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Food additives used in non-alcoholic water-based beverages– a review

Abstract

World consumption of non-alcoholic beverages has significantly increased over the last decade, and data projections indicate that this increase will be even greater, due to factors such as population growth and demand for diversification of products. Among other motivations for this increase are: the motivation to avoid alcoholic beverages by adopting healthier habits and the increase in the temperature of the planet, which causes people the need to hydrate themselves more. Due to the context of the current routine of life, it is undeniable the wide diversity of industrialized beverages drinks available, such as soft drinks and fruit juices. Many of these beverages are ready for consumption, favouring the appeal for practicality, so appreciated these nowadays. On the other hand, the increase in consumption leads to a greater demand for large volume production, causing problems related to quality and conservation. Thus, for this type of product, which in many cases presents high perishability, the use of preservatives to increase the shelf life has become almost essential. Therefore, the objective of this review was to collect information about the main additives applied in the non-alcoholic drinks widely consumed in the world, as well as highlight some of the natural substances that have been studied in the last decades due to their applicability as natural preservatives agents.

Keywords: beverage industry, beverage legislation, natural additives, non-alcoholic drinks, soft drinks

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Marselle M N Silva,[1] Tiago L Albuquerque,[2] Karen S Pereira,[2] Maria Alice Z Coelho[2]
[1]Instituto de Química, UFRJ. Av. Athos da Silveira Ramos, 149, bloco A - Cidade Universitária, Rio de Janeiro - RJ, Brasil
[2]Escola de Química, UFRJ. Av. Athos da Silveira Ramos, 149, bloco E - Cidade Universitária, Rio de Janeiro - RJ, Brasil

Correspondence: Marselle M. N. Silva, Instituto de Química, Universidade Federal do Rio de Janeiro, Avenida Athos da Silveira Ramos, 149, bloco E - Cidade Universitária, Rio de Janeiro – RJ, Brazil, Zip code 21941-909, Tel +55 21 3938-7622, Email marselle@eq.ufrj.br

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Introduction

At the beginning of the development of Food Science and Technology, the methods of conservation were based on techniques such as salting or smoking, afterwards, potassium nitrate was used by the Egyptians. Since the dawn of man, our species has sought better ways to feed, developing more efficient methods of hunting, animal husbandry, vegetable cultivation, food preservation by physical methods, and finally adding substances to food to enhance flavour or preserve it. In this context came the concept of food additive, which in the early 1800s were used intentionally to adulterate food.[1] Currently, more than 2500 additives are intentionally added to foods to maintain certain properties or extend shelf life, while many others have been banned over the years, some of them globally and others only in specific countries.[2] 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 were developed, such as the addition of preservatives, antioxidants and sweeteners, which would provide, in addition to conservation, desirable changes in food. 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 flavouring agents such as caffeine.[3]

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. This increase has triggered the diversification of the beverage sector in general, both for the "recreational" drinks sector, usually alcoholic beverages, and for those with other uses, such as reaching nutritional demands. In this context, the innovation and development of certain types of beverages aimed at a healthy consumption, such as fats and sugars reduced or free drinks, and even beverages considered as prebiotic or probiotic, with beneficial effects that go beyond hydration and/or nutrition. The major category of beverages is divided into alcoholic and non-alcoholic. The alcoholic group includes beer and malt beverages, cider and perry, grapes wines, wines other than grape, mead, distilled spirituous and aromatized alcoholic beverages.[4] Non-alcoholic drinks are subdivided into hot drinks, soft drinks and milk drinks (In Figure 1 it can be observed the division of these categories). According to the Codex Alimentarius, non-alcoholic beverages include waters and carbonated waters, fruit and vegetable juices and nectars, water-based flavoured carbonated and non-carbonated drinks and water-based brewed or steeped beverages such as coffee and tea, as described in Table 1. Dairy-based beverages are generally included in milk products as milk is the majority component.[4] Some authors[5] consider coffee and tea as a different category, separating hot drinks and soft drinks, as they indeed have different process and storage procedures. Following the Food and Agriculture Organization of the United Nations (FAO) premises, for this review purpose, only ready-to-drink coffee and tea drinks, that are classified as "Non-carbonated water-based drinks" will be considered.

Due to the fast pace of activities that the globalized world has imposed on people, the need for practical food and drinks (i.e. easy access and preparation) is increasing. One of the major areas of Food Science and Technology aims to preserve them without undergoing processes that lead to significant changes in their sensory and nutritional characteristics, that is, they are as close as possible to an *in natura* food. There are several ways to achieve products with these characteristics, such as the use of heat or cold chain to retard or inhibit chemical, enzymatic and/or microbiological reactions. However, one modality that has become increasingly necessary and effective is the use of food additives, which act through various mechanisms and can promote the production of foods with high microbiological stability and can eliminate/delay reactions that could compromise food quality.

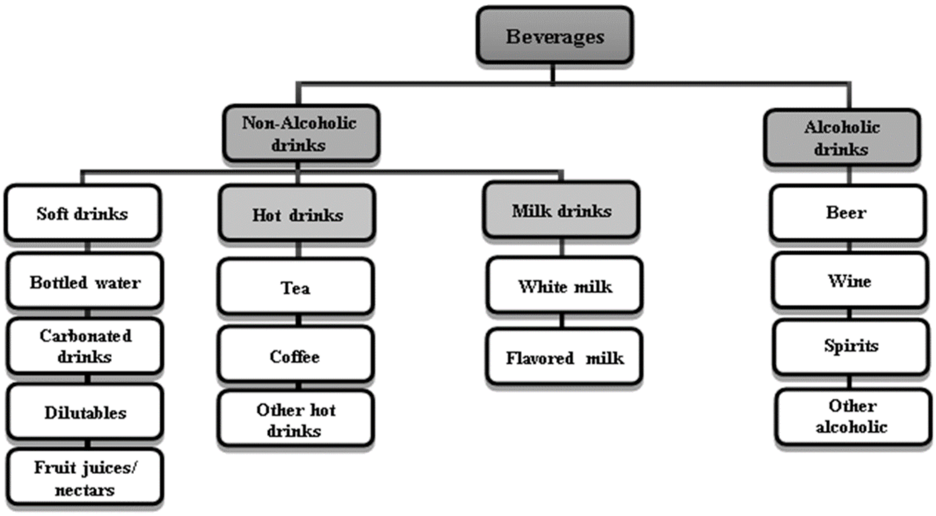

Figure 1 Categories of beverages currently adopted (*Source:* ROETHENBAUGH, 2005).

