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Qualitative Consumption of Processed Foods with Allura Red Additive in Mexican Primary School Children

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Abstract

There is a high supply of industrialized food products that contain many additives, such as colorants. To verify the qualitative consumption of Allura Red in primary school children, the present cross-sectional quantitative work was established under a retrospective expo facto design. On a school child population (5 - 8 years) from the city of Ramos Arizpe, Coahuila, Mexico, selected in a probabilistic way, a questionnaire applied to qualitatively verify the consumption of said additive. Descriptive and frequency analyses applied to the data obtained, as well as the Mann-Whitney U test and Pearson's X^2 test ($p \leq 0.05$). The child population evidenced a high consumption of processed products containing Allura Red additive, the intake of jellies and candies ($p = 0.025$ and $p = 0.043$, respectively) showed differences between girls and boys. There was a very frequent consumption of "red soft drinks", dairy - yogurt, oatmeal - flour, and box cereals (61 and 54%, respectively). Likewise, a high association was found between the intake of dairy products - yogurt and cereals ($p = 0.008$), oats and flour for pancakes and cereal in the box ($p = 0.010$), as well as consumption of candies and jellies ($p = 0.000$). High qualitative consumption of processed foods with Allura Red additive was found; it's imperative to reduce the excessive consumption of these products by establishing comprehensive strategies.

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Introduction

World Health Organization (WHO) suggests that infants should achieve an adequate recommended daily intake (RDI) for full and optimal development, between 4-6 years 1,800 kcal day^{-1} (90 kcal kg day^{-1}), 7-12 years: 2,000 kcal day^{-1} (70 kcal kg^{-1} weight day^{-1}), distributed 50-60% of carbohydrates, 30-35% lipids and 10-15% of high-quality proteins and 10-15 fiber gr, distributed proportionally in breakfast, lunch, snack, and dinner (25, 30, 15 and 30%, respectively) avoiding intakes between hours.[1,2] To achieve this nutritional demand, the food industry is accessed, which has implemented technological alternatives, such as the use of additives, to improve the shelf life of food and stimulate people's perception and appetite,[3] the high rates of food marketing processed and ultra-processed have resulted in the high use of additives.[4,5]

Additives are any substance that, regardless of its nutritional value, is intentionally added to food for technological purposes in controlled quantities. The most widely used are colorants, preservatives, sweeteners, texturing agents, and flavor enhancers.[6] Some additives seek to add color to food, reduce the loss in color due to environmental and storage conditions, add greater attractiveness to the product, and even generate commercial identity with the product.[6] With colorants, there is high government regulation to validate their safety in their consumption.[7] which can be classified by their origin, solubility, and covering capacity, being the distinction between soluble and insoluble the most used.[6]

Particularly Allura Red additive (2-hydroxyl-1-(2-methoxy, 5-methyl, 4-sulphonato phenylazo)-naphthalene-6-sulphonate), disodium salt, additive E129 (according to European Union) or FD&C Red 40 (US) is a synthetic anionic monoazo dye soluble in water widely used in food industry.[6,8] At a metabolic level, it appears to be degraded by azo-reduction of the intestinal flora to cresidine-4-sulfonic acid and 1-amino-2-naphthol-6-sulfonic acid.[9,10] The daily allowable consumption of Allura Red ranges from 0 – 7 mg kg^{-1} of body weight/day for a 30 kg child.[6,8,10]

In this sense, and considering American Latin economic progress and commercial globalization, there is a large supply of foods with a high content of added sugar and additive such as Allure Red additive. As an example of these products, we can cite, among others, sugary drinks, juices, nectars, and other processed and ultra-processed foods, which have a high energy value, high glycemic index, and low satiety index,[11] the main contributors to intake of artificial colors are desserts and drinks,[4] so that, high consumption of these products implies a high energy intake that can cause problems such as for overweight and obesity.[11,12] Specially Allura Red, Yellow 5, and Yellow 6 account for about 90% of additives used, in addition, their consumption has increased dramatically in recent years thanks to the high rate of production by companies,[10] for which a large number of products marketed foods may contain Allura Red.

