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Cover Page Footnote

We would like to extend our warmest thanks to all the volunteers who answered our questionnaire and all the managers of the places of sale (small and medium surfaces, supermarkets and hypermarkets) which opened the doors and facilitated the access to the inventoried products.

HEALTH SAFETY IN DRINKS: EVALUATION OF CERTAIN FOOD ADDITIVES IN ALGERIA

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ABSTARCT

Consumption of drinks remains a controversial issue for public health. For more than 50 years, potential adverse reactions to additives have been suggested, but data to date are conflicting. The purpose of this article is to provide an approach to the health threat by inventorying the food additives used in 304 local and imported drinks sold in the Algerian market and classifying them according to their toxicity. In second time, survey population destinated to 1200 subjects to evaluate their drink consumption and health problems. The results show that the inventoried drinks contain many food additives, mostly consisting of dyes. Toxic and very toxic additives are incorporated in local products, while moderately toxic additives are present in imported ones. Children consume mostly soft drinks and juices and suffer from hyperactivity, gastro-intestinal disorders, and food allergies. Adults suffer from gastro-intestinal disorders, obesity, food allergies, and diabetes. This study provides a broad overview of available scientific knowledge and cites numerous studies on various aspects of drinks and their implications for health safety. Particular attention is given to ingredients, including artificial flavorings, colorings, and preservatives, and to the lesser known risks of microbiological and chemical contamination during processing and storage.

Keywords: Food additives, drinks, survey, human health, toxicity.

INTRODUCTION

Food additives have an essential role in the food industry and consumer habits, giving differentials to foods and increasing their stability and safety. Due to the evolution of science, new conservation techniques have been developed, such as the addition of preservatives, antioxidants, and sweeteners, which provide, in addition to conservation, desirable changes in food (Moll and Moll, 1998; Jen et al., 2017; Anses, 2019). Currently, food additives play a vital role in the industry, especially artificial sweeteners such as saccharin, acesulfame potassium and aspartame, preservatives such as benzoic and sorbic acid, and flavoring agents such as caffeine (Diogo et al., 2013; Kregial, 2015; Doepker et al., 2016).

The consumption of beverages has intensified over the years, mainly due to changes in eating habits and the search for a healthier diet by the population (Meunier, 2011). This increase has triggered the diversification of the beverage sector in general, both for the "recreational" drink sector and for those with other uses, such as meeting nutritional demands (Burniat et al., 2002; Muhammad et al., 2019; Silva et al., 2019).

According to the Association of Algerian Beverage Producers (APAB), Algeria marketed approximately 4.8 billion liters of soft drinks in 2016. To date, soft drinks have dominated with 2 billion liters sold at the end of 2014 and a growth of 8 % each year (APAB 2019). Soft drinks are made up of mostly water (at least 85 %), sugar, and potentially

vegetable extracts in colas or a percentage of fruit juice, varying according to the recipe (between 5 % and 12 %), together with food additives (Comission CA 2014; Muhammad et al., 2019).

Studies have shown that the food additives most likely to affect children's behavior are tartrazine (SIN102), propionate (SIN282), artificial colors (SIN110, E122, E124), and benzoate (E211) ((Macioszek, 2004; Linke, 2018; Rowland, 2018). Safety assessments of food additives are provided by specialized authorities, such as the Joint FAO/WHO Committee of Experts on Additives food, which establishes the lists of authorized and unauthorized additives and their specific acceptable daily doses (ADI or DJA). This ADI is an estimate of the amount of a food additive in food or beverages, expressed on the basis of body weight, ingested daily for a lifetime that is safe to the consumer's health (Ben Marzouq, 2017; FAO/WHO 2018).

It is therefore important to evaluate additives in food in an important industrialized product in the Algerian market, such as the soft drink, and identify which additives are used in their manufacture. This endeavor requires a careful examination of the labels, which is a more or less tedious task due to the ingenuity introduced in labels to distract consumers from the composition of the product. The list of components is usually written in lowercase letters for the packaging, or the product must be rotated in all directions for retrieval. We therefore decided to carry out a study on the evaluation of additives used in soft drinks marketed in our region.

