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Distribution and patterns of use of food additives in foods and beverages available in Brazilian supermarkets†

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The growing consumption of ultra-processed foods and beverages has drawn attention to the use of different food additives in these products. The use of these additives for different purposes in food products is permitted under specific legislation. The objective of the present study was to assess the distribution and patterns of occurrence of the different categories of food additives present in packaged foods and beverages sold in Brazil. A descriptive cross-sectional study was conducted based on data from lists of ingredients used in foods and beverages sold in supermarkets in Brazil, collected by photographing product labels. The number, technological purpose and proportion of food additives in 9856 items (25 groups) were assessed. Exploratory factor analysis was employed to derive the patterns of food additive categories. Linear regression models were used to assess the association between the patterns and food items analyzed. Only 20.6% of the products analyzed contained no food additives, while 24.8% contained ≥6 additives. The use of food additives was high, particularly cosmetic additives, predominantly flavoring agents, colorings and stabilizers. Five patterns of food additive categories were identified and associated with ultra-processed foods and beverages. The results revealed that food additives are highly prevalent in several types of food items sold in the Brazilian market. Also, the same additive category was common to several different food groups, as were specific food additive combinations. This exposure is potentially harmful to human health, given the known deleterious effects associated with the consumption of these substances.

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Introduction

Globally, there is rising consumption of ultra-processed foods and beverages (henceforth called ultra-processed foods) where, in some cases such as the United States, Canada, the United Kingdom and Australia, these products now constitute the main source of dietary energy.[1] In Brazil, and other middle-income countries, traditional diets have been steadily replaced by ultra-processed foods in recent years.[1–3]

Ultra-processed foods can be defined as formulations comprising ingredients, particularly industrialized, produced through a series of industrial processes and often contain food additives incorporated to enhance or intensify the flavour and taste of the final product.[4] Current evidence shows that ultra-processed foods have harmful effects on health, where different factors may be associated with this outcome: unfavourable nutritional profile, stimulant for overeating, contaminants from packaging, toxic substances produced during processing, and the presence of food additives.[5–8]

Many types of food additives have been individually associated with adverse health effects, such as changes in intestinal microbes and permeability,[9,10] hyperactive behavior,[11] memory deficits,[12–14] metabolic alterations,[9,10,15,16] and carcinogenic effects.[17–19] However, ultra-processed foods often contain a mix of food additives and little is known about the impact of these combinations on health.[11,20,21]

In Brazil, the use of food additives is regulated by the National Health Surveillance Agency (ANVISA), which sets out the types of food additives permitted by food category. The agency defines food additives as all and any ingredient intentionally added to food without the purpose of nourishment but to modify the physical, chemical, biological or sensory

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characteristics, during manufacture, processing, preparation, treatment, packaging, storage, transport or manipulation of food.[22] Food additives fulfil a range of functions as preservatives, antioxidants, emulsifiers, thickeners, and sweeteners, among others. Some of these functions play an important role in the preservation of foods and even in improving their nutritional profile, while also ensuring greater food safety. However, ultra-processed foods commonly contain a type of additive categorized by the NOVA food classification as "cosmetic", whose purpose is to make the final product more attractive and palatable, *e.g.*, colourings and flavouring agents.[4,23]

Thus, given the potential consequences of a high intake of different food additives, alone or in combination, it is important to elucidate the frequency of their use and the way they are typically used and/or combined in foods. Therefore, the objective of this study was to assess the distribution of food additives in packaged food and beverages sold in Brazil and to analyse patterns of additive combinations in the food categories studied.

Methods

Study type and sample

A descriptive cross-sectional observational study was carried out using data from ingredients listed on labels of foods and beverages commercially available in major supermarket retail chains in two large cities in Brazil. Formal permission was sought from the supermarket chains before performing the study.

A total of 10 outlets of major retail chains selling foods and beverages in the cities of São Paulo and Salvador were selected for the study. Initially, the five largest food retailer chains in the country were identified from information on annual sales volumes in the retail market for 2016.[24] The criterion for selecting the stores from each retail chain in the cities studied was the income of the census sector in which the stores were located. To this end, the information on mean family income per capita of the census sectors was used,[25] considering a 1 km buffer zone around each store of the supermarket chains selected. The stores in each chain for the two cities were distributed according to mean family income terciles per capita, and stores located in the first (low income) and last (high income) income terciles were selected, prioritizing stores with the larger physical area.

Data collection

Data collection took place between April and July 2017. Trained assessors used the photographic method to record the labels by photographing each side of the packaging of the foods and beverages included.[26]

All packaged foods and beverages commercially available at the selected supermarkets were included in the study, giving a total of around 14 000 products photographed. After exclusion of duplicates, products with multi-packs and assorted items, bottled waters, and products lacking nutritional information were also excluded. Further details on the data collection process adopted can be found in Duran *et al.*[27] The present study included all foods and beverages for which data were available from listed ingredients, totalling 9856 items.