Given the evidence of an analogous food preference between the consumption of sugar-sweetened beverages – soft drinks with the natural water consumption,[13] high rates of additive consumption can be induced in the world population. In this sense, some works cited an estimated average intake of Allura Red of 0.3 - 0.6 mg day^{-1} in juices and soft drinks.[8] Likewise, was reported a high intake (Allura Red) through the consumption of juices and beverages, ice cream and cakes and chocolates in schoolchildren aged 6-17 years.[14] In a study carried out in Kuwait with children between 5-14 years of age, a higher intake of Tartrazine, Sunset Yellow, Carmoisine, and Allura Red was found;[15] the consumption of these additives in infants is related to the body mass index, it can also lead to hyperactivity and may even present a link with autism spectrum disorder.[16–18] These problems can be maximized by factors such as hunger, family finances, appetite, craving, emotional state, and availability of the product in the environment.[11] To verify how is the consumption of processed foods and beverages containing Allure Red in girls and boys of primary education, this work was established to qualitatively verify the consumption of said products. A qualitative approach that is intended to be developed can be a starting point to know the potential consumption of Allura Red, in the same way, it will lay the foundations for future studies at a quantitative level in the Mexican population.

Materials and Methods

Study Design and Ethical Considerations

Cross-sectional quantitative study with a relational level of a study conducted under a simple retrospective expo facto design with a descriptive approach.

The present investigation was carried out in the city of Ramos Arizpe, Coahuila Mexico. Approved the research protocol by the Ethics Committee of the University, the participants signed Informed Consent (included in the digitized survey) emphasizing maintaining anonymity and confidentiality of their data, following the guidelines of the Declaration of Helsinki (https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/, accessed on 21 December 2021), National Bioethics Commission and article 100 of the General Health Law in the field of research for health.

Subjects, Recruitment of Volunteers

This study consisted of potential candidates of girls and boys of the first, second, and third grades of José Clemente Orozco primary school (Ramos Arizpe, Coahuila México) were considered as apopulation of interest. We selected by under a random probability sampling, using the equation for finite populations (132 participants). Participation in the study was voluntary. All those girls and boys enrolled in the school cycle were included and their ages ranged from 5 to 8 years. No girl - boy were excluded.

Measuring instrument - Questionnaire

Qualitative quantification of consumption of foods and beverages with Allura Red was determined with a Questionnaire for Evaluating the Consumption of Food with Red Allura,[19] which has been previously validated for a Mexican population (Cronbach's α; internal consistency of items α = 0.8571, correlation matrix α = 0.822 and reliability α = 0.857). The instrument is made up of 21 items with a Likert scale: Very frequently (daily consumption), frequently (1 to 3 times a week), occasionally (1 time a fortnight), and never (they have not tried it). Those questionnaires with unfinished and/or ambiguous answers were annulled.

Data collection and Statistical analysis

Derived from the prevailing conditions in the country because of SARS-CoV2, a survey was digitized (on the Google Forms platform) and distributed digitally to the tutors of the infants for their completion (the questionnaire was applied during April–July 2020). Data analysis was carried out with IBM SPSS (Statistical Package for Social Sciences) version 19 (SPSS, Inc., Chicago, IL, USA, 2020). Mann-Whitney U test to determine the relationship between sex and consumption of products with Allura Red additive was applied, in the same way, Pearson's X^2 test was applied to detect the relationship between the consumption of products, these tests were run at a significance level of $p \leq 0.05$. Intake frequency data are presented as frequencies (percentages), p-values is indicated for intake frequency between boys and girl data, finally the relation between higher consumption products are presented as frequencies (percentages) and the p-value indicate statistical relationship.

Results

As it can be seen in Table 1, we found high consumption of processed products containing Allura Red additive in the study population, only a statistical difference was observed between girls and boys in the intake of jellies and candies ($p=0.025$ and $p=0.043$, respectively) (Figure 1).

Consumption of “red soft drinks” showed 41% of very frequently consumption, followed by occasional consumption. Similarly, consumption of flavored water shows close to 36% of very frequently consumption, followed by occasional consumption (32%). In the case of dairy - yogurt consumption, infants consume these products very frequently (43%).

Among the different commercialized products to which infants are exposed, a greater propensity was found to have a very frequent intake of oats - flour and boxed cereals (61 and 54%, respectively). On the other hand, there was an occasional consumption of cupcakes (70%), candies and chocolate-covered peanuts - marshmallows (63%), covered candies (59%), chili peanuts (58%), energy bars (58%), sweet gummies (57%), hot sauce (54%), tomato puree (53%), lollipop-popsicles (51%) and bagged chips (51%).