Because of their possibility of transmitting diseases, such as malaria, encephalitis and filariasis, these diseases are caused by pathogens and parasites that they transmit to humans (Azari-Hamidian et al., 2019). Several species of mosquitoes are vectors of zoonotic diseases. *Aedes (Stegomyia) albopictus* (Skuse, 1894) can transmit several viruses that cause serious human diseases (Wang et al., 2021), In particular Dengue, Chikungunya, yellow fever and Zika fever (Ducheyne et al., 2018).

A good knowledge of the Culicidian fauna, by studying its taxonomy along with abundance, is very important before carrying out mosquito control. Larval surveys continued to be important for assessing population size and the impact of control measures. A good knowledge of pre-imaginal ecology is essential for understanding mosquito population dynamics (Service, 1993).

The present work aims to make a more extensive inventory of the Culicidae fauna in various stations in Tizi-Ouzou. It was being carried out as part of an updated inventory to deepen our knowledge of the faunal richness of the Culicidae, which can

MATERIALS AND METHODS

Food Additive Survey

From the start, it was challenging to study the countless compositions of food products sold on the shelves of stores, which led us to consider selecting criteria for the survey sites (small and medium surfaces, supermarkets, or hypermarkets) and their locations (metropolitan, cities, or small towns, etc.) for better representation. Thus, the selected sites were as follows: Metropolis Algiers; three hypermarkets, Setif Province; 1 hypermarket, Annaba Province; 5 hypermarkets and 6 small areas, Skikda Province; and 17 hypermarkets and 9 small areas. Setif, Annaba, and Skikda are 3 large departments in eastern Algeria. After carefully inspecting the list of selected local and imported products, we focused our survey on those purchased by different social classes (with different economic performance) of all ages.

Our sample consisted of 304 products that were sorted into four classes: soft drinks (SD), juices (J), syrups (S), and sugar-free drinks (SFD). We browsed shelf

by shelf and class by class the drinks in all the above mentioned commercial sites. During this operation, a range of products was inventoried, stored in data files for each class, and photographed, focusing on the following information: trade name and place of manufacture (country); composition of the product (ingredients list).

Through this investigation, we clearly noticed the unreadable labeling on many products due to the significantly small size, which did not allow the consumer to check on the purchased product's composition.

We classified all the additives found according to their category based on the classification of the *Codex Alimentarius* used in the European Union. This classification is the same as that chosen by the Algerian Trade Ministry (JORA, 2012). We proceeded to classify all food additives (all categories) that we came across during our investigation within four drink classes (SD, J, S, and SFD) of local or imported origin according to their degree of toxicity based on the European classification (2016).

Population Survey

The study was conducted using two methods with a structured questionnaire to reach the four corners of Algeria. The first method was carried out directly with consumers at different schools, and the second method was conducted online. We surveyed 1200 volunteers: the first population consisted of 600 school aged children, and the second population consisted of 600 adults. The survey covered sex, age, type of beverage consumed, the number of times per day and/or per week of consumption, and health problems.

RESULTS

Based on the products placed on the Algerian market and due to the limited number of some imported beverages (S and SFD), the number of products inventoried was as follows: SD, n = 68; J, n = 174; S, n = 42; SFD, n = 20.

Food Additive Survey

The results of our survey showed that the local and imported SFD contained 9 additives, including 2 sweeteners, SIN950 (Acesulftame potassium) and SIN955 (Sucralose). SIN950 had percentages of 83.3 % in both lots, and SIN955 had values of 67.7 % (Local) and 33.3 % (imported). We noticed that local and imported SD included all categories, followed by SFD, J, and finally S where few additives were listed.