Table 1 The general classification of non-alcoholic beverages according to Codex Alimentarius (*Sources*: FAO/WHO, 2005 and FAO/WHO, 2016)

Non-alcoholic beverages	Description
Waters	1. **Natural mineral waters and source waters:** naturally carbonated (with CO_2 from the source), carbonated (with added CO_2 of another origin), decarbonated (with less CO_2 than present in the water at the source) or fortified (with CO_2 from the source), and non-carbonated (contains no free CO_2). 2. **Table waters and soda waters:** waters other than natural source waters that may be carbonated by addition of CO_2 and may be processed by filtration, disinfection, or other suitable means. These waters may contain added mineral salts.
Fruit and vegetable juices:	1. **Fruit juice:** unfermented but fermentable liquid obtained from the edible part of mature and fresh fruit usually by mechanical extraction 2. **Vegetable juice:** liquid unfermented but fermentable obtained by the mechanical extraction of fresh vegetables. 3. **Concentrates for fruit juice:** prepared by the physical removal of water from fruit juice to increase the Brix level. Can be sold in liquid, syrup and frozen forms for the preparation of a ready-to-drink juice by addition of water. 4. **Concentrates for vegetable juice:** prepared by the physical removal of water from vegetable juice. Sold in liquid, syrup and frozen forms for the preparation of a ready-to-drink juice by addition of water.
Fruit and vegetable nectars:	1. **Fruit nectar:** unfermented but fermentable product obtained by adding water with or without the addition of sugar, honey, syrups, and/or sweeteners to fruit juice, concentrated fruit juice, fruit purees or concentrated fruit purees, or a mixture of those products. 2. **Vegetable nectar:** product obtained by adding water with or without the addition of sugar, honey, syrups, and/or sweeteners to vegetable juice or concentrated vegetable juice, or a mixture of those products. 3. **Concentrates for fruit nectar:** prepared by the physical removal of water from fruit nectar. Sold in liquid, syrup and frozen forms for the preparation of ready-to-drink nectar by addition of water. 4. **Concentrates for vegetable nectar:** prepared by the physical removal of water from vegetable nectar. Sold in liquid, syrup and frozen forms for the preparation of ready-to-drink nectars by addition of water.
Water-based drinks	1. **Carbonated water-based flavoured drinks:** includes water-based flavoured drinks with added CO_2 with nutritive, non-nutritive and/or intense sweeteners and other permitted food additives. Includes so-called "energy" drinks that are carbonated and contain high levels of nutrients and other ingredients (e.g. caffeine, taurine, carnitine). 2. **Non-carbonated water-based flavoured drinks:** includes water-based flavoured drinks without added CO_2, fruit and vegetable juice-based drinks (e.g. almond, coconut-based drinks), ready-to-drink coffee and tea drinks with or without milk or milk solids, herbal-based drinks and "sports" drinks containing electrolytes. Can be clear or contain particulate matter (e.g. fruit pieces), and can be unsweetened or sweetened with sugar or a non-nutritive high-intensity sweetener. Includes so-called "energy" drinks that are non-carbonated and contain high levels of nutrients and other ingredients (e.g. caffeine, taurine, carnitine). 3. **Concentrates (liquid or solid) for water-based flavoured drinks:** includes powder, syrup, liquid and frozen concentrates for the preparation of carbonated or non-carbonated water-based non-alcoholic beverages by addition of water or carbonated water. Examples include fountain syrups (e.g. cola syrup), fruit syrups for soft drinks, frozen or powdered concentrate for lemonade and iced tea mixes.

Food Protection Committee of the Food and Nutrition Board defined food additives as one or a group of substances, different from the basic ingredients, present in food because of any aspect of production, such as process, storage or packaging, excluding contaminants.[6] The most utilized additives in the food industry are preservatives, colouring, flavouring and texturizing agents, and nutritional additives, but its use and regulation vary according to the laws of each country. In the USA, for example, food additives are divided into 26 functional classes: sweeteners, colorants, preservatives, antioxidants, carriers, acids, acidity regulators, anticaking, antifoaming, firming, foaming, gelling, glazing, bulking, raising agents, emulsifiers, emulsifying salts, flavour enhancers, humectants, modified starches, packaging gases, propellants, sequestrants, stabilizers, thickeners, and flour treatment agents.[1] According to the European Commission (Regulation (EC) No 1333/2008), the main additives used in industrialized beverages are: phosphoric and phosphate acids, sorbic acid, benzoic, ascorbic, citric, fumaric, succinic, saccharin, sucralose and others.

It is also important that there is a reliable assessment of the amount of exposure to food additives, requiring detailed information on the values and frequencies that individuals consume certain foods and beverages, making it essential to standardize values to ensure consumer safety. Thus, given the potential and importance of food additives and the great increase in the consumption of non-alcoholic beverages, this work sought to provide information considered relevant about the use of these additives in this group of beverages, as well as identify trends and innovations in its use. Throughout the text, it was evaluated the development of the market for soft drinks throughout the world, the main additives that have been used and the new additives that have been developed for the purpose of use in these drinks, obtaining relevant information of this field.

To provide increased shelf life and enhancement of appearance, flavour and aroma in soft drinks, synthetic colourants, preservatives and sweeteners are widely used in these products. Among the main substances used as additives that are found in soft drinks are: tartrazine, amaranth, ponceau 4R, sunset yellow, Allura red AC, acid red 13, pontacylrubine R, auramine O, acid red 52, erythrosine, metanil yellow, acid red 92, rhodamine B, 2,4-dichlorophenoxy acetic acid, methyl paraben, thiabendazole, ethyl paraben, isopropyl paraben, propyl paraben, benzyl paraben, butyl paraben, Brilliant Blue FCF, ponceau 3R, quinolone yellow, patent blue V, acesulfame, sodium cyclamate, saccharin, neotame and aspartame.[7] Thus, throughout this paper, gathers literature about the most relevant additives used not only in soft drinks but in various types of non-alcoholic beverages, such as fruit juices and nectars, milk beverage, tea and coffee drinks. In addition, this review presents a contextualization of the use of additives that has promising application for the non-alcoholic beverage industry in relation to traditional ones already used nowadays.

World market of non-alcoholic beverages consumption

Non-alcoholic beverages are available in most of the countries in the world, as their production is relatively simple, and a great variety of local raw materials can be used. In general, the consumption of beverages around the world is based on self-administered questionnaires, which can lead to errors in the data collection, mainly in relation to the quantification of the variety of the nature of the beverages consumed within the populations.[8] Table 2 presents an overview of 2018 non-alcoholic drinks market statistics, which includes bottled waters, juices and other soft drinks.