The child population studied lower consumption of hot sauce (occasionally or no, 120 people), followed by chili peanuts (122 people), chili-coated lollipop/candies (112 people), energy bars (110 people), and finally chocolate-covered peanuts - marshmallows and cupcakes (both with 105 people).

Table 1: Frequency consumption of processed food containing Allura Red in school children José Clemente Orozco, Ramos Arizpe Coahuila, 2020.

Processed food (item)	Intake frequency			
	Very frequently	Frequently	Occasionally	Never
1: Red soft drink	54 (41%)	10 (8%)	53 (40%)	15 (11%)
2: Flavored bottles water	47 (36%)	26 (20%)	42 (32%)	17 (13%)
3: Packaged juices	52 (39%)	11 (8%)	61(46%)	8 (6%)
4: Hydrating drinks	47 (36%)	8 (6%)	53 (40%)	24 (18%)
5: Fruit flavored water	29 (22%)	28 (21%)	57 (43%)	18 (14%)
6: Boxed cereals	71 (54%)	49 (37%)	12 (9%)	0 (0%)
7: Biscuits	52 (39%)	12 (9%)	62 (47%)	6 (5%)
8: Energy bars	21 (16%)	1 (1%)	77 (58%)	33 (25%)
9: Packaged cupcakes	26 (20%)	1 (1%)	93 (70%)	12 (9%)
10: Lollipop-popsicle	37 (28%)	14 (11%)	67 (51%)	14 (11%)
11: Sweet gummy candy	36 (27%)	2 (2%)	75 (57%)	19 (14%)
12: Jellies	42 (32%)	14 (11%)	64 (48%)	12 (9%)
13: Candies	28 (21%)	3 (2%)	83 (63%)	18 (14%)
14: Chocolate covered peanuts- marshmallows	24 (18%)	3 (2%)	83 (63%)	22 (17%)
15: Chili-coated lollipop/ candies	17 (13%)	3 (2%)	78 (59%)	34 (26%)
16: Bagged chips	50 (38%)	6 (5%)	67 (51%)	9 (7%)
17: Chili peanuts	8 (6%)	2 (2%)	76 (58%)	46 (35%)
18: Dairy -yogurt	57 (43%)	39 (30%)	32 (24%)	4 (3%)
19: Tomato puree	27 (20%)	4 (3%)	70 (53%)	31 (23%)
20: Red packaged hot sauce	9 (7%)	3 (2%)	71 (54%)	49 (37%)
21: Oatmeal-flour pancakes	80 (61%)	12 (9%)	34 (26%)	6 (5%)

Red products (tutti-frutti, blueberry, sangria, grape, apple, strawberry, prune) were considered. Number on the left side int the first column corresponds to the questionnaire item.

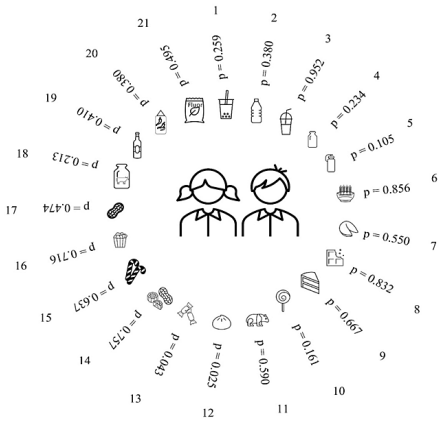

Fig. 1: Intake processed food containing Allura Red in school children José Clemente Orozco, Ramos Arizpe Coahuila, 2020. (n= 132; 47 girls, and 85 boys).Outdoor number corresponds to the questionnaire item. p-value corresponds to statistical difference between girls and boys.

Likewise, a great association was found between the consumption of different foods that contain the Allura Red additive, in that sense, there is a high relationship between the intake of dairy - yogurt with the intake of cereals (p=0.008) in a higher proportion frequently, with a percentage of 23% of the total population (Table 2). Similar behavior was found between the consumption of oats and flour for pancakes with the intake of boxed cereal (p=0.010) with a frequency of 46 infants (boys-girls). On the other hand, the consumption of candies showed a high association with the ingestion of jellies (p = 0.000), although in a greater proportion it was low with occasional consumption, where about 34% of the total population was found in this category (Table2).

Table 2: Distribution of consumption of processed food containing Allura Red in school children José Clemente Orozco, Ramos Arizpe Coahuila, 2020.