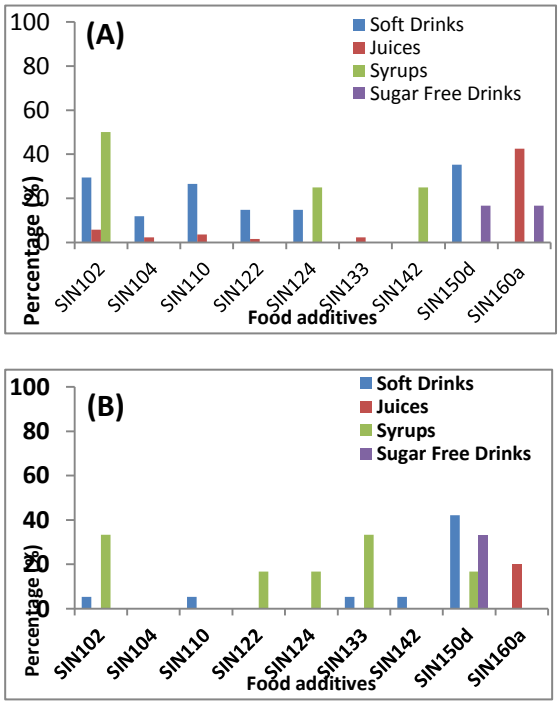

Figure 1 : Percentages of dyes incorporated in local (A) and imported (B) drinks inventoried.

