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Frequency and Diversity of Stabilizers, Thickeners and Gelling Agents Used as Food Additives in Food Products Sold on Dakar Markets

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Abstract

The industrial use of food additives is growing rapidly worldwide. These additives include stabilizers, thickeners and gelling agents. These substances help to improve texture and protect against food modification. The result is food products with improved sensory quality, acceptable to consumers and with increased profits for companies. However, the use of these substances must comply with standards to guarantee food safety. These standards are regularly revised to take account of any new safety data. This implies the need to obtain information on the presence and level of use of these additives in foodstuffs sold in distribution chains. This study therefore set out to identify the profile and frequency of stabilizers, gelling agents and thickeners in various food categories sold on Dakar markets. The methodology adopted is based on a collection of labels from food samples sold in various trading venues. Food additives as well as the functions indicated on the labels are listed, recorded and classified based on Codex Alimentarius standards. The results of this study showed the predominance of stabilizers (59%), made up largely of plant hydrocolloids, particularly guar gum and cellulose gum. Of the 4 substances used as thickeners, most were xanthan gum and acetylated diamidon adipate. As for additives indicated as gelling agents, the presence of pectin and gelatin was noted. Generally speaking, most of the additives encountered are of natural origin and can be extracted from local plant resources.

Subject Areas

Food Science & Technology

Keywords

Food Additives, Stabilizers, Thickeners, Gelling Agents, Industry, Food Safety

1. Introduction

With strong global production, the use of food additives has become fashionable in the food industry over recent decades. Indeed, the size of the food additives market is estimated at 136.17 billion USD in 2023 with a forecast compound annual growth rate (CAGR) of 3.55% for the period 2023 to 2028 [1]. Food additives are substances generally used to prevent chemical and microbial spoilage, increase shelf life, facilitate processing or improve the sensory quality such as color, taste and texture of food products. A food additive can also be defined as a substance or mixture of substances which is added to a food and takes part in its production, processing, packaging and/or storage, without being a major ingredient [2]. Additives include thickeners, gelling agents and stabilizers. Thickening additives improve the texture of foods through their positive action on viscosity. Thickening is mainly achieved through the use of gums such as carob or guar, or modified starches [3]. Gelling agents are substances that modify the texture of foods by forming a gel [3]. In fact, gelling agents are characterized by the formation of gels, which are continuous three-dimensional networks resulting from interactions between certain proteins and polysaccharides [4]. Hydrocolloids such as gelatin, starch, pectin, carrageenan and alginate account for a significant proportion of gelling agents [5]. In addition to their use in improving the rheological and textural properties of food products, some hydrocolloids can replace fats to reduce calorie intake [6]. As for stabilizers, these are food additives that help maintain a uniform dispersion of two or more components [7]. Generally speaking, food stabilizers act by modifying the intermolecular forces that stabilize or destabilize the structure of emulsions, colloids and food gels [8]. Stabilizing additives are used in a wide range of foodstuffs, including ice creams, sauces, beverages and seasonings, to improve their organoleptic properties and prevent phase separation [9]. Like gelling agents, most stabilizers are hydrocolloids [10] [11]. In addition to their technological role on foods, some stabilizer additives, gelling agents and thickeners, mostly natural substances, have positive effects on human health [12]. Thus, although consumers have a generally negative perception of food additives, hydrocolloids are not often indexed by them [13]. On the other hand, potential negative health effects have been identified with some of these additives. For example, carrageenans and xanthan gums have been associated with bloating, diarrhoea, insulin resistance, reduced testosterone levels,

increased estrogen levels, reduced sperm counts and increased risk of colon cancer [9]. In addition, the combination of certain stabilizers such as carrageenans and xanthan gum has been shown to have carcinogenic effects in vitro [14]. As a result, standards and regulations have been established by health authorities to prevent the misuse of these food additives and damage to consumer health [7]. The aim of our work is to identify the types and frequency of thickeners, gelling agents and stabilizers in industrial food products marketed in Senegal, through a pilot study carried out in Dakar.

