparations marketed to the simple consumer in order to be used in homemade food recipes without any indication of the maximum limit of use. Dyes E102 (about one-third of coloring preparations), E110 (about one-fifth of coloring preparations) and E171 (about one-fifth of coloring preparations) were the most common among these harmful dyes. In addition to their mere presence, harmful dyes have been found in combination by two and sometimes even by three in the same coloring product, which represents a real danger for the consumer. In addition, the analysis of compliance and labeling of these coloring preparations revealed labeling flaws (49% of coloring preparations) that could reach the total absence of a composition label.

Author contributions: DB: designed the study; **DB & ML:** analyzed the data and wrote and revised the manuscript; & **KL &IK:** conducted the experimental work. All authors have agreed with the results and conclusions.

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Ethical statement: The project was approved by the Scientific Council of the Department of Agronomy of the University of Djelfa on July 2020.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

1. Olusegun ET, Olajire AA. Toxicity of food colours and additives: A review. Afr J Pharm Pharmacol. 2015;9(36):900-14. https://doi.org/10.5897/AJPP2015.4385
2. Uchegbu N, Nnamocha T, Ishiwu C. Natural food colourants juxtaposed with synthetic food colourant: A review. Pak J Nutr. 2020;19(8):404-19. https://doi.org/10.3923/pjn.2020.404.419
3. Merinas-Amo R, Martínez-Jurado M, Jurado-Güeto S, Alonso-Moraga Á, Merinas-Amo T. Biological effects of food coloring in in vivo and in vitro model systems. Foods. 2019;8(5):176. https://doi.org/10.3390/foods8050176 PMid:31137639 PMCid:PMC6560448
4. Rangan C, Barceloux DG. Food additives and sensitivities. Dis Mon. 2009;55(5):292-311. https://doi.org/10.1016/j.disamonth.2009.01.004 PMid:19362177
5. Solymosi K, Latruffe N, Morant-Manceau A, Schoefs B. Food colour additives of natural origin. In: Scotter MC, editor. Colour additives for foods and beverages. The Netherlands: Elsevier; 2015. p. 3-34. https://doi.org/10.1016/B978-1-78242-011-8.00001-5
6. Shim S-M, Seo SH, Lee Y, Moon G-I, Kim M-S, Park J-H. Consumers’ knowledge and safety perceptions of food additives: Evaluation on the effectiveness of transmitting information on preservatives. Food Control. 2011;22(7):1054-60. https://doi.org/10.1016/j.foodcont.2011.01.001
7. Jandrić-Kočić M. Real and perceived risk: Food additives. Med Glas Spec Boln Za Boles Štitaste Žlezde Boles Metab. 2021;26(82):50-67. https://doi.org/10.5937/medgla2182050J
8. Ghaffar F. Identification & spectrophotometric quantification of dyes in the selected confectionery items available in the local markets of Peshawar, Pakistan. Pure Appl Biol. 2020;9(3):1690-700. https://doi.org/10.19045/bspab.2020.90179
9. Gomes KMS, de Oliveira MVGA, de Sousa Carvalho FR, Menezes CC, Peron AP. Citotoxicity of food dyes sunset yellow (E-110), bordeaux red (E-123), and tatrazine yellow (E-102) on Allium cepa L. root meristematic cells. Food Sci Technol. 2013;33(1):218-23. https://doi.org/10.1590/S0101-20612013005000012
10. Swetha C, Annie Supriya R, Jagadeesh Babu A, Madhava Rao T. A survey on the public awareness about harmful effects of artificial food colours in milk and meat products on human health. Pharm Innov J. 2017;6(9):306-9.
11. Global food colors market. Opportunities and forecast 2020-2027. 2022.
12. Kobylewski S, Jacobson MF. Toxicology of food dyes. Int J Occup Environ Health. 2012;18(3):220-46. https://doi.org/10.1179/1077352512Z.00000000034 PMid:23026007
13. Kobylewski S, Jacobson MF. Food dyes: A rainbow of risks. Center for Science in the Public Interest. 2010. Available at: https://www.cspinet.org/resource/food-dyes-rainbow-risks (Accessed 1 october 2022).
14. McCann D, Barrett A, Cooper A, et al. Food additives and hyperactive behaviour in 3-year-old and 8/9-year-old children in the community: A randomized, double-blinded, placebo-controlled trial. Lancet. 2007;370(9598):1560-7. https://doi.org/10.1016/S0140-6736(07)61306-3