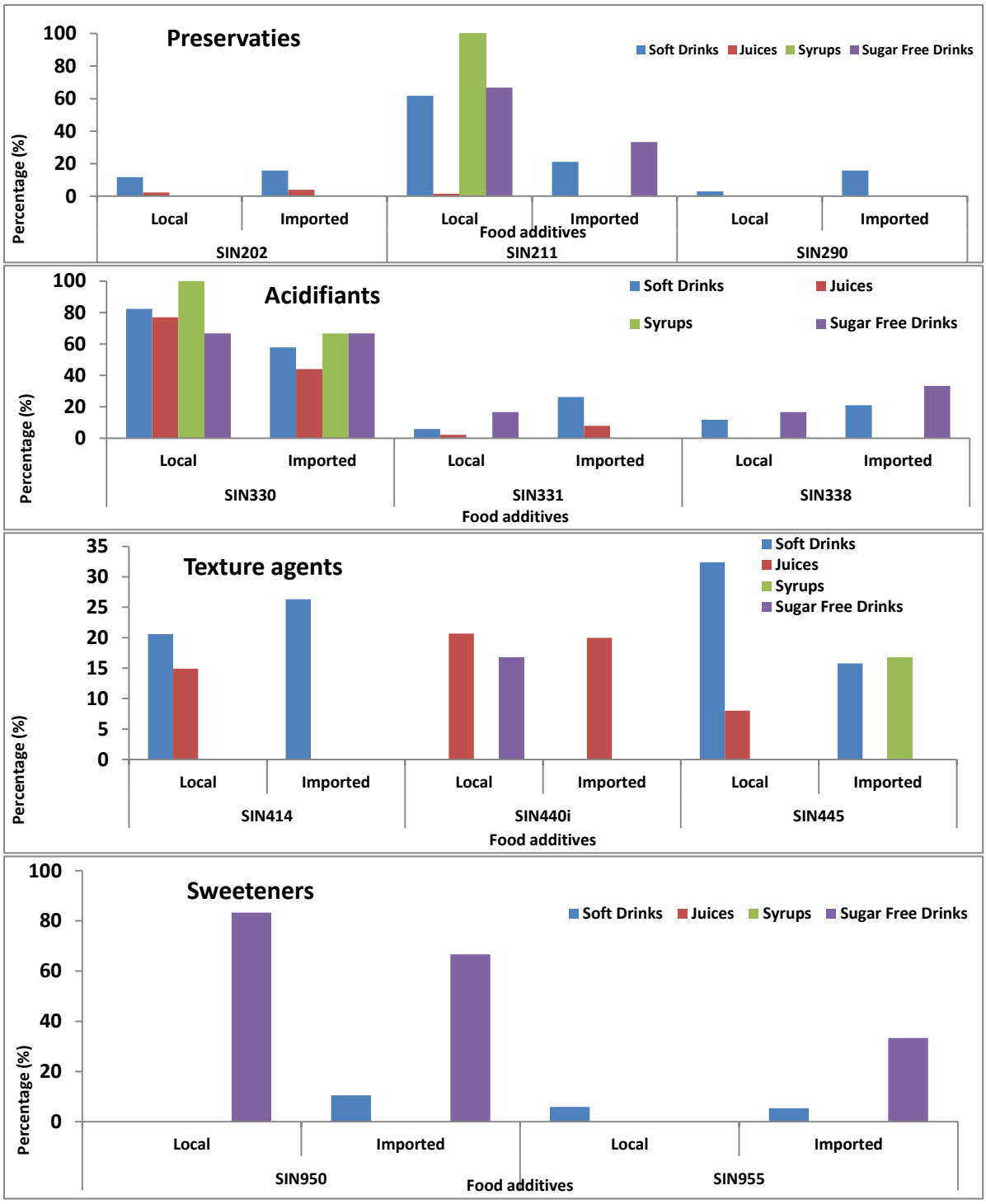

Figure 2: Percentages of food additives incorporated in local and imported drinks inventoried according to categories.

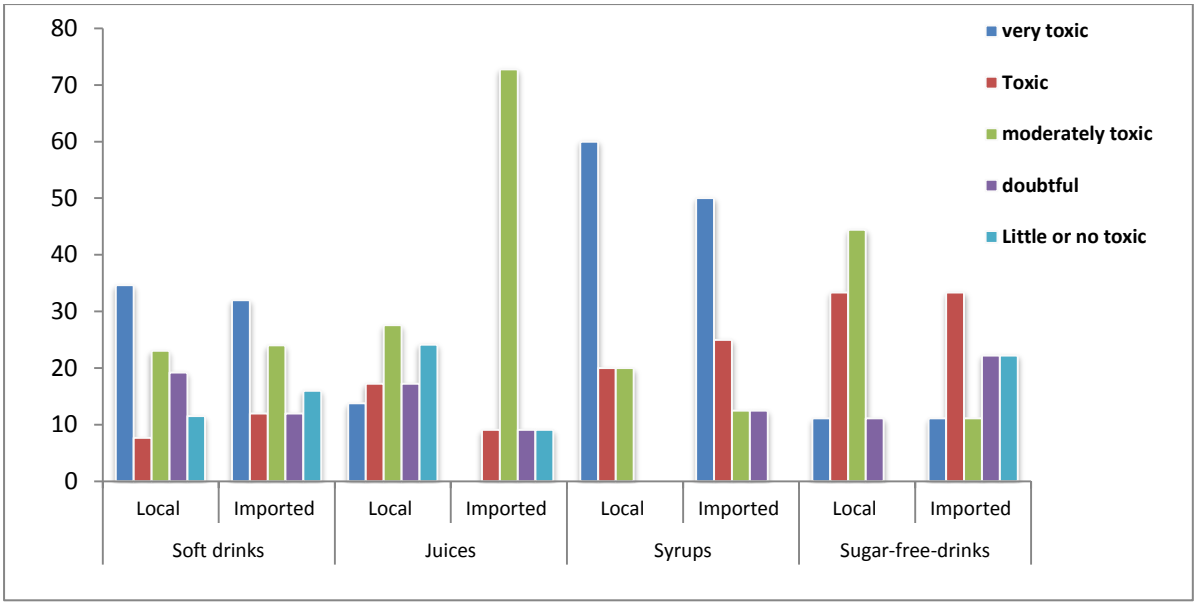

Figure 3: Distribution of food additives incorporated in the local and imported drinks according to the degree of toxicity.

According to the results (Figure 1), dyes were the most widely used category of food additive in the manufacturing of SD and S. Caramel IV (SIN150d) was incorporated in 35.3 % and 42.1 % of local and imported soft drinks, respectively. Tartrazine (SIN102) was found in 50 % of local S and 33.3 % of imported S.

Figure 2 illustrates that the preservative sodium benzoate (SIN211) was incorporated in all local S and in 66.7 % and 61.7 % of the local SFD and SD, respectively. The antioxidant ascorbic acid (SIN300) was used in 42.5 % of local J and 32 % of imported ones.