2. Materials and Methods

The study concerned samples of labels of industrial foodstuffs marketed in Dakar over the period from October to December 2022. Data collection was carried out in Dakar, with the owners' approval, at 9 stores, 2 wholesalers, 4 petrol station minimarkets and one supermarket, in order to obtain a diverse range of products. The data collection process involved checking whether the product contained at least one food additive of any type, in order to determine the profile of stabilizers, thickeners and gelling agents and the proportion of all food additives in the listed products. To this end, a photo of the ingredients and the product name on the packaging was taken to avoid duplication. The samples were made up of various food products covering most of the food products commonly distributed on the national market. These samples were grouped into 16 food categories based on the Codex classification of foods [7]. The number of samples for each category depended on the availability of the products concerned on the market and the presence of information on food additives.

The approach consisted in collecting this information from food product labels at randomly selected sales outlets, *i.e.* local stores, mini-markets, markets and supermarkets. The methodology applied is based on the identification of food additives from information on food packaging, as adopted in several studies [15] [16]. Indeed, standards and regulations governing the development of food products require information that objectively informs the consumers about food additives. Regulation (EU) No. 1169/2011 of the European Parliament on the provision of food information to consumers was published in the Official Journal of the European Union on November 22, 2011. Similarly, the General Standard on the Labeling of Prepackaged Foods specifies that the full list of ingredients is a mandatory label statement [17].

The survey was carried out using a smartphone equipped with a digital camera for photographing product labels and a computer for data recording. Statistical data processing is carried out using Microsoft Excel version 2016). A qualitative approach was applied to identify additives in food products. The names of the substances on the labels and, above all, the indication of the function sought by the manufacturers made it possible to identify the additives in question by reference to the Codex standard [18].

For determination stabilizers, thickners and gelling agents frequency in a food

category, the calculation takes into account the food additives of this group present on the labels for this food category. On the other hand, the relative frequencies of each additive (Fadd) is calculated as follows:

$$F_{add} = \frac{N_{al}}{N_{Tadd}} \times 100$$

F_{add}: relative frequency of the food additive;

N_{al} number of times the additive in question appears on food labels;

N_{Tadd}: total number of times the food additive category (stabilizers, thickeners and gelling agents) appear on food labels.

3. Results

A total of 368 food packaging labels recording the presence of a stabilizers, thickners and gelling agent were evaluated during our investigations. The various products concerned belonged to 15 food categories according to the Codex Alimentarius classification [7]. They include beverages (10.1%; N = 74), broths, soups and sauces (19.8%; N = 73), fruits and vegetables (11.7%; N = 43), confectionery (10.9%; N = 40), bakery products (9.2%; N = 34), cereals and cereal-based products (8.2%; N = 30), milk and dairy products (6.8%; N = 25), meat and meat products (6.5%; N = 24), ready meals (2.4%; N = 9), ice cream (2.2%; N = 8), syrups (1.4%; N = 5) and canned fish (0.8%; N = 3). The results revealed the presence of 17 stabilizers, 4 thickeners and 2 gelling agent on the food labels. These food additives were distributed very variably across the different food categories (**Figure 1**). Overall, stabilizers, thickeners and gelling agents identified on food labels represent 8.7%, 4.4% and 2.3% respectively of all food additives. However, this breakdown conceals variations according to the different categories of food products. Among these categories of additives, stabilizers are in the majority on dairy products (21%), ice cream or edible glace (42%), meat products (24%), canned fish (33%), prepared foods (32%), beverages (9%) and fats (4%). Thickeners come in second place, with a marked presence on the labels of syrups (77%), prepared foods (19%) and canned fish (25%). Gelling agents, on the other hand, are only found on a few products, such as canned fish (7%) and confectionery (4%).

Compared to thickeners and gelling agents, additives declared as stabilizers on labels are in the majority, both in number and frequency of appearance. Stabilizers account for more than half of this group of food additives, with 17 substances identified (**Figure 2**). The main stabilizers are guar gum (E412) in ready meals, sauces, mayonnaises, beverages, cereals and bakery products. Cellulose gum (E466) is found on syrups, ice cream and beverages. Carrageenans (E407) are found particularly on dairy products such as liquid milks, condensed milks, milk powder and cheeses. Triphosphates (E451) are the thickeners most often found on meat products, and meat and poultry dishes. Gum arabic (E414) has been identified on the labels of fruit drinks and juices, and on chewing gum.