		Dairy – yogurt					
		Very frequently	**Frequently**	**Occasionally**	**Never**	**Total**	**p-value**
Boxed cereals	Very frequently	23 (17%)	21 (16%)	5 (4%)	0 (0%)	49 (37%)	p=0.008
	Frequently	14 (11%)	31 (23%)	23 (17%)	3 (2%)	71 (54%)	
	Occasionally	2 (2%)	5 (4%)	4 (3%)	1 (1%)	12 (9%)	
	Total	39 (30%)	57 (43%)	32 (24%)	4 (3%)	132 (100%)	
		Oatmeal – flour pancakes					
		Very frequently	**Frequently**	**Occasionally**	**Never**	**Total**	
Boxed cereals	Very frequently	9 (7%)	29 (22%)	11 (8%)	0 (0%)	49 (37%)	p=0.010
	Frequently	2 (2%)	46 (35%)	17 (13%)	6 (5%)	71 (54%)	
	Occasionally	1 (1%)	5 (4%)	6 (5%)	0 (0%)	12 (9%)	
	Total	12 (9%)	80 (61%)	34 (26%)	6 (5%)	132 (100%)	
		Candies					
		Very frequently	**Frequently**	**Occasionally**	**Never**	**Total**	
Jellies	Very frequently	2 (2%)	4 (3%)	8 (6%)	0 (0%)	14 (11%)	p=0.000
	Frequently	1 (1%)	16 (12%)	24 (18%)	1 (1%)	42 (32%)	
	Occasionally	0 (0%)	8 (6%)	45 (34%)	11 (8%)	64 (48%)	
	Never	0 (0%)	0 (0%)	6 (5%)	6 (5%)	12 (9%)	
	Total	3 (2%)	28 (21%)	83 (63%)	18 (14%)	132 (100%)	

Red products (tutti-frutti, blueberry, sangria, grape, apple, strawberry, prune) were considered. Data are expressed as frequencies and percentage for qualitative variable, and comparability groups was evaluated by Pearson´s X^2 test (p≤0.05).

Discussion

Additives, specifically artificial colors, are used highly in the food industry. However, they can contain a great variety of chemical products whose sources are extremely toxic. The foregoing can probably induce some alteration in the population's health, particularly in infants.[14,20]

In the present study, it was found that the studied population presented a high consumption of processed products containing Allure Red additive (Table 1), which may be because infants are highly exposed to the food (biscuits, cakes, chocolates, potato chips, ice cream, juices and drinks, candy, jelly, and chewing gum) that contain this compound,

besides the fact that the main additives in the food industry are Brilliant Blue (E133), Carmoisine, Fast Green FCF, Sunset Yellow (E110), Tartrazine (E102) and Allura Red (E129).[14] These products (cookies, carbonated sugar-sweetened beverages, candies and sweets, yogurt and milk-based beverages, non-carbonated sugar-sweetened beverages, breakfast cereal, sausage) contribute close to 30% of energy in the Mexican diet (in 2012) in a higher proportion in young people.[21] The same authors point out a greater propensity to consume in urban populations in the northern region of the country, with a high socioeconomic level and with a high educational level of the home tutor, the foregoing can be derived from the accessibility and purchasing power of families; however, the direction in the consumption of these products in infants reflects a lack of knowledge and/or lack of nutritional education by the head of the family.

In this sense, in a study carried out in North Carolina (2014) where information regarding 810 products offered in grocery stores was collected, it was found that about 43% of them contained additives, in a higher proportion Allura Red, Blue 1, Yellow 5 and Yellow 6. Among the products that presented high content of additives were candies-sweets (≈96%), fruit-flavored snacks (≈94%), and drink mixes/ powders (≈90%), likewise when categorizing the products, a greater amount of cereals (13%), juices/ juice drink (12%), and canned/packaged pasta and soups (9%) were found.[20] The same authors cite that of the 66 companies quantified, about 40 companies use additives in their products. This situation is alarming since the adoption of the "western" food model in Mexico (the northern zone to a greater extent) may reflect a similar behavior in the supply of processed and ultra-processed products in convenience stores.