Regarding North America, 80.4% of the total revenue was from the United States, that was alone greater than the revenues of South America, Europe and Australia. In South America, the available data shown in the table were composed only by statistics from Brazil and Argentina. Data from Asia were obtained from 11 countries and from Europe, 27 countries. In South America and Asia, the perspectives of annual growth were greater than 5% annually until 2021.

Table 2 Revenue, per capita consumption and volume per person of non-alcoholic drinks in 2018 and perspectives (2019-2021). *(Sources:* STATISTA, 2018, based on IMF, World Bank, UN and Eurostat)

	Non-alcoholic drinks market statistics in 2018			
Region	***Revenue***	***Per capita consumption***	***Volume per person***	***Expected annual growth until 2021***
North America	*US$164,404m*	*US$330.73*	*355.5L*	*2.1%*
South America	*US$40,402m*	*US$156.86*	*173.0L*	*6.7%*
Europe	*US$89,738m*	*US$171.65*	*217.8L*	*1.7%*
Australia	*US$6,621m*	*US$267.59*	*177.0L*	*2.3%*
Asia	*US$144,823m*	*US$41.34*	*82.7L*	*7.7%*

All this expressive market growth, indicated in the table from 2018 to 2021, is due to the high availability of those products in supermarkets and general merchandisers, food service and drinking places, convenience stores and vending machines. Those numbers show the greater importance of non-alcoholic drinks worldwide, suggesting that this sector needs more attention regarding the quality of the ingredients and additives that are daily introduced in human alimentation.

The global food and beverage market has grown substantially over the past 10 years and is expected growth in this scenario. According to data from Persistence Market Research, non-alcoholic beverages are gaining great popularity in Asia-Pacific, due to the large consumption of tea and coffee in the region, especially in countries like India. Consumption of non-alcoholic beverages in the Asia Pacific was 200 billion litters in 2016 and is expected to reach 301 billion litters until 2027. In this same trend, North American consumers are pursuing healthier eating habits and therefore has increased the consumption of energy drinks and is expected to increase by approximately 150% until 2027. Already Europe is considered the third largest market for non-alcoholic beverage consumers, after Asia-Pacific and North America, especially given the growing popularity of tea in the whole region.[9]

Food additives used in beverages and their functions

Additives are generally divided into five different groups in accordance with their properties: preservatives, colouring agents, flavouring agents, texturizing agents and nutritional additives.

Their functions are going to be discussed in this topic to clarify the importance of additives in non-alcoholic drinks' properties.

Preservatives

Preservatives can be classified as any substance capable of inhibiting or decelerate the growth of microorganisms and dissemble evidence of any kind of deterioration, whether they are caused by microorganisms or not. In food and beverages, preservatives are widely used to restrict microbial contamination and to prevent destabilisation and can be divided into three types: antimicrobials, antioxidants and anti-browning agents.[2,10]

Antioxidants

Antioxidants are molecules capable of inhibiting oxidation processes acting previously or during a free radical chain reaction at any point: initiation, propagation, termination, decomposition, and on oxidation products already formed, preventing the deterioration of flavours and colours. Depending on the molecule and in which stage of chain reaction it will act, different mechanisms can be attributed to antioxidants. The most important are metal inactivation, that acts in the initiation usually using metal chelators, and inhibition of hydroperoxide formation.[10,11]

In soft drinks, ascorbic acid is widely used as an antioxidant to retard deterioration of flavours and colours. Generally, non-alcoholic beverages are packaged in oxygen-permeable bottles and cartons, which make antioxidants a key additive to reduce lost in beverage quality.[12] Regarding the addition of ascorbic acid as an antioxidant, is important to highlight that it does not, by itself, constitute a claim for vitamin C as this claim should respect the daily recommended intake.[13]

In the amounts generally used in food production, antioxidants are usually nontoxic but, in excess, the utilization can promote lipid peroxidation in copper and iron-containing foods such as meats.[14,15]

Antimicrobial agents

Antimicrobial agents are substances used to preserve food by preventing the growth of microorganisms and subsequent spoilage [16], prolonging shelf life. Organic acids are commonly used by the beverage industry as antimicrobial or acidulants in a variety of products. Sorbic and benzoic acid salts are the most effective preservatives against bacteria, yeasts and filamentous fungi in beverages. Salts are more stable, more soluble in water and have the most effective antimicrobial action in pH levels < 4.5, in which undissociated form exists in the majority because pH is below the pKa of these compounds. Sorbates and benzoates are often used in combination, especially in high-acid drinks.[12.17] Sodium benzoate, for example, is widely used in soft drinks and fruit juices. This antimicrobial compound was tested in vitro and was reported as non-toxic; however, some authors have observed some toxicity with mutagenic and cytotoxic effects on peripheral snag lymphocytes.[18]

Anti-browning agents

Browning can occur by enzymatic, generally involving polyphenol oxidase (PPO) enzyme, or non-enzymatic reaction, most known as Maillard reaction. Anti-browning agents can prevent browning either by acting in the enzyme or in the intermediates of pigment formation.

Antioxidants can prevent the initiation of browning by reacting with oxygen. Ascorbic acid, already discussed due to its antioxidant activity, also has anti-browning action because it is a reducing agent. Hexylresorcinol, erythorbic acid, N-acetyl cysteine and glutathione were reported because of antioxidant capability, but are not commonly used in the beverage industry, where ascorbic acid is widely employed.[19] If the beverage is pasteurized or heat treated after ascorbic acid addition, its effect can be destroyed, and this acid can initiate its own chemical browning reaction.[10]

Ethylene diamine tetra acetates (EDTA) and phosphate-based compounds can act as chelating agents, reducing the copper available for PPO formation. Phosphate-based agents are commonly used at levels of 0.5-2%(w/v) and, as EDTA and other chelating agents, are used in combination with other anti-browning agents.[20]

PPO is usually inactivated at pH below 4, so acidulants can also act well to avoid browning, the most commonly used is citric acid. Citric acid has a double action regarding anti-browning, as it can chelate copper ion as well. Organic acids such as malic, tartaric and malonic, and inorganic acids such as phosphoric and hydrochloric can also be used as acidulants but, due to their higher price and/or negative impact on taste, are less used then citric acid.[19,20]

Colouring agents

Colour is one of the most important attributes in food and beverages as it is the first characteristic that consumers observe and can influence positively or negatively the choice of the product. Despite the growing demand for natural beverages, the use of artificial colourants is still widely used to provide a colouring of the fruit to beverages with low juice concentration. Thus, the industrial objective is to make these products more accepted by the consumers and standardize the colour during the storage, including reproducing colours that refer to the presence of functional substances, such as anthocyanins.[21] According to Food and Drugs Administration (FDA), colouring agents are substances used to concede, preserve or enhance the colour of food, and can include stabilizers, fixatives and retention agents.[16] In soft drinks, these classes of additives are important to make the product more aesthetically appealing and to correct natural variations in colour or changes during processing or storage, patterning the characteristics by which the drink is recognized. Colouring agents can be divided into natural colours and artificial colours.