15. Musial J, Krakowiak R, Mlynarczyk DT, Goslinski T, Stanisz BJ. Titanium dioxide nanoparticles in food and personal care products–What do we know about their safety? Nanomaterials (Basel). 2020;10(6):1110. https://doi.org/10.3390/nano10061110 PMid:32512703 PMCid:PMC7353154
16. Tsuda S. DNA damage induced by red food dyes orally administered to pregnant and male mice. Toxicol Sci. 2001;61(1):92-9. https://doi.org/10.1093/toxsci/61.1.92 PMid:11294979
17. Bettini S, Boutet-Robinet E, Cartier C, et al. Food-grade TiO2 impairs intestinal and systemic immune homeostasis, initiates preneoplastic lesions and promotes aberrant crypt development in the rat colon. Sci Rep. 2017;7:40373. https://doi.org/10.1038/srep40373 PMid:28106049 PMCid: PMC5247795
18. Lehto S, Buchweitz M, Klimm A, Straßburger R, Bechtold C, Ulberth F. Comparison of food colour regulations in the EU and the US: A review of current provisions. Food Addit Contam Part A Chem Anal Control Expo Risk Assess. 2017;34(3):335-55. https://doi.org/10.1080/19440049.2016.1274431 PMid:28004607
19. Official Journal of the Algerian Republic. N° 30. 2012.
20. Official Journal of the Algerian Republic, Annexes III. 2012.
21. Official Journal of the Algerian Republic, Annexes I. 2012.
22. Medina-Reyes EI, Rodríguez-Ibarra C, Déciga-Alcaraz A, Díaz-Urbina D, Chirino YI, Pedraza-Chaverri J. Food additives containing nanoparticles induce gastrotoxicity, hepatotoxicity and alterations in animal behavior: The unknown role of oxidative stress. Food Chem Toxicol. 2020;146:111814.https://doi.org/10.1016/j.fct.2020.111814 PMid:33068655
23. Official Journal of the French Republic. Arrêté du 17 avril 2019 portant suspension de la mise sur le marché des denrées contenant l'additif E 171 (dioxyde de titane-TiO2) [Order of 17 April 2019 suspending the marketing of foodstuffs containing the additive E 171 (titanium dioxide-TiO2)]. 2020.
24. AbuKhader M, Um D, Nazmi A. Identification and prevalence of food colors in candies commonly consumed by children in Muscat, Oman. Int J Nutr Pharmacol Neurol. 2021;11(2):128-36. https://doi.org/10.4103/ijnpnd.ijnpnd_2_21
25. Ahmed MA, Al-Khalifa AS, Al-Nouri DM, El-Din MFS. Dietary intake of artificial food color additives containing food products by school-going children. Saudi J Biol Sci. 2021;28(1):27-34. https://doi.org/10.1016/j.sjbs.2020.08.025 PMid:33424279 PMCid:PMC7783677
26. Canadian Food Inspection Agency. Food colours in essences/flavourings, oils, sweets and processed vegetables–April 1, 2018 to March 31, 2019. 2021. Available at: https://inspection.canada.ca/DAM/DAM-food-aliments/STAGING/text-texte/food_color_in_essences_2018-2019_1614887875530_eng.pdf (Accessed 1 October 2022).
27. Dixit S, Khanna SK, Das M. All India survey for analyses of colors in sweets and savories: Exposure risk in Indian population. J Food Sci. 2013;78(4):T642-7. https://doi.org/10.1111/1750-3841.12068 PMid:23464814