Given the high range of foods with Allura Red additive to which children are exposed, the consumption of said additive can cause allergic reactions (i.e., urticaria, asthma).[6] Under this context was demonstrated (in a randomized, double-blinded, placebo-controlled trial) slight clinical differences and statistically significant association between the consumption of additives (sodium benzoate, Sunset Yellow, Azorrubine, Tartrazine, Ponceau 4R, Quinoline Yellow, Allura Red) and the development of attention-deficit hyperactivity disorder (ADHD) in children 3 and 8-9 years old.[17] However, the consumption of these synthetic additives is not the main cause of these disorders, but they could push consumers above the thresholds for diagnosis of these disorders.[22]

The present works show a very frequently consumption of red soft drinks, as well as flavored water, dairy and yogurt, oatmeal - flour, and boxed cereals, similar results are reported[23] who when estimating the dietary exposure in a population in the United States (children 2 - 5 years old and adolescents 13-18 years old) found high dietary exposure to Allura Red, Yellow 5 and Yellow 6, in a higher proportion in breakfast cereal, juice drinks, soft drinks, ice cream, frozen yogurt, and sherbet. On the other hand, school children (6-17 years old) in Saudi Arabia consume a higher proportion of juices and drinks, ice cream, and cakes, in the same way, the authors point out a prevalence of Brilliant Blue (E133) and Tartrazine (E102) and to a lesser extent Allura Red.[14] The same authors indicate levels above international standards, so regulation is imperative. On the other hand, in a study carried out in Italy it was found that the amount of Allura Red in red drinks (red soft drink, product based on red juice) ranged between 10.9 - 55.9 ml^{-1}, despite this, an intake less than the acceptable daily intake (0 - 7 mg kg BW^{-1} day^{-1}). Similarly, exposure evaluation showed high intakes of Allura Red (6.5 - 13.9 mg kg BW^{-1} day^{-1} for juice-based drinks) and up to 25.0 - 33.0 mg kg BW^{-1} day^{-1} (in soft drinks), likewise, the intake increases as the concentration of the additive increases (> 40 mg^{-1}).[8] Similarly, children aged 5 - 14 years from Kuwait, from a 24-hour reminder, show an intake of artificial colors Tartrazine, Sunset Yellow, Carmoisine, and Allura Red.[15] Under this trend, the presence and consumption of processed foods with additives are global.

The results aforementioned lead to know that a high intake of Allura Red additive can probably lead to diseases and/or some type of disorder in consumers,[14] since one of the biological responses of the body to the consumption of these products is the release of histamine, which in turn affects the absorption of nutrients,[22] causing eating disorders in infants. In addition to this, the activity of the enzyme responsible for splitting Allura Red (azoreductase) is affected by dietary factors, cellulose, proteins,

fibers, antibiotics, or supplementation with live cultures of lactobacilli.[9] On the other hand,based on a study carried out in vitro, a high possibility of additive interaction (Allura Red, Brilliant blue, Carmoisine, Sunset Yellow, Tartrazine) – with drug,[24] which is mediated by a series of transporters in the intestine altering pharmacokinetics,[25] therefore, consumption of additive in question can induce an alteration in the infant's metabolism with consequences in its nutritional profile. Likewise, the addition of additives in (natural) beverages can influence the availability of certain antioxidants.[26]

Based on the high prevalence of artificial additives in products,[20] great exposure by television marketing and social networks,[27] and high dietary consumption of these products (specifical biscuits) in the child population, it would be appropriate to establish strategies to promote human health such as bio fortification, the inclusion of nutrients, reduction of the content of fats and sugars,[28] as well as a null or reduced use of synthetic colorants or natural origin.

Although the different governing bodies worldwide establish programs to improve children's nutritional health, a comprehensive intervention is necessary;[29] normativity in the commercialization and regulations of products containing additives, especially in the child population,[27] regulation of digital food marketing as well as verifying policies, commercial agreements, tariffs, and even clear nutritional labeling and commercial restrictions,[30] but also establishing surveillance systems to document the possible effects of Allura Red additive[4] to promote responsible consumption and induce nutritional well-being. In the same way, a nutritional education of the head of the family, as well as in the infant, can be an adequate strategy to establish that food has a nutritional value and reduce, for example, the high association between the consumption of cereals and dairy products - yogurt, as well as the consumption of cereals and oats - flour for pancakes, jellies, and candies, found in the study (Table 2). The high intake frequency of the consumption of these products may be due to advertising exposure and, since they are unhealthy, it may lead to a risk factor for child overweight and obesity.[27]

Conclusion

There is high qualitative consumption of processed foods with Allura Red additive, showing that infants have a very frequent consumption of red soft drinks, flavored water, dairy and yogurt, oatmeal - flour, and boxed cereals, in addition to a high association between consumption of cereals and dairy products - yogurt, cereals, and oats - flour for pancakes, as well as jellies and candies. Since during the infantile-school stage (5 to 8 years) food autonomy is developed to develop eating habits, it is imperative to reduce the excessive consumption of products that contain the Allura Red additive, establishing strategies from within the family, such as nutritional education.