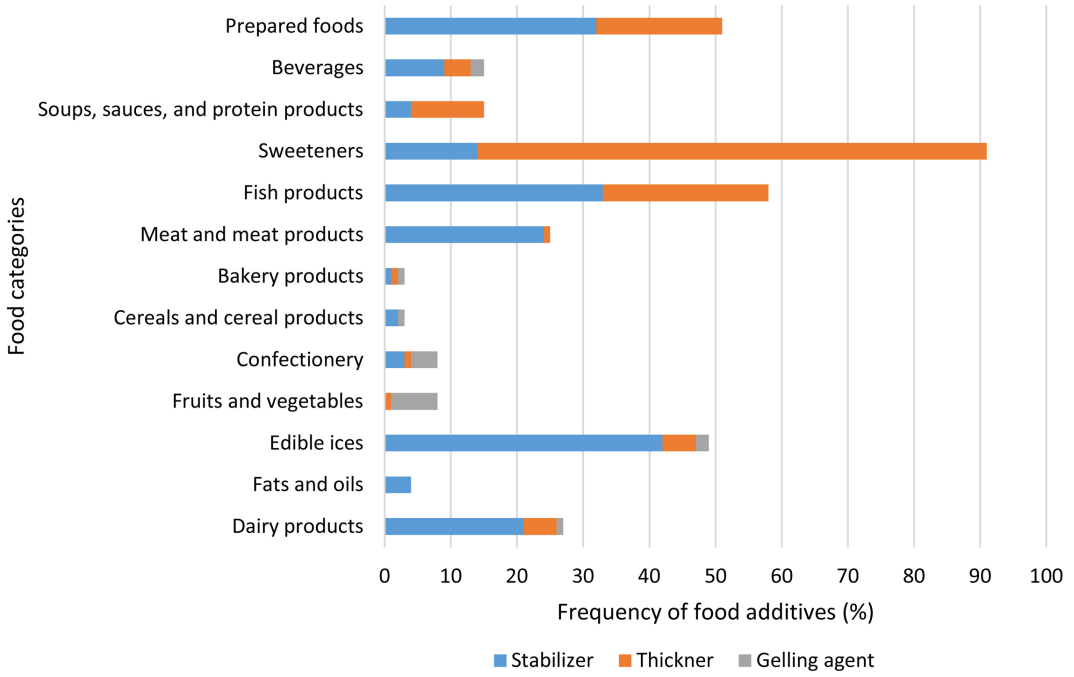

Figure 1. Frequency of stabilizer, gelling agents and thickener food additives identified in different food categories sold in Dakar markets.