Data was entered by trained standardized typists on the RedCap online platform using a specific form developed together with the University of North Carolina at Chapel Hill (UNC) in the USA and the Instituto de Nutrición y Tecnología de los Alimentos (INTA) in Chile and adapted for use in the Brazilian study. For 10% of the sample records, data were keyed in twice (double data entry) by the same individual and again by a second individual to verify intra- and inter-observer reliability, respectively.

In this study, 9856 foods and beverages were categorized into 25 groups to facilitate the analytical process, including: breakfast cereals and granola bars; bakery products; convenience foods; unsweetened dairy products; sweetened dairy products; salty snacks; cookies; canned vegetables; oils and fats; sauces and dressings; coffee and tea; candies and desserts; cereals, beans and other grain products; packaged fruit and vegetables; meats; poultry, seafood and eggs; sugar and other non-caloric sweeteners; processed meats; juices; nectars; fruit-flavoured drinks; sodas; other beverages; nuts and seeds; cheeses; and fruit-based sweets.

Additive identification and classification

Based on the ingredients listed for the foods analysed, food additives and technological adjuvants were identified, as defined by ANVISA,[22] and other ingredients were also classified such as fresh or minimally processed foods, cooking ingredients, vitamins and added minerals. The presence of maltodextrin, polydextrose and extracts was also identified. Each food additive was categorized according to function into the following types: flavouring agent, preservative, colouring, stabilizer, emulsifier, antioxidant, thickener, flavour enhancer, acidity regulator, sweetener (natural and artificial), leavening agent, antihumectant, humectant, flour improving agent, sequestrant, acidifier agent, gelling agent, bulking agent, release agent, glazing agent, coagulant, firming agent, antifoaming agent, anticaking agent, propellant, softener and maturing agent.

In addition to categorizing food additives by function according to ANVISA, cosmetic additives were also categorized using the NOVA classification. Cosmetic additives are used to imitate the flavour, colour and aroma of other foods, enhance sensory qualities of the foods and/or mask aspects that make the final product unpalatable. This group of additives includes colourings, flavouring agents, flavour enhancers, sweeteners, emulsifiers, and glazing agents, among others.[4,23] Furthermore, maltodextrin, a type of modified starch, and also polydextrose, a glucose polymer used as either soluble fibre or a food additive (INS1200), were deemed cosmetic additives. This decision was based on the fact that maltodextrin is used as a sugar substitute, gelling agent, thickener and cryoprotectant, *i.e.*, functions attributed to cosmetic agents. Polydextrose can be used as a bulking agent, thickener, stabilizer and humectant in a range of foods.[28–30]

Data analysis

The presence of food additives in the foods and drinks analysed was determined by estimating the distribution of the number of items by food group, the percentage of food additives as a proportion of total ingredients, the proportion of foods containing 0, 1, 2–3, 4–5 and ≥6 food additives by food group, and prevalence of food additive categories in the foods analysed.

Based on the finding that the majority of the foods analysed contained more than 1 additive (67.8%), factor analysis was performed to explore patterns showing possible combinations of food additive categories present in the foods and beverages. Additives found in fewer than 100 foods were not included in the analysis. The applicability of factor analysis and sample adequacy was checked using the Kaiser–Meyer–Olkin (KMO) index with KMO values >0.60 considered acceptable. The number of factors (patterns) to be retained in the exploratory factor analysis was determined as follows: eigenvalue (autovalue) >1.0; scree plot (Cattell test), on which values located before the inflection point on the line in the graph indicate the number of factors to be retained; and interpretation of factor loadings determined by the principal components method to allow linear combinations of these initial factors. After deriving the number of factors, the orthogonal rotation of the factors was done using the Varimax method, which allows provisional factors to be transformed, maximizing factors with high loadings and minimizing those with low loadings, to determine a better distribution of factor loadings which was easier to interpret. The food additive groups with factor loadings >0.30 after rotation were considered representative of a food additive pattern. Positive factor loadings >0.30 exhibited positive correlations between food additive and additive pattern. Communality was also assessed and a minimum cut-off of 0.20 was considered acceptable for each food additive in the model. Additive factor scores were then calculated for each food item assessed, where higher scores indicated greater adherence to the respective factor. The factors were interpreted as the additive category patterns.

The association between each pattern and food group was assessed using linear regression models, where the score was defined as the outcome variable and the 25 food groups as the exposure variable (with packaged fruit and vegetables serving as reference). A coefficient of association >1.0 was considered a strong positive association.

All statistical analyses were performed using Stata version 15.1 (StataCorp LP, College Station, Texas, United States).

Results

The 9856 items assessed were categorized into 25 food groups, 6 of which represented over 50% of the items, namely: candies and desserts (12.4%), processed meats (8.2%), convenience foods (8.1%), sauces and dressings (8.0%), cookies (7.6%) and cheeses (6.2%). The frequency of the other groups is shown in Chart 1.