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Conflict of Interest

The author(s) declares no conflict of interest.

References

1. Haua NK. D: Alimentación: estrategias de evaluación. In: Suveraza FA, Haua NK. *El ABCD de La Evaluación Del Estado Nutricional.* México, D.F.: McGraw-Hill Interamericana Editores, S.A. de C.V.; 2010:225-273.
2. Polanco-Allué I. Alimentación del niño en edad preescolar y escolar. *An Pediatr Monogr.* 2005;3 (1):54-63.
3. Oplatowska-Stachowiak M, Elliott CT. Food colors: Existing and emerging food safety concerns. *Crit Rev Food Sci Nutr.* 2017;57(3):524-548. doi:10.1080/10408398.2014.889652
4. Jain A, Mathur P. Evaluating hazards posed by additives in food: A review of studies adopting a risk assessment approach. *Curr Res Nutr Food Sci.* 2015;3(3):243-255.

doi:10.12944/CRNFSJ.3.3.08

5. Elizabeth L, Machado P, Zinöcker M, Baker P, Lawrence M. Ultra-processed foods and health outcomes: A narrative review. *Nutrients.* 2020;12(7):1-36. doi:10.3390/nu12071955
6. Amchova P, Kotolova H, Ruda-Kucerova J. Health safety issues of synthetic food colorants. *Regul Toxicol Pharmacol.* 2015;73(3):914-922. doi:10.1016/j.yrtph.2015.09.026
7. 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):335-355. doi:10.1080/19440049.2016.1274431
8. Fallico B, Chiappara E, Arena E, Ballistreri G. Assessment of the exposure to Allura Red colour from the consumption of red juice-based and red soft drinks in Italy. *Food Addit Contam - Part A Chem Anal Control Expo Risk Assess.* 2011;28(11):1501-1515. doi:10.1080/19440049.2011.596166
9. Chung KT, Stevens S. The reduction of azo dyes by the intestinal microflora. *Crit Rev Microbiol.* 1992;18(3):175-190. doi:1040-84 IW92/$.50
10. Kobylewski S, Jacobson MF. Toxicology of food dyes. *Int J Occup Environ Health.* 2012;18(3):220-246. doi:10.1179/1077352512Z.00000000034
11. Araneda FJ, Lobos FL, Olivares CS, Oliva MF, Quezada FG, Sandoval P. Bebidas azucaradas: Representaciones de escolares con sobrepeso y obesidad. *Rev Chil Nutr.* 2017;44(3):276-282. doi:10.4067/S0717-75182017000300276
12. Castro AM, Toledo-Rojas AA, Macedo-De la Concha LE, Inclán-Rubio V. La obesidad infantil, un problema de salud multisistémico. *Rev Med Hosp GenMex.* 2012;75(1):41-49.
13. Sánchez-García R, Reyes-Morales H, González-Unzaga MA. Food preferences and nutritional status in school-age children living in Mexico City. *Bol Med Hosp Infant Mex*. 2014;71(6):358-366. doi:10.1016/j.bmhimx.2014.12.002
14. 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. doi:10.1016/j.sjbs.2020.08.025
15. Husain A, Sawaya W, Al-Omair A, Al-Zenki S, Al-Amiri H.Estimates of dietary exposure of children to artificial food colours in Kuwait. *Food Addit Contam.* 2006;23(3):245-251. doi:10.1080/02652030500429125
16. Jiménez-Aguilar A, Flores M, Shamah-Levy T. Sugar-sweetened beverages consumption and BMI in Mexican adolescents: Mexican National Health and Nutrition Survey 2006. *Salud Publica Mex.* 2009;51(SUPPL.4):604-612. doi:10.1590/S0036-36342009001000015
17. McCann D, Barrett A, Cooper A, Crumpler D, Dalen L,Grimshaw K, Kitchin E, Lok K, PorteousL, Prince E, Sonuga-Barke E, Warner JO, Stevenson J. Food additives and hyperactive behaviour in 3-year-old and 8/9-year-old children in the community: a randomised, double-blinded, placebo-controlled trial. *Lancet.* 2007;370(9598):1560-1567. doi:10.1016/S0140-6736(07)61306-3
18. Bakthavachalu P, Kannan SM, Qoronfleh MW. Food Color and Autism: A Meta-Analysis. In: Essa M, Qoronfleh M. (eds). *Personalized Food Intervention and Therapy for Autism Spectrum Disorder Management.* Advances in Neurobiology, volume 24. Cham, Switzerland: Springer Nature Switzerland AG.; 2020:481-504.https://doi.org/10.1007/978-3-030-30402-7_15.(Accessed october, 2021).
19. Dey R, Linares G, Munguía R, Chávez E. Construcción y Validación de un Instrumento para Evaluar el Consumo de Alimentos con Rojo Allura. *Inf Tecnol.* 2019;30(3):219-226. doi:10.4067/S0718-07642019000300219
20. Batada A, Jacobson MF. Prevalence of Artificial Food Colors in Grocery Store Products Marketed to Children. *Clin Pediatr (Phila).* 2016;55(12):1113-1119. doi:10.1177/0009922816651621
21. Marrón-Ponce JA, Sánchez-Pimienta TG, Da Costa Louzada ML, Batis C. Energy contribution of NOVA food groups and sociodemographic determinants of ultra-processed food consumption in the Mexican population. *Public Health Nutr.* 2018;21(1):87-93. doi:10.1017/S1368980017002129