In addition, citric acid (SIN330) was incorporated into all the inventoried products ranging from 44-100 %. In addition, several food additives were registered in only one class among the four studied. Among them, Allura Red AC (SIN129) was present in local (8.8 %) and imported (5.3 %) SD. Additionally, the sweetener SIN951 (Aspartame) was present in SFD at 83.3 % for local products and 33.3 % for imported ones.We proceeded to classify all food additives (all categories) found during our investigation within four classes (SD, J, S, and SFD) of local or imported origin depending on their degree of toxicity. All other additives with percentages and categories are shown.

According to the results, we first noticed the presence of additives that are considered very toxic in all inventoried local drinks, whereas the imported J did not contain such a high degree of toxicity (Figure 3).

In addition, the highest percentage was found in local (60 %) and imported (50) S. Toxic food additives were present in all products at 33.3 % each of local and imported SFDs, 20 % of local S, and 25 % of imported J. Moderately toxic food additives were registered at 72.7 % of imported J, while in local products, 44.4 % was observed in SFD. However, the incorporation of doubtful and little/non-toxic food additives remained limited. Local S did not contain these two degrees, and imported S as well as local SFD contained only doubtful additives. The highest rate was recorded for these two degrees in SFD at 22.2 %. The most important percentage of additives with little or no toxicity was noted in local juices at 24.1 %. Conversely, moderately toxic additives represented the highest percentage (72.7 %) in imported J. For local drinks, the highest rate was

represented by toxic additives (60 %) in local S. In summary, we found that highly toxic and toxic food additives were used excessively in Algerian beverages, while in imported drinks, moderately toxic food was the most utilized. In our survey, there was no indication or mention of the presence of nanoparticles on the packaging of all drinks that we examined.

Population Survey

Among the children, we surveyed 51 % girls and 49 % boys. There were also two age groups: the first group (0-5 years old) represented 17.6 % of the subjects, and the parents answered the questionnaire; the second group (6-15 years old) formed the majority at 83.4 %. The results of the survey showed that 6.2 % of children between the ages of 1-5 years consumed J several times per day; 3.3 % of them consumed it once per day and 3.3 % 2-4 times/week. In addition, 4.5 % of these children consumed SD 2-4 times/week. The disorders observed in these children mostly consisted of gastrointestinal disorders (12 %) and food allergies (8 %), while the parents reported that 53 % had no disorders. For children aged 6-15 years old, we found that 18.4 % consumed SD once a day, although this value reached several times per day for 12.7 %. A rate of 15.2 % was determined for children between 6-15 years old for J, 14.3 % several times/day, and 18 % 2-4 times/week. The S was not consumed by 57.38 % of the children and less than once a week by 13.9 % of them. Concerning disorders recorded in this age group, hyperactivity was observed the most at 21.3 %, followed by gastrointestinal disorders (6.2 %), obesity (5.3 %), and food allergies (4.1 %).

For adults, respondents to our questionnaire were predominantly female at 60 %. We distributed the population according to consumption frequency of different classes of drinks, as shown in Table 1.

The age groups studied were the same for both sexes: 15-25 years old (71.9 % women and 28.1 % men), 26-45 years old (56.3 % women and 43.7 % men), and 46-75 years old (34.4 % women and 65.6 % men). The results shown in Table 1 indicate that among consumers aged 15-25 years (adolescent to young), men consumed mainly SD at least once or twice per day (5.2 %), while 10.9 % of women in the same age group did not consume them more than 2-3 times/week. We found that 6 % of men consumed J 2-3 times/week, while 9.6 % of women consumed it once a day and 8.3 % of them consumed it 4-6 times/week and 2-3 times/week. S was rarely consumed (12.1 % of men and 17.9 % of women) or never consumed (8.6 % of men and 22.4 % of women).