The percentage of food additives as a proportion of total ingredients listed for the items analysed is depicted in Chart 2. Regarding the flavoured-fruit drinks, sodas, sugar and other non-caloric sweeteners, other beverages and sweetened dairy products food groups, additives made up over 50% of the total ingredients listed.

Of the food additives permitted in Brazil, 32 categories were identified according to function, 19 of which were found in at least 100 items assessed and thus included in the analysis. Flavouring agents were present in 47.1% of the items assessed. Preservatives, colourings, stabilizers and emulsifiers were present in 28.9%, 27.8%, 27.6% and 19.4% of the foods and beverages analysed, respectively (Chart 3). Of the five most prevalent additives, only one (preservatives) was not a cosmetic additive.

With regard to the distribution of the number of food additives present in the food and beverage groups, 20.6% had no additives listed, 11.6% had one additive, 19.8% had two or three, 23.2% had four or five, and 24.8% of groups had six or more additives listed in ingredients. The percentage of foods and beverages by food group according to the number of food additives present is given in Table 1. The food groups containing the greatest proportion of six or more additives were fruit-flavoured drinks, sweetened dairy products, other beverages and processed meats at 74.5%, 55.6%, 53.2%, 46.8% and 37.0%, respectively.

Exploratory factor analysis of the patterns of food additive categories in the foods and beverages assessed, based on scree plot (Cattell test), eigenvalue >1.0 and interpretation of the patterns, confirmed the retention of five factors explaining 46.8% of the variability of occurrence of the food additives in the data analysed. The factors retained and interpreted as patterns are given in Table 2 and are described below.

- Pattern 1 comprising flavouring agents, colouring, antihumectant, artificial sweetener, flavour enhancer, acidity regulator, maltodextrin-polydextrose;
- Pattern 2 comprising flavouring agents, emulsifier, humectant, baking powder, flour improvers;
- Pattern 3 comprising antioxidant, acidifier agents, preservative, sequestrant;
- Pattern 4 comprising colouring, stabilizer, thickener, preservative, coagulant; and
- Pattern 5 comprising natural and artificial sweeteners.

Linear regression analysis showed a strong positive association between Pattern 1 and the food groups fruit-flavoured drinks (2.93; 95%CI 2.78;3.07), salty snacks (1.41; 95%CI 1.28; 1.54), convenience foods (1.05; 95%CI 0.94;1.17), candies and desserts (1.02; 95%CI 0.91;1.13), other beverages (1.02; 95%CI 0.89;1.16) and breakfast cereals and granola bars (1.00; 95%CI 0.86;1.13); between Pattern 2 and the groups cookies (2.52; 95%CI 2.43;2.62), bakery products (1.81; 95%CI 1.71;1.90) and candies and desserts (1.01; 95%CI 0.92;1.10); Pattern 3 and the groups sodas (1.85; 95%CI 1.66;2.05), processed meats (1.16;