Synthetic organic dyes are widely used as colour additives in processed foods, and the use of these substances is responsible for damages to the health of consumers, especially children.[22] Studies have shown that there are possible connections between the consumption of some food colourings with harmful effects on the health of children, among them: Yellow, Ponceau 4R, Carmoisine, Quinoline Yellow, and Allura Red AC.[23] In the 1900s, in the United States, 80 different dyes were used in addition to food, however, over the years they were withdrawn from the market due to concerns about food safety, reducing to an amount of 9, which are currently allowed by the Food and Drug Administration.[24]

Natural colourings are the ones extracted from plants, fruits and vegetables. Usually, they vary from yellow to orange when are carotenoids extracted from plants or bright red to purple when are anthocyanins obtained from fruits and vegetables.[12] Scooter[25], based on European Union legislation, divides the natural dyes into 9 groups: (1) curcumin (E100), (2) riboflavins (E101i–ii), (3) cochineal – including carminic acid (E120), (4) chlorophylls – including chlorophyllins and copper analogues (E140–141); (5) caramels – Classes I–IV (E150a–d), (6) Carotenoids – (E160a–f, E161b, E161g), (7) Beetroot red, betanin (E162), (8) Anthocyanins (E163), and (9) Others: Vegetable carbon (E153), Calcium carbonate (E170), Titanium dioxide (E171) and Iron oxides and hydroxides (E172).

Another dye widely used in the food industry, especially in beverages and confectionery, is caramel, which is a complex mixture of fat globules surrounded by a high concentration sugar solution. It is usually made by heating a mixture of glucose syrup, milk and vegetable fat at a temperature between 118 and 130°C.[26] There are 4 different types of caramel colouring that meet the different requirements for use in food and beverages: Caramel Colour I (also known as plain or spirit caramel), Caramel Colour II (caustic sulphite caramel), Caramel Colour III (ammonia or beer caramel, baker's and confectioner's caramel) and Caramel Colour IV (known as sulphite-ammonia, soft drink caramel, or acid-proof caramel).[27] This dye has been highlighted as beneficial against non-enzymatic browning when added to foods. Another advantage is that, in comparison to other natural dyes, the caramel does not degrade under high temperatures and pressures, allowing its addition in foods that undergo the extrusion process.[28] Despite being considered a natural additive to colour food and drink, some studies have shown the existence of compounds that may be toxic to consumer health, among these by-products, such as 2-methylimidazole, 4-methylimidazole (2-MI and 4-MI), 2-acetyl-4- (1,2,3,4-tetrahydroxybutyl) imidazole (THI) and 5-hydroxymethylfurfural -HMF) have been found in carbonated beverages such as beers, which can affect the health of consumers.[29]

Flavouring agents

Flavouring agents are substances added, in small amounts, to supplement, enhance or modify the original taste and/or aroma of food, without imparting a characteristic taste or aroma of its own.[16] Flavour can be defined as a single or a blend of chemicals of natural or synthetic origin, capable to provide all or part of the taste of any food or other product. In contrast with other additives added to beverages, flavourings are used in small amounts, so the consumer exposure to these substances is relatively low. European Union legislation defines the different types of flavourings as natural, natural-identical, and artificial.[12]

In recent years, several new Regulations and European Directives regarding flavours and fragrances have been adopted, especially respect to oils and extracts, impacting directly not only the European Union but also worldwide. Some of the main substances considered natural currently regulated for use as flavourings in foods and beverages are agaric acid, β-asarone, coumarin, hypericin, quassine, pulegone, thujone, aloin, hydrocyanic acid and santonin.[30] A natural flavouring substance can be obtained either directly from the plant, animal or microbiological material in the raw state or after processing for human consumption. In the first case, it can be obtained by various processes, such as physical, enzymatic or microbiological processes. In the second case, after the first processing, a second stage is required for human consumption, making the flavouring suitable for food use.[30]

In the past, essential oils were widely used in perfumery, food and pharmaceutical industries, and more recently they have been used in the beverage industry, being various substances have been used as flavouring agents. Lemongrass and lemon, for example, are some of the most exploited natural sources for these additives and have proven antioxidant and antimicrobial properties. Kieling and Prudencio,[31] for example, developed a blend of lemongrass derivatives (aqueous extract, lyophilized extract and essential oil) and lime juice for the preparation of mixed drinks, evaluating the physicochemical and antioxidant characteristics. In addition, the sensorial acceptance was analysed and satisfactory results were obtained. Another substance widely used as a flavouring agent is methyl eugenol, commonly found in many plants and vegetables. The EU determines maximum levels for the use of this substance in the food and in the case of non-alcoholic beverages the permitted quantity is up to 1 mg/kg.[32]

Texturizing agents

Another large group of substances used in beverages are the texturizing agents, which can be added as emulsifiers, stabilizers, thickeners and bulking agents and are extensively used to modify their texture. This class of additives has extensive use especially in the liquid food and beverage industry since in many cases it is essential to keep the texture of processed foods more attractive to consumers. Thickeners, for example, when added to blends increase the viscosity without modifying other properties, while the bulking agents increase the bulk without affecting their nutritional value. On the other hand, emulsifiers allow water and oil to remain mixed in an emulsion.[33]

Matta et al.[34] studied possible sensory changes due to the use of starch-based commercial thickeners in the preparation of some beverages (coffee, milk, apple juice and orange juice) and water. In general, none was better in relation to the others in taste and texture; on the other hand, all thickeners suppressed the original taste of the beverages and transferred strange tastes (sour, bitter, metallic or astringent), indicating that there is still a need for further studies to develop these additives in this sector.

The main texture modifying agents are from the mannan group, substances widely distributed in nature and isolated from a variety of sources. Mannan is used in many food products, especially fluids. In the beverage industry, some mannan, such as guar gum is added to modify or adjust their physicochemical properties, balancing the organoleptic characteristics of these products.[35] The resistance of this gum to degradation under conditions of low pH and its solubility in cold water makes it applicable in the beverage industry, used as viscosity control agent and thickener because due to its rheological characteristics. The use of this gum to adjust viscosity and thickener in products, such as coffees,[36] milk-sour cherry juice mixture[37] and soft drinks[38] are reported.