The population aged between 26-45 years preferred SD and J once a day (6.9 % and 12.9 %, respectively) and twice a day (7.8 % for both drinks) every day. This same age group rarely (12.9 %) or never (9.5 %) consumed S. We also found that the female population in this age group consumed J twice/day (7.1 %) and SD 2-3 times/week (7.7 %), while S were rarely (12.8 %) or never (20.5 %) consumed. The oldest population in our survey (46-75 years) was different from the other two groups; men consumed SD (11.2 %) and J (9.5 %) once a day every day, but women rarely consumed them (5.1 % for both drinks). This population rarely (12.9 % of men and 8.9 % of women) or never (11.2 % of men and 7.1 % of women) consumed “S”. The two populations (15-25 and 26-45 years old) stated that they never consumed SFD, whereas 0.32 % of the population aged 46-75 years consumed it rarely. Gastrointestinal disorders were the most common health problem (28.7 %) suffered by adults, followed by obesity (12.9 %), food allergies (7.7 %), and diabetes (5.5 %).

Table 1: Distribution of the population according to the consumption frequency of drinking classes

Drinks	Ages (years)	Sex	Once / day (%)	2 times / day (%)	3 times / day (%)	4 times and more / day (%)	4-6 times / week (%)	2-3 times / week (%)	Once / week (%)	Rarely (%)	Never (%)
Soft Drinks (SD)	15-25	M[a]	5.17	5.17	1.72	1.72	1.72	2.59	0	3.45	1.72
		W[b]	4.49	4.49	3.21	5.13	5.13	10.9	3.00	8.97	1.92
	26-45	M[a]	6.90	7.76	2.59	1.72	2.59	3.45	0.86	11.21	2.59
		W[b]	3.21	4.49	0	2.56	1.28	7.69	1.92	12.82	5.13
	46-75	M[a]	11.21	3.45	0	0.86	0	2.59	0.86	12.93	1.72
		W[b]	2.56	2.00	1.28	1.28	0.64	3.21	1.28	5.13	0
Juices (J)	15-25	M[a]	3.45	1.72	2.59	0.86	4.31	6.03	0.86	5.17	0
		W[b]	9.62	5.77	2.00	0.64	8.33	8.33	1.28	10.26	1.00
	26-45	M[a]	12.93	7.76	3.45	0.86	0	0.86	7.76	6.90	0
		W[b]	5.13	7.05	0.64	3.85	0.64	10.9	1.92	8.33	0.64
	46-75	M[a]	9.48	2.59	0.86	1.72	2.59	3.45	0.86	7.76	4.31
		W[b]	2.56	2.00	0	1.28	1.28	3.21	1.28	5.13	0
Syrups (S)	15-25	M[a]	0.86	0	0	0.86	0	0	0.86	12.07	8.62
		W[b]	1.92	0	1.00	0	0	3.00	3.00	17.95	22.44
	26-45	M[a]	2.53	0	0	0	0	2.59	1.72	12.93	9.48
		W[b]	1.92	0.64	0	0	0.64	1.28	0.64	12.82	20.51
	46-75	M[a]	3.45	0	0.86	0.86	0.86	0.86	2.59	12.93	11.21
		W[b]	0.64	0	0	0	0	0	0	8.97	7.05

During our investigation, we noticed that some manufacturing/expiration dates and ingredient lists were difficult to read due to their small size. The results of our questionnaire showed that 23.7 % of subjects read the date of manufacture/expiration of the products and ingredient lists, while 41 % of them did not. We found that 30.8 % of them simply read the date of manufacture/expiration, and only 4.5 % read the ingredient lists. Concerning their knowledge of food additives incorporated in beverages, we noted that 61 % of the interviewers did not know that beverages contain food additives, and of the 39 % who knew, 58 % did not know that these additives could be toxic and dangerous for public health.