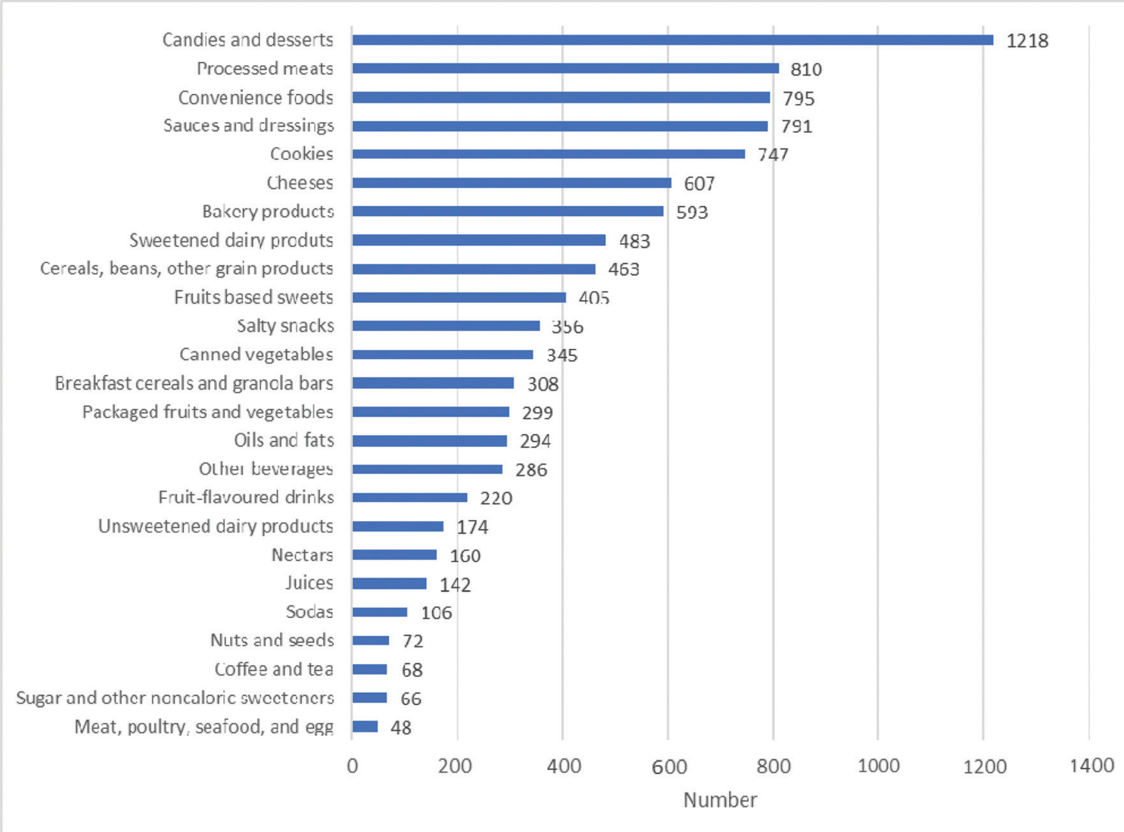

Chart 1 Distribution of the number of items analysed by food group.

95%CI 1.04;1.28) and nectars (1.16; 95%CI 0.99;1.33); Pattern 4 and the groups cheeses (2.22; 95%CI 2.11;2.33), unsweetened dairy products (1.89; 95%CI 1.77;2.01) and sodas (1.00; 95%CI 0.82;1.18); and Pattern 5 and the food groups sugar and other non-caloric sweeteners (2.31; 95%CI 2.08;2.54), fruit-flavoured drinks (1.09; 95%CI 0.94;1.23) and other beverages (1.01; 95% CI 0.87;1.15) (Chart 4A and B and the ESI).

Discussion

The present study yields important information on the use of food additives in packaged foods and beverages commercially available in Brazilian supermarkets: (1) few of the products analysed were free of food additives, while a quarter contained 6 or more; (2) the prevalence of food additive use was high, particularly cosmetic additives; and (3) patterns of food additive categories were derived showing possible combinations positively associated with certain food and beverage groups.

The analysis found that beverages (fruit-flavoured drinks, sodas and other beverages), sweetened dairy products and sugar and non-caloric sweeteners were the food groups with the highest amount of food additives relative to other components in the ingredients list. Also, a quarter of the foods assessed contained six or more additives, again predominantly ultra-processed beverages (fruit-flavoured drinks, sodas, and other beverages), sweetened dairy products, and processed meats. In a French study assessing the distribution and co-occurrence of food additives in 126 000 food products, the results also showed a high rate of additive use in the foods analysed: 53.8% of foods assessed contained at least one food additive (*versus* 79.4% in the present study) and 10% had five or more (*versus* 24.8% containing six or more additives in the present study),[31] which may indicate that foods available to Brazilians are of lower quality.

Another noteworthy finding of the present study was that cosmetic additives predominated (except for preservatives and leavening agents) among the most common categories of food additives in the items assessed. With this category, the main purpose of using food additives is to intentionally modify the physical and sensory characteristics of the foods (texture, flavour and colour) to make them more palatable and appealing for consumption, rather than making food safer. According to Baker *et al.* (2020),[1] there is a growing trend for greater use of cosmetic additives globally. In middle-income countries such as Brazil, cosmetic additives used in the production of ultra-processed foods represent 0.7 kg per capita in 2019. The annual rate of increase in the use of cosmetic additives among low, middle and high-income countries was estimated at 7.0%, 2.9% and 4.8%, respectively. Other studies