Nutritional additives

These substances include those which are necessary for the body's nutritional and metabolic processes,[16] as such antioxidants, and has been extensively added to certain beverages to improve their nutritional quality. Beverages fortified with vitamins and/or minerals are continuously being developed, leading to an increase in the diversification of these products, contributing to an increase in nutrient intake, which can be an effective tool to improve public health conditions.[39]

Today's consumers are becoming very demanding not only about the sensory quality of foods but also about their nutritional value. Environmental conditions (extrinsic factors) and food composition (intrinsic factors) interfere directly with its conservation status, which is essential for the maintenance of food safety. However, increasingly, in addition to safe and microbiologically stable food, consumers demand the availability in the market of foods and beverages that have high nutritional value.[40]

One of the main classes of additives introduced in beverages with nutritional value are antioxidants, such as hydroxyanisole (BHA), butylated hydroxytoluene (BHT), tertbutylhydroxyquinone (TBHQ), and propyl gallate (PG) that have been used in antioxidative food systems. Tocopherols and ascorbic acid or their derivatives are being used as alternatives to BHA, BHT, TBHQ and PG as antioxidants considered natural[41]

Some studies are also being conducted aiming the production of beverages with the addition of substances that increase the bioavailability of the compounds present, thus increasing their nutritional value. Blanco-Morales et al.[42] evaluated the impact of the addition of galactooligosaccharides on the bioaccessibility of sterols in a fruit-based beverage (mandarin and banana) enriched with plant sterols. The results indicated that this beverage can be successfully used as a food matrix for simultaneous enrichment with GOS and plant sterols, making it a more functional beverage option on the market due to the properties that these additives would provide. Many microorganisms have also been used in vegetable-based beverages in order to improve the nutritional value of fermented fruit beverages. Peerajan et al.[43], in this context, developed a fermented herb juice (*Phyllanthus emblica* fruit) to produce a functional juice. The use of *Lactobacillus paracasei* as the starter culture provided a beverage with high phenolic content and antioxidant properties.

A point to be considered in determining the nutritional quality of beverages is the methods of analysis that may be effective in measuring additional nutritional components. There are some studies in the literature regarding, for example, the measurement of vitamins contained in beverages. In this context, Kakitani et al.[44] evaluated the simultaneous determination of water-soluble vitamins in diet beverages and supplements by the LC-MS/MS method. The vitamins evaluated in a total of 8 energy drinks were thiamine (B1), riboflavin (B2), nicotinic acid (NA), nicotinamide (NAD), pantothenate (B5), pyridoxine (B6), biotin B9), cyanocobalamin (B12), ascorbic acid (AA), dehydroascorbic acid (DHA), dibenzoyl thiamine (DBT), bisbentiamine (BBT), riboflavin tetrabutylate (RFT) and ascorbic acid 2-glucoside (AAG). The authors concluded that the method used is a viable alternative to the traditional methods already applied.

Legislation

Several international institutes such as the European Food Safety Authority (EFSA) are reviewing the safety of food additives. In the European Union, the European Commission is also reviewing the legislation regulating the authorization of additives. Among other items, the EFSA review considers the potential intake of additives over acceptable daily doses. In this way, it is opportune to develop a knowledge of current patterns of use and consumption of these substances.[45]

The International Numbering System for Food Additives (INS) was adopted by the Codex Committee on Food Additives and Contaminants in 1989 aiming to consolidate all the current authorised additives and to provide a short designation to be used worldwide. The INS is an open list to the inclusion of additional additives or removal of existing ones, frequently being revised as proposed demands.

Waters and carbonated waters, fruit and vegetable juices and their concentrates, fruit and vegetable nectars and their concentrates, water-based flavoured carbonated and non-carbonated drinks, and water-based brewed or steeped beverages are the categories that compose non-alcoholic water-based drinks in General Standards for Food Additives of Codex Alimentarius. The maximum concentration of each additive permitted is displayed in Table 3.

According to Codex Alimentarius, all additives submitted to Good Manufacturing Practice (GMP) standards should have food grade quality and be prepared and handled in the same way as a food ingredient. Also, the addition should be limited to the lowest possible level necessary to accomplish its desired effect.[4]

Table 3 The maximum concentration of additives allowed in non-alcoholic water-based drinks according to Codex Alimentarius (*Source:* FAO, 2016)

Additive	Codex Alimentarius
Acesulfame potassium (INS 950)	**350 mg/kg** (FN,VN, CFN, CVN); **600 mg/kg** (NWFD, CaWFD, WBSB)
Acetic acid, glacial (INS 260)	**GMP** (WBSB)
Acetic and fatty acid esters of glycerol (INS472a)	**GMP** (WBSB)
Acetylated distarch adipate (INS 1422)	**GMP** (WBSB)
Acetylated distarch phosphate (INS 1414)	**GMP** (WBSB)
Acid-treated starch (INS 1401)	**GMP** (WBSB)
Agar (INS 406)	**GMP** (WBSB)
Alginic acid (INS 400)	**GMP** (WBSB)
Alitame (INS 956)	**40 mg/kg** (NWFD, CaWFD)
Alkaline treated starch (INS 1402)	**GMP** (WBSB)
Allura red AC (INS 129)	**300 mg/kg** (NWFD, CaWFD)
Ascorbic acid, L- (INS 300)	**GMP**(FJ,VJ, CFJ, CVJ, FN,VN, CFN, CVN, WBSB)
Ascorbyl esters (INS 304-5)	**1000 mg/kg** (NWFD, CaWFD)
Aspartame (INS 951)	**600 mg/kg** (FN,VN, CFN, CVN, NWFD, CaWFD, WBSB)
Beeswax (INS 901)	**GMP** (WBSB); **200 mg/kg**(NWFD, CaWFD)
Benzoates (INS 210-13)	**1000 mg/kg** (FJ, CFJ, FN, CFN, WBSB); **600 mg/kg** (CVN), **250 mg/kg** (NWFD, CaWFD)
Bleached starch (INS 1403)	**GMP** (WBSB)
Brilliant blue FCF (INS 133)	**100 mg/kg** (NWFD, CaWFD)
Calcium ascorbate (INS 302)	**GMP**(FJ, CFJ, FN, CFN)
Calcium carbonate (INS 170(i))	**GMP** (WBSB)
Calcium chloride (INS 509)	**GMP** (WBSB)
Calcium lactate (INS 327)	**GMP** (WBSB)
Candelilla wax (INS 902)	**200 mg/kg** (NWFD, CaWFD); **GMP** (WBSB)
Canthaxanthin (INS 161g)	**5 mg/kg** (NWFD, CaWFD, CWFD)

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Table Continued...