22. Arnold LE, Lofthouse N, Hurt E. Artificial Food Colors and Attention-Deficit/Hyperactivity Symptoms: Conclusions to Dye for. *Neurotherapeutics.* 2012;9(3):599-609. doi:10.1007/s13311-012-0133-x
23. Doell DL, Folmer DE, Lee HS, Butts KM, Carberry SE. Exposure estimate for FD&C colour additives for the US population. *Food Addit Contam - Part A Chem Anal Control Expo Risk Assess.* 2016;33(5):782-797. doi:10.1080/19440049.2016.1179536
24. Sjöstedt N, Deng F, Rauvala O, Tepponen T, Kidron H. Interaction of Food Additives with Intestinal Efflux Transporters. *Mol Pharm*. 2017;14(11):3824-3833. doi:10.1021/acs.molpharmaceut.7b00563
25. Tikkanen A, Pierrot E, Deng F, Barras SV, Hagström M, Koenderink JB, Kidron H. Food Additives as Inhibitors of Intestinal Drug Transporter OATP2B1. *Mol Pharm.* 2020;17(10):3748-3758. doi:10.1021/acs.molpharmaceut.0c00507
26. Ling L, Loong C, Loke WM. Food additives in commercial cocoa beverage products and their effects on total polyphenol contents, cellular antioxidant and anti-inflammatory activities. *Curr Res Nutr Food Sci.* 2021;9(1):20-30. doi:10.12944/CRNFSJ.9.1.03
27. Omidvar N, Al-Jawaldeh A, Amini M, Babashahi M, Abdollahi Z, Ranjbar M. Food Marketing to Children in Iran: Regulation that Needs Further Regulation. *Curr Res Nutr Food Sci.* 2021;9(3):722-744. http://dx.doi.org/10.12944/CRNFSJ.9.3.02
28. Goubgou M, Songré-Ouattara LT, Bationo F, Lingani-Sawadogo H, Traoré Y, Savadogo A. Biscuits: a systematic review and meta-analysis of improving the nutritional quality and health benefits. *Food Prod Process Nutr.* 2021;3(1): 1-18. doi:10.1186/s43014-021-00071-z
29. Ghosh S. Factors responsible for childhood malnutrition: A review of the literature. *Curr Res Nutr Food Sci.* 2020;8(2):360-370. doi:10.12944/CRNFSJ.8.2.01
30. Khandpur N, Neri DA, Monteiro C, Mazur A, Frelut ML, Boyland E, Weghuber D, Thivel D. Ultra-Processed Food Consumption among the Paediatric Population: An Overview and Call to Action from the European Childhood Obesity Group. *Ann Nutr Metab.* 2020;76(2):109-113. doi:10.1159/000507840