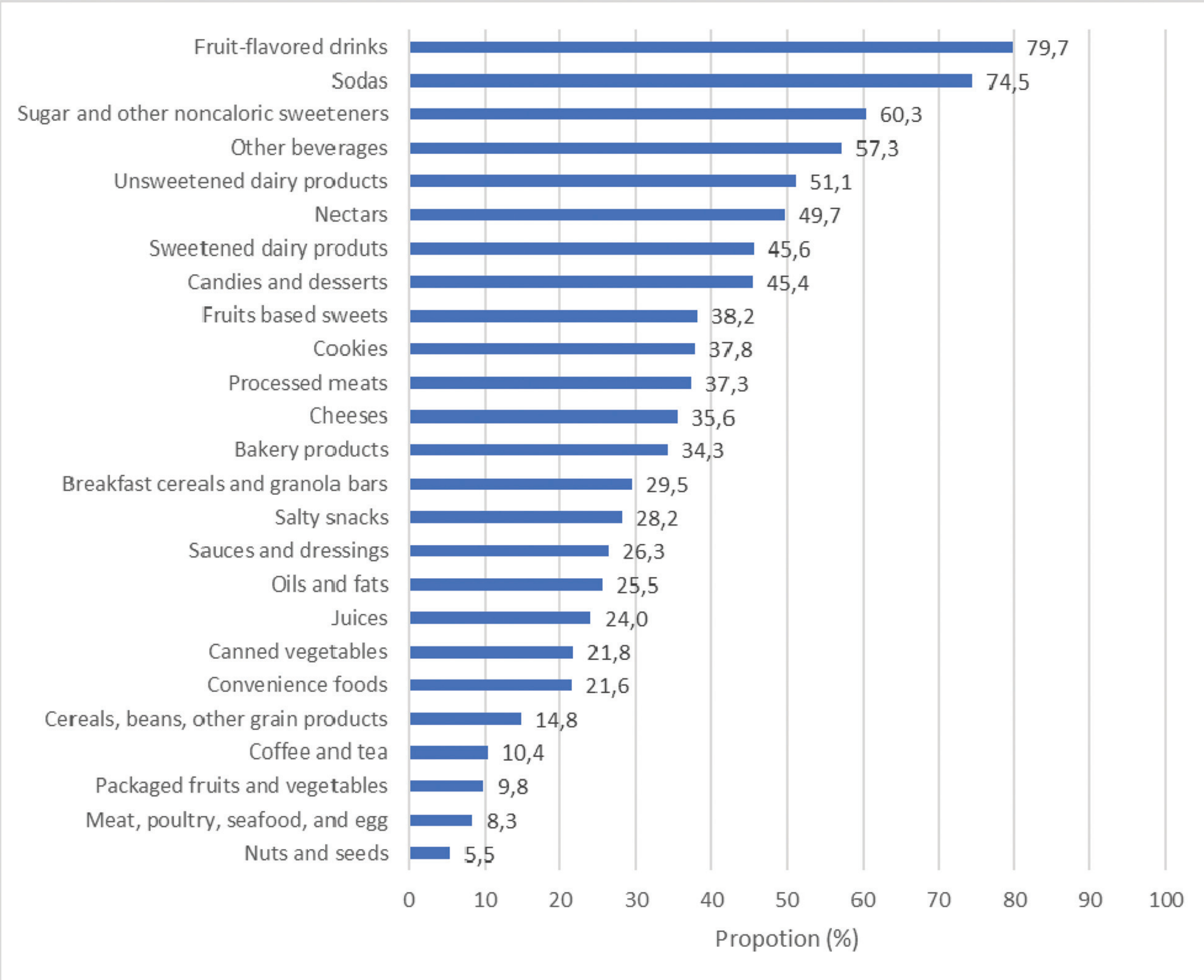

Chart 2 Percentage (%) of food additives as a proportion of the total number of ingredients.

have also shown a high prevalence of cosmetic additive use in foods and beverages. In a Brazilian study of foods labelled "home-made", 11 classes of food additives were identified in the products. Flavouring agents were found to be the most common, and cosmetic additives also predominated (colourings, emulsifiers, thickeners, flavour enhancers, stabilizers and sequestrants).[32] In the French study cited before, considering the three most common additives found, only citric acid, a preservative, is used for ensuring food safety. The other two leading additives, lecithin (emulsifier) and modified starch (a polysaccharide used for controlling or changing characteristics such as texture, moisture, consistency and stability), can be regarded as cosmetic additives.[31] Notably, although the Brazilian food regulatory body ANVISA does not recognize modified starch as a food additive, the European Food Safety Authority (EFSA) does.[33]

It is important to point out that, according to the NOVA food classification,[23] a predominance of food additives over other ingredients, as found in some foods in the present study (fruit-flavour drinks, sodas, other beverages, sweetened dairy products, processed meats, sugar and sweeteners group) classifies these as ultra-processed foods.

There is evidence showing a rise in ultra-processed food consumption in Brazil and, between 2002–2003 and 2017–2018, the consumption of sweeteners has risen sharply from 0.1% to 8.4%, respectively.[34] In Latin America and the Caribbean for instance, although fizzy drinks sales are declining, sales of juices and nectars are on the rise.[1] This scenario represents a cause for concern because it exposes the population to a higher intake of food additives.[3,34]

A study investigating global trends in sales of ultra-processed foods and ingredients used in their production, based on data from the Euromonitor Passport between 2006 and 2019, found a major increase in the sales of ultra-processed beverages across all the regions assessed (Central and Eastern Europe, North Africa and the Middle East, Central and East Asia, South Africa and Southeast Asia). Although sales of ultra-processed foods in the other regions (North America and