Additive	Codex Alimentarius
Caramel III (INS 150c)	**5000 mg/kg** (NWFD, CaWFD); **10000 mg/kg** (WBSB)
Caramel IV (INS 150d)	**50000 mg/kg** (NWFD, CaWFD); **10000 mg/kg** (WBSB)
Carbon dioxide (INS 290)	**GMP**(FJ, CFJ, FN, CFN, WBSB)
Carmines (INS 120)	**100 mg/kg** (NWFD, CaWFD)
Carnauba wax (INS 903)	**200 mg/kg** (NWFD, CaWFD, WBSB)
Carob bean gum (INS 410)	**GMP** (WBSB)
Carotenes, beta-, vegetable (INS 160a)	**2000 mg/kg** (NWFD, CaWFD)
Carotenoids (INS 160a,e,f)	**100 mg/kg** (NWFD, CaWFD)
Carrageenan (INS 407)	**GMP** (WBSB)
Chlorophylls and chlorophyllins, copper complexes (INS 141)	**300 mg/kg** (NWFD, CaWFD)
Citric acid (INS 330)	**GMP** (VJ, CVJ, VN, CVN, WBSB); **3000 mg/kg** (FJ, CFJ); **5000 mg/kg** (FN, CFN)
Citric and fatty acid esters of glycerol (INS 472c)	**GMP** (WBSB)
Cyclamates (INS 952)	**400 mg/kg** (FN, VN, CFN, CVN); **350 mg/kg** (NWFD, CaWFD)
Cyclodextrin, beta- (INS 459)	**500 mg/kg** (NWFD, CaWFD)
Dextrins, roasted starch (INS 1400)	**GMP** (WBSB)
Diacetyltartaric and fatty acid esters of glycerol (INS 472e)	**5000 mg/kg** (NWFD, CaWFD); **500 mg/kg** (WBSB)
Dimethyl dicarbonate (INS 242)	**250 mg/kg** (NWFD, CaWFD, WBSB)
Disodium 5'-guanylate (INS 627)	**GMP** (WBSB)
Disodium 5'-inosinate (INS 631)	**GMP** (WBSB)
Disodium 5'-ribonucleotides (INS 635)	**GMP** (WBSB)
Distarch phosphate (INS 1412)	**GMP** (WBSB)
Ethylene diamine tetra acetates (INS 385-86)	**200 mg/kg** (NWFD, CaWFD); **35 mg/kg** (WBSB)
Fast green FCF (INS 143)	**100 mg/kg** (NWFD, CaWFD)
Ferric ammonium citrate (INS 381)	**10 mg/kg** (CWFD)
Fumaric acid (INS 297)	**GMP** (WBSB)
Gellan gum (INS 418)	**GMP** (WBSB)
Glycerol (INS 422)	**GMP** (WBSB)
Glycerol ester of wood rosin (INS 455)	**150 mg/kg** (NWFD, CaWFD)
Grape skin extract (INS 163)	**300 mg/kg** (NWFD, CaWFD)
Guar gum (INS 412)	**GMP** (WBSB)
Gum Arabic (INS 414)	**GMP** (WBSB)

Table Continued...

Additive	Codex Alimentarius
Hydroxybenzoates, para- (INS 214, 218)	**450** (WBSB); **500 mg/kg** (NWFD, CaWFD)
Hydroxypropyl cellulose (INS 463)	**GMP** (WBSB)
Hydroxypropyl distarch phosphate (INS 1442)	**GMP** (WBSB)
Hydroxypropyl methyl cellulose (INS 464)	**GMP** (WBSB)
Hydroxypropyl starch (INS 1440)	**GMP** (WBSB)
Indigotine (INS 132)	**100 mg/kg** (NWFD, CaWFD)
Iron oxides (INS 172)	**100 mg/kg** (NWFD, CaWFD)
Isopropyl citrates (INS 384)	**200 mg/kg** (NWFD, CaWFD)
Karaya gum (INS 416)	**GMP** (WBSB)
Konjac flour (INS 425)	**GMP** (WBSB)
Lactic and fatty acid esters of glycerol (INS 472b)	**GMP** (WBSB)
Lauric arginate ethyl ester (INS 243)	**50 mg/kg** (NWFD, CaWFD, CWFD)
Lecithin (INS 322(i))	**GMP** (WBSB)
Magnesium carbonate (INS 504(i))	**GMP** (WBSB)
Magnesium chloride (INS 511)	**GMP** (WBSB)
Magnesium hydroxide (INS 528)	**GMP** (WBSB)
Magnesium hydroxide carbonate (INS 504(ii))	**GMP** (WBSB)
Malic acid, DL- (INS 296)	**GMP** (FJ, VJ, CFJ, CVJ, FN, VN, CFN, CVN, WBSB)
Methyl cellulose (INS 461)	**GMP** (WBSB)
Methyl ethyl cellulose (INS 465)	**GMP** (WBSB)
Microcrystalline cellulose (INS 460(i))	**GMP** (WBSB)
Mono- and diglycerides of fatty acids (INS 471)	**GMP** (WBSB)
Monosodium L-glutamate (INS 621)	**GMP** (WBSB)
Monostarch phosphate (INS 1410)	**GMP** (WBSB)
Neotame (INS 961)	**50 mg/kg** (WBSB); **65 mg/kg** (VN, CVN); **33 mg/kg** (NWFD, CaWFD)
Nitrogen (INS 941)	**GMP** (WBSB)
Oxidized starch (INS 1404)	**GMP** (WBSB)
Pectins (INS 440)	**GMP** (FJ, CFJ, FN, VN, CFN, CVN, WBSB)
Phosphated distarch phosphate (INS 1413)	**GMP** (WBSB)
Phosphates (INS 338-43; 450-52; 542)	**300 mg/kg** (WBSB); **1000 mg/kg**(FJ, CFJ, FN, CFN, NWFD, CaWFD)

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Table Continued...