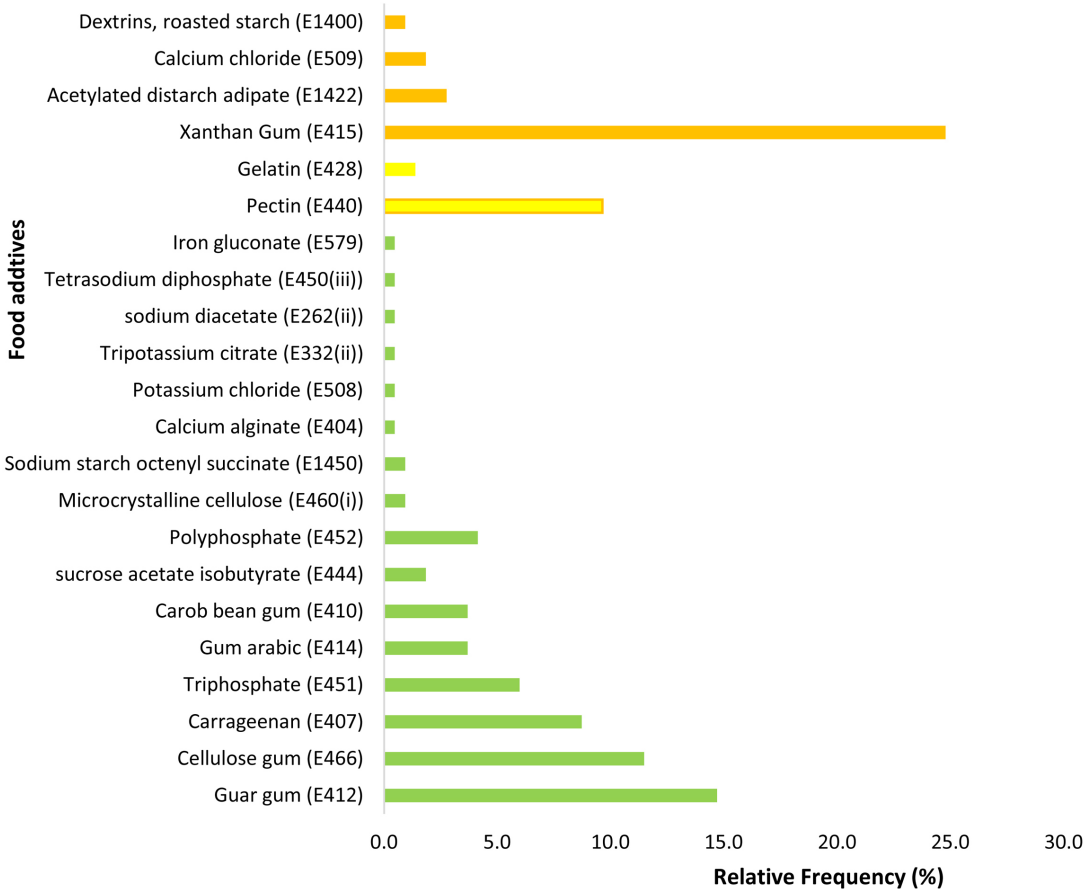

Figure 2. Stabilizer, gelling agent and thickners additives identified in market food products sold in Dakar.

Carob bean seeds are particularly noticeable in ice cream. As regards additives declared as thickeners on food labels, 4 substances were listed. This group includes xanthan gum (E415), which is found on salad dressings, sauces, mayonnaises, mustards and bouillon cubes. Next, acetylated diamidon adipate (E1422) is found on dairy products (liquid milk, yoghurt and cheese), sauces and mayonnaise. Calcium chloride (E509) and dextrins (E1400) were identified as thickeners in cookie and beverage samples respectively. Finally, only 2 substances were identified on the labels as gelling agents. Firstly, pectins (E440) were identified on jams, fruit juice concentrates, confectionery, cereal-based desserts, bakery products, chewing gums and edible ices. Next, the presence of gelatins (E415) was noted on cheese and chewing gum labels.

In this study, we noted a high variability in the types of additives used as stabilizers, gelling agents and thickeners in the various food categories collected (**Table 1**). Texture additives are very common in the beverage category, with 9 different thickeners present in products such as soft drinks, hot drinks, sweet drinks, vegetable concentrates, fruit juice concentrates and fruit nectars. Similarly, in the milk and dairy products category, the presence of 7 stabilizers was noted on cheeses, liquid milks, flavored milks, condensed milks and powdered milks.

4. Discussion

This study shows that all the additives listed are considered suitable for use in food, as they comply with the general standard for food additives [7]. The various stabilizing, gelling and thickening additives found on the labels of the foods collected fulfil important technological functions. In addition to these properties, they may also offer health benefits thanks to the bioactive compounds they contain. Guar gum, derived from the endosperm of the guar bean (*Cyamopsis tetragonoloba*), is a linear polymer of galactomannan [19]. The use of this gum increases viscosity and consistency in ice cream production [20]. In cake and cookie doughs, the addition of guar gum facilitates demolding and prevents crumbling during cutting [21]. What's more, it is also beneficial for controlling diabetes, intestinal disorders, heart disease and colon cancer [21]. Furthermore, used as a soluble dietary fiber with a low glycemic index, guar gum has a proven prebiotic effect and helps lower blood glucose and cholesterol levels [22]. Sodium carboxymethylcellulose (CMC) or cellulose gum, developed as a potential gelatin substitute, has several interesting rheological properties [23]. Indeed, cellulose gum is used to increase the thickening of beverages and sauces [23], and for the stabilization of dairy products [24]. Carrageenans are a family of sulfated polysaccharides extracted from certain red algae (*Rhodophyta*) [25]. Carrageenan is widely used in food products, notably as a gelling agent, thickener, emulsifier and to stabilize food properties [26]. In cheese samples where they were identified in our investigations, carrageenans can replace emulsifying salts to maintain the organoleptic and structural values of defatted cheese [27]. However, the presence of carrenghenans is not without health consequences. They

Table 1. Food additives identified on labels as stabilizers, thickeners and gelling agents in food products collected in Dakar markets.