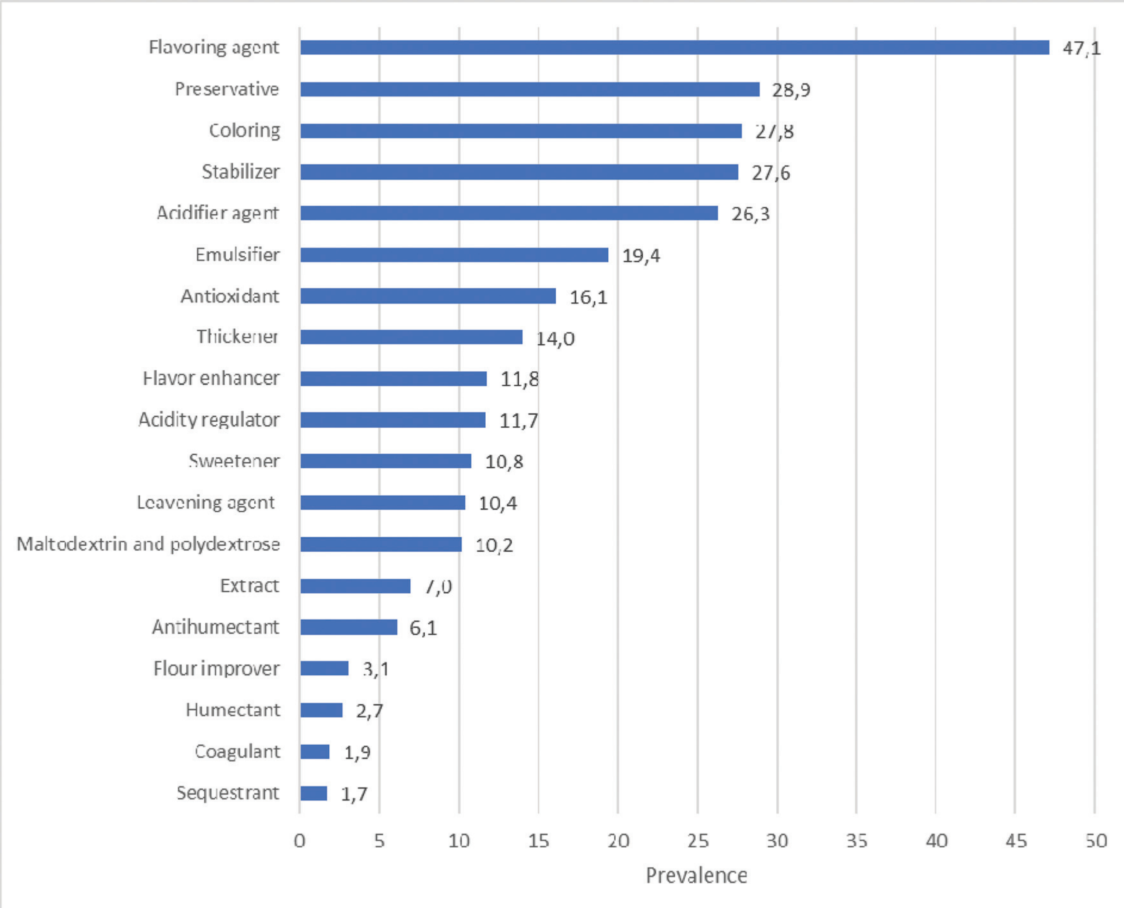

Chart 3 Prevalence of food additive categories in the food items analysed.

Table 1 Proportion of food groups according to the number of food additives

Food groups	No additives (%)	1 additive (%)	2–3 additives (%)	4–5 additives (%)	≥6 additives (%)
Breakfast cereals and granola bars	6.5	18.5	22.4	20.7	31.8
Bakery products	11.6	11.4	14.8	30.7	31.3
Convenience foods	23.0	13.3	21.7	17.3	24.5
Unsweetened dairy products	27.6	17.2	10.3	44.8	0
Sweetened dairy products	2.7	2.7	9.7	31.6	53.2
Salty snacks	25.3	12.3	26.9	19.1	16.3
Cookies	6.9	5.3	10.7	41.4	35.4
Canned vegetables	32.7	26.1	30.7	10.4	0
Oils and fats	56.1	17.3	8.5	3.4	14.6
Sauces and dressings	19.2	16.5	28.4	21.8	13.9
Coffee and tea	57.3	39.7	2.9	0	0
Candies and desserts	5.7	4.9	23.9	29.7	35.7
Cereals, beans, and other grain products	64.1	9.3	19.6	5.8	1.1
Packaged fruit and vegetables	81.6	9.0	9.3	0	0
Meats, poultry, seafood and eggs	83.3	12.5	4.1	0	0
Sugar and other non-caloric sweeteners	27.3	4.5	19.7	37.8	10.6
Processed meats	15.3	6.4	12.9	28.2	37.0
Juices	39.4	32.3	25.3	2.8	0
Nectars	6.3	7.5	29.3	49.3	7.5
Fruit-flavored drinks	0.9	0.4	5.9	18.1	74.5
Sodas	0.0	0.9	5.6	37.7	55.6
Other beverages	10.1	2.7	12.5	27.6	46.8
Nuts and seeds	84.7	5.5	6.9	1.4	1.4
Cheeses	9.2	20.2	37.8	20.2	12.3
Fruit-based sweets	19.7	24.2	29.6	16.7	9.6
All groups	20.6	11.6	19.8	23.2	24.8