Additive	Codex Alimentarius
Polydimethylsiloxane (INS 900a)	**20 mg/kg** (NWFD, CaWFD)
Polyethylene glycol (INS 1521)	**1000 mg/kg** (NWFD, CaWFD)
Polyvinylpyrrolidone (INS 1201)	**500 mg/kg** (CWFD)
Polysorbates (INS 432-36)	**500 mg/kg** (NWFD, CaWFD)
Ponceau 4R (INS 124)	**50 mg/kg** (NWFD, CaWFD)
Potassium carbonate (INS 501(i))	**GMP** (WBSB)
Potassium chloride (INS 508)	**GMP** (WBSB)
Potassium dihydrogen citrate (INS 332(i))	**GMP** (WBSB)
Powdered cellulose (INS 460(ii))	**GMP** (WBSB)
Processed eucheuma seaweed (INS 407)	**GMP** (WBSB)
Propyl gallate (INS 310)	**1000 mg/kg**(NWFD, CaWFD)
Propylene glycol esters of fatty acids (INS 477)	**500 mg/kg** (NWFD, CaWFD)
Pullulan (INS 1204)	**GMP** (WBSB)
Quillaia extracts (INS 999)	**50 mg/kg** (NWFD, CaWFD)
Riboflavins (INS 101)	**50 mg/kg** (NWFD, CaWFD)
Saccharins (INS 954(i)-(iv))	**80 mg/kg** (FN, VN, CFN);**200 mg/kg** (WBSB);**300 mg/kg** (NWFD, CaWFD, CWFD)
Salts of myristic, palmitic and stearic acids with ammonia, calcium, potassium and sodium (INS 470(i))	**GMP** (WBSB)
Salts of oleic acid with calcium, potassium and sodium (INS 470(ii))	**GMP** (WBSB)
Shellac, bleached (INS 904)	**GMP** (WBSB)
Silicon dioxide, amorphous (INS 551)	**GMP** (WBSB)
Sodium acetate (INS 262(i))	**GMP** (WBSB)
Sodium alginate (INS 401)	**GMP** (WBSB)
Sodium ascorbate (INS 301)	**GMP** (FJ, CFJ, FN, CFN, WBSB)
Sodium carbonate (INS 500(i))	**GMP** (WBSB)
Sodium carboxymethyl cellulose (INS 466)	**GMP** (WBSB)
Sodium dihydrogen citrate (INS 331(i))	**GMP** (WBSB)
Sodium DL-malate (INS 350(ii))	**GMP** (WBSB)
Sodium fumarates (INS 365)	**GMP** (WBSB)
Sodium gluconate (INS 576)	**GMP** (WBSB)
Sodium hydrogen carbonate (INS 500(ii))	**GMP** (WBSB)
Sodium lactate (INS 325)	**GMP** (WBSB)
Sorbates (INS 200-03)	**1000 mg/kg** (FJ, CFJ, FN, CFN); **500 mg/kg** (NWFD, CaWFD, WBSB)
Stannous chloride (INS 512)	**20 mg/kg** (NWFD, CaWFD)
Starch sodium octenyl succinate (INS 1450)	**GMP** (WBSB)

Table Continued...

Additive	Codex Alimentarius
Starches, enzyme treated (INS 1405)	**GMP** (WBSB)
Stearyl citrate (INS 484)	**500 mg/kg** (NWFD, CaWFD)
Steviol glycosides (INS 960)	**200 mg/kg** (FN, VN, NWFD, CaWFD, WBSB)
Sucralose (INS 955)	**300 mg/kg** (FN, VN, CFN, CVN, NWFD, CaWFD, WBSB)
Sucroglycerides (INS 474)	**200 mg/kg** (NWFD, CaWFD); **1000 mg/kg**(WBSB)
Sucrose acetate isobutyrate (INS 444)	**500 mg/kg** (NWFD, CaWFD)
Sulphites (INS 220-25, 539)	**50 mg/kg**(FJ, VJ, CFJ, CVJ, FN, VN, CFN, CVN); **70 mg/kg**(NWFD, CaWFD)
Sunset yellow FCF (INS 110)	**100 mg/kg**(NWFD, CaWFD)
Tara gum (INS 417)	**GMP** (WBSB)
Tartrates (INS 334-5, 337)	**4000 mg/kg**(FJ, CFJ, FN, CFN)
Thiodipropionates (INS 388-89)	**1000 mg/kg**(NWFD, CaWFD)
Tragacanth gum (INS 413)	**GMP** (WBSB)
Tripotassium citrate (INS 332(ii))	**GMP** (WBSB)
Triethyl citrate (INS 1505)	**200 mg/kg**(NWFD, CaWFD)
Trisodium citrate (INS 331(iii))	**GMP** (WBSB)
Xanthan gum (INS 415)	**GMP** (WBSB)

GMP, Good Manufacturing Practice; FJ, Fruit Juices; VJ, Vegetable Juices; CFJ, Concentrates for Fruit Juices; CVJ, Concentrates for Vegetable Juices; FN, Fruit Nectars; VN, Vegetable Nectars; CVN, Concentrates for Vegetable Nectars; CFN, Concentrates for Fruit Nectars; NWFD, Non-carbonated Water-based Flavoured Drinks; CaWFD, Carbonated Water-based Flavoured Drinks; CWFD, Concentrates for Water-based Flavoured Drinks; WBSB, Water-based brewed or steeped beverages

Development of new additives

Food additives may be present in a variety of foods, and consumers are exposed to their intake from childhood, which can cause health damage over the years, however, food additives are now considered essential in modern foods. Sweeteners, preservatives, colourings and flavourings are added to foods during processing, and almost all processed foods contain food additive.[46] Most countries or regions have established safety criteria for food additives; however, some reports show that food additives are associated with increased risks of immunological diseases such as cancer (nitrates and nitrites)[47] and allergies (artificial sweeteners).[48] Some additives have been found to be directly responsible for causing various diseases (i.e., in addition to those supposedly attributable to excessive consumption of unhealthy foods).[49] Although some of the possible associations are probably unfounded, there is strong evidence for some claims. Several public interest groups have drawn up lists of additives that should generally be avoided or used with caution, especially by individuals considered susceptible.

As mentioned above, food additives are non-nutritional ingredients added to foods to modify physical, chemical, biological or sensory characteristics during manufacturing, processing, preparation, treatment, packaging, storage, transport or delivery. However, they should have the main characteristic of consumers' safety. In recent years new substances have been used as food additives, including drinks. Consumers around the world are demanding natural ingredients in products. In the industry of beverages, many manufacturers are responding with the removal of dyes, but the costs and stability problems can create barriers against this change.[50]

Many classes of substances such as chemical preservatives and organic acids are used to preserve food, especially beverages. However, the demand for synthetic chemical preservatives is gradually decreasing due to the possible side effects that have been demonstrated as research progresses, causing pressure from society for safe food, forcing the reduction or restriction of the application of these substances. Thus, the development of natural preservatives that can replace synthetic ones has been increasingly preferred.[51] Since ancient times man has used plants both as food and as sources of various valuable bioactive compounds. Nowadays, medicinal and aromatic herbal extracts are used as food and cosmetic additives (such as essential oils, rosmarinic acid, vanillin), natural dyes (such as betaines, anthocyanins), biopesticides (such as nicotine, rotenone, rhinidine) and herbal medicines (terpenes). acids, phenolic acids, alkaloids: vinblastine, vincristine, caffeine, nicotine, ephedrine).[52] Even with the wide variety of compounds already known and employed with preservative properties in food, food science and technology continue to seek out substances that are harmless to consumers and which can be used for the purpose of preserving or improving some of the food properties. In this section, we sought to address food additives that have been used more recently in the food industry.