DISCUSSION

Concerning the categories of food additives used in the inventoried products, we found dyes, preservatives, acidifiers, texture agents, and sweeteners in the four studied classes. SD, J, and SFD also contained antioxidants. Only SD and J contained coating agents and modified starches. According to the British Food Standard Agency, dyes can alter several functions, especially in children, by increasing their hyperactivity and impulsivity, thus promoting attention disorders (André, 2013). Since 2009, in the European regulation (2016), dyes SIN102, 104,110, 122, 124 and 129 have been labeled with the following statement: 'it has adverse effects on activity and attention in children'. All of these dyes were used in the inventoried local drinks but present to a reduced extent in imported beverages. These dyes cause various disorders (AFSSA, 2009), in particular hyperactivity and skin reactions, potentially justifying the percentage of surveyed children with hyperactivity (21.31 %) and food allergies (8 % of those 0-5 years old and 4.10 % of those 6-15 years old). Diezi et al. (2011), found that these additives could intervene in the

nervous system, causing abnormalities in the neuronal receptors responsible for hyperactivity. Tartrazine (SIN 202) and cochineal red A (SIN124) were highly incorporated in local SD and S, where they were present in lower proportions in the same products of foreign origin. Gallen and Pla (2013) have indicated that these two dyes are used to add color to products or restore their original color if altered by processing, and they appear to cause allergies. However, according to AFSSA (2009), in susceptible individuals, they can aggravate existing neurodermatitis and cause dyspnea and asthma attacks. In the study by Gallen and Pla (2013), SIN102 was prohibited in some countries (Austria, Finland, Norway, and Tunisia), and its presence must be indicated on labels in other countries (Gallen and Pla, 2013). Becker et al.(2009) reported food additives that are capable or incapable of inducing abnormal proliferation of cells, leading to tumor formation.

In addition, the Association for Therapeutic Anticancer Research established in 2010-2011, according to data from the international scientific literature, a classification of the additives depending on their toxicity. Tartrazine (SIN102) and yellow quinolone (SIN104) were classified as possibly carcinogenic agents. We also found red Allura AC (SIN129), brilliant blue (SIN133), and bright green (SIN142), which may also be carcinogenic according to the ARTAC. All of these dyes were present in our inventoried products. Sunset yellow FCF (SIN110), Azorubin (SIN122), and red Cochineal A (SIN124) are probably or certainly carcinogenic (ARTAC 2012), which were detected mainly in local products in our survey. André (2013) declared that many dyes of natural or synthetic origin are found at the heart of controversies. In the study reported by Bourrier (2006) and Coumoul (2016), preservatives were used to maintain food freshness and to protect against the effects of microorganisms to increase lifespan. Potassium sorbate (SIN202) was found at higher rates in imported SD and J compared with local ones. In her book, Marano (2016) indicated that potassium sorbate is one of the most harmless preservatives that can present certain allergenic traits, triggering hypersensitivity reactions such as urticaria. In large amounts, it can additionally cause damage to the cells that might lead to cancer. The Algerian consumer is in real danger because of the frequency of SD and J consumption of at least 1-2 times/day. Sodium benzoate (SIN211) was present in all local inventoried products (1.49-100 %) and only in imported SD (21.05 %) and SFD (33.33 %). Gouget (2015) described this preservative, known for its ability to block the development of certain yeasts and molds, as incorporated into certain sweet beverages to extend their shelf life. According to Gallen (2013), it is a hazardous and toxic agent that is carcinogenic and may cause allergy (Fontana-Tachon, 2013; Clémens 2015).

Gaffet (2011) also elucidated that the reactions of food additives are related to the dose, and at present, it is the simultaneous consumption of several additives that sometimes raises concern regarding what we call the synergistic or cocktail effect of additives. The adverse effects of combinations of a class of preservatives, including SIN211 with six dyes (SIN102, SIN104, SIN110, SIN122, SIN124 and SIN129), on children's behavior was demonstrated by a team of British researchers in 2007.These combinations are likely to cause attention deficit disorders in children with or without hyperactivity (McCann et al., 2007), which might explain the rate of children in our survey who were hyperactive due to the high amount of daily consumption of SD and J containing a wide range of dyes that can interact with the preservatives found in the inventoried products. Despite the danger of these combinations to the health of consumers, especially children, there is no indication