Food categories Products collected	Stabilizers	Thickeners	Gelling agents
Dairy and similar products Cheese, liquid milk, flavored milk, condensed milk, powdered milk	Polyphosphate (E452) Carrageenan (E407) Microcrystalline cellulose (E460) Tripotassium citrate (E332) Tetrasodium diphosphate (E450) Cellulose gum (E466) Polyphosphate (E452)	Acetylated distarch adipate (E1422) Xanthan gum (E415)	Gelatin (428)
Edible ice	Carrageenan (E407) Cellulose gum (E466) Guar gum (E412) Carob bean Gum (E410)	Xanthan gum (E415)	Pectins (E440)
Fruits and vegetables canned vegetables	Iron gluconate (E579)	Calcium chloride (E509)	-
onfectionery Chocolate, Chewing gum, Spreads	Gum arabic (E414) Triphosphate (E451)	Dextrins, roasted starch (E1400)	Pectins (E440) Gelatin (428)
Cereals and cereal products wheat cakes	Guar gum (E412) Cellulose gum (E466)	-	Pectine (E440)
Bakery products Cookies	Guar gum (E412)	Xanthan gum (E415) Calcium chloride (E509)	Pectins (E440)
Meat, meat products, poultry Processed chicken, processed meat, processed poultry	Carrageenan (E407) Sodium diacetate (E262(ii)) Polyphosphate (E452) Triphosphate (E451)	Xanthan gum (E415)	-
Fish Canned fish	Guar gum (E412) Microcrystalline cellulose (E460) Cellulose gum (E466)	Xanthan gum (E415) Calcium chloride (E509)	-
Sweeteners Syrups	Cellulose gum (E466) Polyphosphate (E452)	Xanthan gum (E415)	-
Salts, spices, soups, sauces, salads and protein products Mayonnaise, sauce, condiment, broth cube, bouillon, mustard, vinaigrette	Guar gum (E412) Potassium chloride (E508) carob bean gum (E410)	Xanthan gum (E415) Acetylated distarch adipate (E1422) Calcium chloride (E509)	-
Beverages, excluding dairy products Soft drinks, hot drinks, sweet drinks, vegetable concentrates, concentrates for fruit juices, fruit nectars	Sucrose acetate isobutyrate (E444) Calcium alginate (E404) Carrageenan (E407) Gum arabic (E414) Cellulose gum (E466) Guar gum (E412) Carob bean Gum (E410) Starch sodium octenyl succinate (E1450)	Xanthan gum (E415)	Pectins (E440)
Prepared foods Prepared meals	Guar gum (E412) Iron gluconate (E579) Triphosphate (E451) Carrageenan (E407)	Xanthan gum (E415)	-

could cause inflammation, glucose intolerance, insulin resistance, gastrointestinal ulceration and damage to the digestive system [26]. Triphosphates identified in collected meat products play several functions, such as stabilizing pH, increasing water retention capacity to achieve higher yields, reducing weight loss during cooking and increasing shelf life [28]. In addition, triphosphates improve texture and sensory properties such as tenderness, juiciness, color and flavor [28]. As for sodium polyphosphates observed in meat products, their main functional properties are buffering, calcium fixation, dispersion and water retention [29]. However, hyperphosphatemia has been identified over the last decade as an important predictor of mortality in advanced chronic kidney disease [30]. Reducing the use of phosphate additives is therefore essential to protect consumer health. Gum arabic or acacia gum, a complex exudate of *Acacia senegal* and *Acacia seyal*, has emulsifying, stabilizing, binding and shelf-life-enhancing properties that are widely exploited in the food industry [31]. In beverages where it has been identified, gum arabic acts on the one hand as an emulsifier and stabilizer, and on the other hand prevents color degradation [32]. In terms of health, studies have shown that gum arabic protects the heart, kidneys, intestine and teeth, promotes satiety and has antimicrobial, anti-inflammatory and anticoagulant effects [31]. Carob bean gum, identified on the labels of ice cream, fruit juice concentrates and mayonnaises, is a substance extracted from the endosperm of Ceratonia siliqua L. seeds, rich in bioactive compounds such as tocopherols, phenolic compounds [33] and D-pinitol [34]. In addition, locust bean gum has in vitro antioxidant potential and antimicrobial properties [33]. Sucrose acetate isobutyrate, found in beverages, is a mixture obtained by esterification of sucrose with acetic anhydride and isobutyric anhydride. This food additive is used particularly for its emulsifying properties, even in dilute solutions [35]. Microcrystalline cellulose (MCC) or cellulose gel, oberserved on samples of flavored milks and canned fish, is a versatile material made up of bundles of cellulose microfibril aggregates of various sizes, firmly bonded together by hydrogen in a highly crystalline structure [36]. MCC has a wide range of qualities sought after in the food industry, such as the ability to suspend solids, maintain heat stability, prevent the formation of ice crystals, stabilize emulsions, maintain foam stability, modify textures and replace fats [36]. Sodium starch octenylsuccinate, found on the labels of beverages and generally acidic products, has the particularity of maintaining its thickening capacity up to pH 4.5, in addition to its emulsifying properties [37]. Alginates, natural polymers extracted from brown seaweed and featured on beverage labels, have numerous applications, mainly thanks to their thickening, gelling and film-forming properties [38]. In addition to these stabilizers, the 4 thickening additives identified in the food product samples have interesting properties that justify their use by manufacturers. The majority of these stabilizers include xanthan gum, a natural extracellular polysaccharide secreted by the micro-organism *Xanthomonas campestris* [39]. Xanthan gum is a substance that strongly contributes to texture improvement, flavor release, appearance and other properties to boost the quality of food