Table 2 Retained factor loadings of patterns of food additive categories present in the food items analysed

Food additives	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Communality
Flavouring agent	**0.55**	**0.47**	0.26	0.09	0.02	0.60
Antioxidant	0.13	−0.09	**0.67**	−0.04	−0.12	0.49
Colouring	**0.56**	0.12	0.27	**0.34**	−0.04	0.52
Acidifier agent	0.21	0.11	**0.48**	0.28	0.23	0.42
Stabilizer	0.12	−0.05	0.20	**0.63**	0.00	0.46
Emulsifier	0.05	**0.79**	−0.12	−0.06	0.09	0.66
Humectant	0.05	**0.43**	0.14	−0.03	0.16	0.23
Antihumectant	**0.71**	−0.08	−0.14	−0.10	−0.02	0.54
Natural sweetener	0.03	0.02	0.04	−0.04	**0.69**	0.48
Artificial sweetener	**0.38**	−0.10	0.09	0.10	**0.68**	0.64
Leavening agent	−0.02	**0.76**	−0.09	−0.08	−0.05	0.60
Thickener	0.30	0.05	0.13	**0.39**	0.17	0.29
Preservative	−0.17	−0.02	**0.50**	**0.46**	0.05	0.49
Flour improver	−0.10	**0.46**	−0.06	0.07	−0.13	0.25
Flavour enhancer	**0.45**	−0.13	0.22	−0.05	−0.53	0.56
Coagulant	−0.10	−0.08	−0.35	**0.67**	−0.11	0.60
Sequestrant	−0.07	−0.03	**0.59**	0.02	0.03	0.36
Acidity regulator	**0.51**	−0.07	0.05	0.14	0.04	0.29
Maltodextrin-polydextrose	**0.57**	0.07	−0.09	−0.08	0.27	0.42
Explained variance (%)	12.0	10.1	9.2	7.8	7.7	
Cumulative variance (%)	12.0	22.1	31.3	39.1	46.8	
Eigenvalue	2.84	2.00	1.54	1.37	1.14	

Australia, Western Europe and Latin America and the Caribbean) were stable or declining slightly, they remain by far the highest overall.[1]

The present study results elucidated the distribution of additives in foods and beverages commercially available in Brazil and also led to the identification of five food additive patterns (often co-occurring) in the foods and beverages assessed. Three patterns were positively associated with ultra-processed beverages: Pattern 3 (comprising antioxidants, acidifier agents, preservatives and sequestrants) with sodas; Pattern 4 (consisting of colourings, stabilizers, thickeners, preservatives and coagulants) with sweetened dairy beverages; and Pattern 5 (consisting of natural and artificial sweeteners) with fruit-flavoured drinks. Furthermore, a strong association was also found for Pattern 2 (comprising flavour agents, emulsifiers, humectants, leavening agents, and flour improvers) with cookies and bakery products; and for Pattern 4 (colourings, stabilizers, thickeners, preservatives, and coagulants) with cheeses.

A quarter of the products analysed contained six food additives or more in their formulations and combinations of additives were common to several different food groups. This situation highlights that the way in which these food additives are being used is at odds with the conditions under which the safety of their use is established. Consumers are regularly exposed to the same food additive in different food categories and a mix of these additives. The maximum use levels determined for a given food additive by food category are defined so as to protect the consumer against adverse effects of each substance individually. However, there is a dearth of safety studies exploring the risk of cumulative intake of the same food additive through consumption of all foods containing them, or the potential effect of the resultant "cocktail" of additives (many food additives used together) in terms of the synergistic interaction between them in food products. The urgency of this issue becomes more pressing in the context of soaring consumption of ultra-processed foods, in which food additives are widely used.[1–3]

Adverse health effects have been reported for some commonly used food additives found in the foods and beverages assessed, particularly by animal studies. Deleterious effects include behavioural and common mental disorders, associated, for example, with colouring and flavour enhancers;[11,12] hypersensitivity reactions and autoimmune disease related to emulsifiers;[9,10,35] metabolic alterations promoted by sweeteners, emulsifiers and preservatives;[15,16,36] and cancer risk linked to colourings, sweeteners and preservatives.[17–19] Few studies investigating the potential effects of exposure to multiple additives or the possible interaction and synergy among them have been conducted. *In vitro* neurotoxic effects of a combination of bright blue colouring with glutamic acid and quinoline yellow colouring with aspartame have been observed[20] and a mix of colourings was shown to increase oxidative stress in rats.[21] In addition, a UK study assessing the exposure of 3-year-old and 8/9-year-old children to drinks containing artificial colourings and sodium benzoate demonstrated significant adverse effects on hyperactive behavior.[11]

This study has limitations. Firstly, it did not exhaustively cover all foods and beverages available in the Brazilian retail market, but supermarkets are responsible for almost 60% of food energy purchases in Brazil and all packaged food and beverages available for sale were analysed including those available in supermarkets that typically opt for a cleaner ingredient list.[37] Also, the products commercially available were assessed with no attempt to correlate with items consumed more often or in greater amounts, since we could not make a linkage between our data and food consumption data. Further