on the packaging of the inventoried products, local or imported. Citric acid (SIN330) is an acidifier used to control acidity, it was present in all local (66.67-100 %) and imported (44-66.67 %) inventoried drinks. However, in the AFSSA report (2009), it is known to cause dissolution of the dental flora and promote the absorption of metals such as lead or aluminum in the blood (AFSSA, 2009)). Moreover, according to Marano (2016), not only can citric acid affect brain activity leading to memory and learning disorders, but it also plays a role in neurodegenerative conditions such as Alzheimer's or Parkinson's disease (Marano, 2016). In the study by Roberts (2004), sweeteners are described as sweetening additives that endow a sweet taste to the product. Acesulfame potassium (SIN950), aspartame (SIN951), and sucralose (SIN955) were present in our inventoried beverages: SIN950 was present in imported SD and SFD (local and imported) and SIN955 in SD (local and imported) and imported SFDs. Aspartame was present in local (83.33 %) and imported (33.33 %) SFDs. In the official Journal of the Algerian Republic (JORA, 2012), the labeling of table-top sweeteners containing polyols and/or aspartame and/or the aspartame-acesulfame salt should bear the following warnings: (i) polyols: excessive intake may have laxative effects; (ii) aspartame/aspartame-acesulfame salt: contains a source of phenylalanine.

However, in all the local drinks inventoried, none of these mentioned agents were found. The ARTAC (2012) classified aspartame as a toxic additive. Gallen and Pla (2013) described it as the most dangerous additive belonging to the family of excitotoxins. In a publication by Roberts (2001), they are described as neurological excitatory amino acids with the ability to instantly destroy neurons in our brain by exciting them until they resolve (death of nerve cells) (Gouget, 2015). The ARTAC (2012) considered aspartame to be a slow-acting poison with many side effects, such as the deregulation of weight and the formation of different forms of cancer. In our survey, only 20 SFD (10 local and 10 imported) were placed on the Algerian market, among a total of 304 inventoried drinks. The people who answered our questionnaire, despite anonymity, did not contribute information about their consumption of this class of drinks. However, concerning health problems, 5.33 % of children and 12.87 % of adults suffered from obesity, and 5.33 % of adults had diabetes. This result may be due to their consumption of SFD and SD, with a daily consumption frequency (Table 1). Gouget (2015) and Brunellière (2010) described a study that was carried out to examine the combined effect of aspartame (SIN951) and quinoline yellow (SIN104), on the one hand, and brilliant blue (SIN133) with sodium glutamate (SIN621), on the other hand, on the nerve cells of laboratory mice. The results showed that these four additives were potent inhibitors of nerve cell growth, but overall, combining these substances increased their toxicity tenfold on nerve cells.SIN133 + SIN621 resulted in fourfold toxicity and SIN104 + SIN951 in sevenfold toxicity. This study showed that the toxicity of the combined substances was not simply the result of the additional sum of the individual toxicities of the molecules, but a multiplication of toxicities (Brunellière, 2010). These four additives were present in a large number of food products, again raising concern about children with growing brain cells (Robert, 2004).

The results of our survey showed that the diet of Algerian consumers, both children and adults, was characterized by massive consumption of SD and J at a minimum of once per day every day, mainly by men. In addition, we found that S was less consumed regardless of gender. According to the results, an average of 47.89 % of children and 48.51 % of adults suffered from health problems, especially gastrointestinal disorders, obesity, food

allergies, hyperactivity, and diabetes. These health problems could have a direct link to the unhealthy diet of Algerian consumers, which is consistent with the opinions of other scientists such as Marano (2013) and Gaffet (2011), who said that these disorders are directly related to diet. As they shop, most subjects buy beverages without consulting the date of manufacture/expiration or the list of ingredients, which is often difficult to read due to the small font size on millions of packs of groceries placed on the Algerian market. Additionally, the packaging of several products among those listed lacks essential information. Moreover, a large number of consumers are not aware of the incorporation of food additives into beverages, nor are they informed about the toxicity; this could be justified by a lack of nutritional awareness. Regarding children, our questionnaire showed an abuse of SD and J consumption despite their young age. Thus, children could constitute the population most exposed to food additives essential for industrialists. Nevertheless, and as Gouget (2008) specified, the human body is not made to consume large quantities of these additives, and even less should be consumed by children**.**

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS CONTRIBUTION

All authors participated to draft and critically review the manuscript.

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