products [40]. Our study also shows that xanthan gum is sometimes combined with other gums, such as cellulose gum in syrups or guar gum in prepared foods. Beyond the synergistic actions of these stabilizers, this combination can sometimes be explained by economic reasons, in order to reduce production costs [40]. As far as gelling additives are concerned, pectins, found in 3 food categories (confectionery, ice cream and beverages), are polysaccharides of plant origin whose properties are widely exploited in the food industry. Indeed, pectins are used in products such as jams, jellies, frozen foods and low-calorie foods as fat or sugar substitutes [41]. In addition, pectins have excellent functional properties, including antioxidant and free radical scavenging activity, antitumor and anticoagulant activity, anti-inflammatory effects and antibacterial activity [42]. In addition to pectin, gelatin has been indicated as a gelling agent in dairy and confectionery samples. Gelatin is the most popular hydrocolloid in the food industry, selling more than any other gelling agent [43]. In dairy products, gelatin, in the presence of casein, forms strong gels and improves the consistency of these products [44]. However, gelatin sources have become a controversial topic for religious and health reasons [45]. This led Tukiran et al (2016) to develop an analytical method for the determination of gelatin sources in food products by competitive indirect enzyme-linked immunosorbent assay [45]. In terms of thickening additives, Acetylated distarch adipate, identified in samples of dairy products (yoghurt and cheese) and a sample of mayonnaise, can be used in applications for the production of emulsions to reduce fat content and the presence of cholesterol [46]. In addition, Acetylated distarch adipate has the ability to improve yoghurt viscosity [47] and cheese firmness [48]. Calcium chloride (E509), seen on a cookie label, is a thickener also used in the food industry as a firming or stabilizing agent in the manufacture of dairy products, jams and fruit and vegetable marmalades [49]. Dextrins (E1400), a thickener found on a hot drink sample, are polysaccharides generally produced from potato or corn starch by partial hydrolysis [50]. Dextrins are also used as encapsulants for food colorants, thanks to their low cost and their ability to protect against oxidation [51].

5. Conclusion

This pilot study highlighted the diversity and frequency of the main thickening, gelling and stabilizing food additives on products marketed in Dakar. The study is an important contribution to food safety management in that it provides an insight into the types of additives used in different categories of food products marketed in Dakar. However, the survey results presented above must be considered and interpreted in context. Also, the results are not general in scope, since the samples were not chosen at random, but were targeted according to the food additives mentioned. In addition, a number of research avenues are emerging as a result of this survey. Elsewhere, it would be interesting to develop substitutes for these additives from existing plant resources in tropical countries like Senegal, thus creating added value and reducing import costs. On the other hand, the absence of any indication of quantities and the possibility of fraud on food labels

make it impossible to assess the safety of certain additives. This opens up the prospect of carrying out quantitative analyses on these food additives to verify the accuracy of the information on the labels and compliance with the standards laid down.

Conflicts of Interest

The authors declare no conflicts of interest.

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