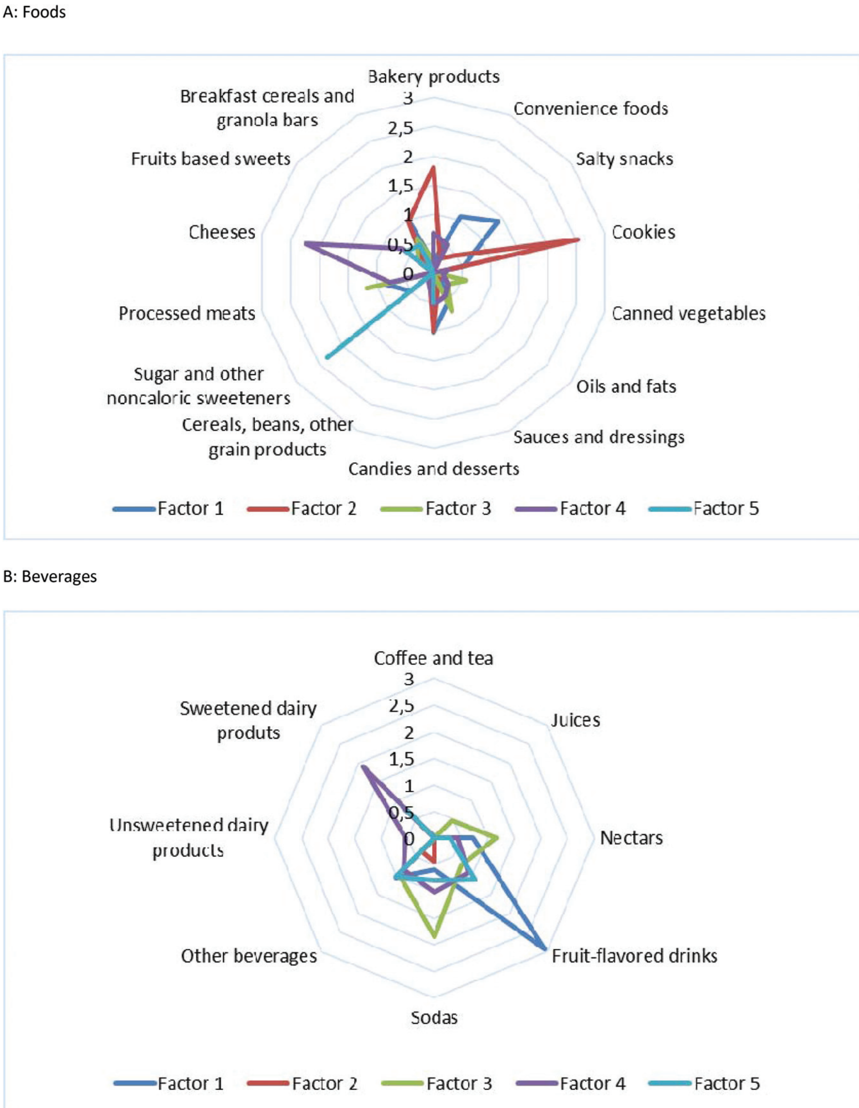

Chart 4 Association (coefficient) between retained food additives factors and food and beverages groups analysed.

research is needed in this area in order to target public regulations on food additives for those foods and beverages, with a high number of food additives, especially cosmetic additives, which seem to be more frequently consumed by the population. However, to do so, it is necessary to advance in the collection of data on food consumption. On the other hand, the present study involved a comprehensive assessment of the occurrence of food additives in almost 10 000 packaged foods and beverages available on the Brazilian retail market and yielded results that have important implications for health and local and global public policies.

Conclusions

The results confirmed a high prevalence of food additives in foods and beverages sold in Brazil, as well as the existence of some food additive patterns. The patterns were found to be common to certain food groups and may be harmful to consumer health, given the evidence for deleterious health effects of food additives. These health effects might be further exacerbated by cumulative and combined intake of multiple additives.

Further studies should be conducted assessing food additives as they are typically consumed, *i.e.*, repeating in different foods and interacting with one another. Finally, this synergism occurs in the context of scant quantitative information on food additives, hampering efforts to determine whether levels of consumption by the population meet current safety criteria.

Author contributions

Conceptualization: VSPM, APBM and DSC. Data curation: VSPM. Investigation: VSPM, APBM and DSC. Methodology:

VSPM, APBM, DSC and CAB. Writing – original draft: VSPM. Writing – review and editing: APBM, DSC and CAB. Funding acquisition: APBM and DSC. Project administration: APBM and DSC. Validation: CAB. Formal analysis: DSC. Resources: DSC. Supervision: DSC.

Conflicts of interest

There are no conflicts to declare.

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