Essential oils

Essential oils are natural aromatic compounds with broad-spectrum biological activities. Many of these substances have strong antibacterial, antiviral and antifungal activities, stimulating their application also as natural antimicrobials in foods and beverages.[53] To achieve an optimal technological application of essential oils as preservatives in food processing, it is necessary to establish ideal conditions of application, such as know the sensitivity of the pathogen and best concentrations of the active compound used. Some substances that have been highlighted in relation to the use as preservatives are the essential oils extracted from the tea tree. The tea tree oils (TTO) are extracted by steam distillation from the leaves of *Melaleuca alternifolia* (belonging to the family *Myrtaceae*), which is a plant native from Australia, and its oil commonly called Australian tea tree oil (a colourless to pale yellow liquid with a strong camphor odour).[54] TTO has been widely used as antimicrobial and anti-inflammatory agents, which is especially due to terpinen-4-ol and 1,8-cineole, the major component of this oil.[55] This extract has antibacterial, anti-inflammatory, antiviral, insecticidal and immunological properties and is also used in aromatherapy techniques with various mixtures, such as lemon, lavender, eucalyptus, ginger and others, in the treatment of various diseases.[56]

Several studies present positive results on the action of TTO against some microorganisms. Neto et al.[57] evaluated the action of some essential oils against the growth of *Penicillium expansum*, a cosmopolitan pathogen that can represent several damages in some fruits. All oils evaluated presented promising effects, including TTO, achieving 100% inhibition of fungal germination, causing damage to their plasma membrane, leading to DNA extravasation. Hammer and co-workers [58] investigated the mechanism of action of tea tree oil and its components against *Candida albicans*, *C. glabrata* and *Saccharomyces cerevisiae* and concluded that these microorganisms were inhibited using doses from 0.2% tea tree oil, proving the activity antifungal properties of these substances. Most studies have considered the encapsulation of essential oils in order to reduce the impact on the sensory properties of foods, making possible the use of these substances in food or drinks. Lin et al.[59] investigated the synthesis of TTO microspheres with antibacterial properties and concluded that this oil had greater stability in the encapsulated form developed during the studies (using butyl methacrylate (BMA) and styrene (St) as support), being completely decomposed as the temperature increased from 110 °C to 150 °C. In addition, tests were carried out to evaluate the antimicrobial activity against the bacteria *Escherichia coli* by the analysis of the zones of inhibition, which were larger proportionally the amount of TTO used.

The use of this substance as a food preservative is a promising tool for the industry due to the need to apply products considered natural and that cause less harmful effects to consumers' health. The use of essential oils as a mild preservation technique in the food industry has received much attention in recent years, especially due to negative consumer perceptions about the use of chemical preservatives.[60]

Antimicrobial peptides

Usually, the food industry depends on chemicals for preservation and for the increase in the shelf life of the products. The use of chemical preservatives such as nitrites and sulphur dioxide can cause adverse effects on human health since in many cases the excessive addition of certain substances has caused the resistance of microorganisms.[61] The growth and resistance of bacteria to traditional antibiotics have led to the search for new effective substances against these microorganisms, encouraging the research and development of new antimicrobials. A promising area in this field is the development of antimicrobial peptides (AMPs), which act as potential defence weapons against a broad spectrum of bacterial and fungal pathogens.[62]

Active peptides are fragments of specific proteins with multifunctional properties and many of them have biological activity, among which we can highlight: antimicrobial, antihypertensive, immunomodulatory, opioid and antioxidant.[63] These peptides have short chains (generally between 12 and 100 amino acid residues) and exhibit effective toxicity against a wide variety of pathogens. The literature reports more than 1700 isolated endogenous antimicrobial peptides and an even greater number of reported synthetic analogues.[64] Structural analyses indicate that antimicrobial activity is governed primarily by charge and hydrophobicity and that the initial target is the bacterial cell membrane negatively charged.[65]

The beverage industry is also susceptible to microbial contamination, although the low pH of soft drinks prevents bacterial deterioration, fungal growth may occur. Yeasts are the primary contaminants in these products because of their ability to grow in beverages highly carbonated and with low pH, being derived from weak acids, such as sorbic or benzoic acids, the preservatives most commonly used in soft drinks.[66] The greatest benefit of using antimicrobial peptides is the possibility of preserving food without altering its quality and, given the difficulties that exist in maintaining

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its natural state, the use of microorganisms and their antimicrobial products can extend shelf life and increase the food safety.

Some studies have shown the use of peptides in polysaccharide films with potential antibacterial activity against both Gram-positive and Gram-negative bacteria.[67,68] Other studies sought to produce bioactive peptides from bovine and goat milk, which were generated from fungal products of *Aspergillus oryzae* and *A. flavipes*.[69,70] Abrioueland co-workers[71] studied the use of bacteriocins (called AS-48) in various plant products, including fruit juices, and concluded that this antimicrobial peptide may act as a natural additive or disinfectant. In these beverages, bacteriocin is shown to be highly active against spore-forming, spoilage bacteria, as well as for lactic acid bacteria, having effectiveness even at low concentrations.

Saponins

Saponins are structurally complex amphipathic glycosides of steroids and triterpenoids that are widely produced by plants and by certain marine organisms such as starfish and sea cucumbers.[72] These substances have high molecular weight and are widely distributed, especially in plant species, being glycosides that, due to their structure, exhibit multiple biological and conservation properties, as well as antioxidant, antimicrobial, hypoglycemic, anti-inflammatory, cytotoxic and antitumor activity.[73]

Some studies have been published in the literature and demonstrate the success of the saponins use like antimicrobial activity. For example, Chan and co-workers[74] studied the potential of underutilized agroindustry residues as a source of natural preservatives, nutraceuticals and functional food ingredients extracting saponins from seed. Choi and co-workers[51] investigated the applicability of green tea seed extracts (containing asaponin E1, Assamsaponin A, and Assamsaponin *B saponins*) as a natural preservative with anti-yeast action in soy sauce. In order to develop natural food preservatives, Gundewadiand co-workers[75] developed oily-based nanoemulsion formulations using the extract of pericarp from *Sapindusmukorossi* and verified its inhibitory action against spoilage fungi, such as *Penicillium chrysogenum* and *Aspergillus flavus*, achieving the effectiveness of 64-67% inhibitory activity when compared to fungicide commercial Carbendazin.

In South America, there is the high consumption of beverages based on leaves of mate (*Ilex paraguariensis* A. St. Hil.), which are rich in saponins, which gives these beverages certain antioxidant properties besides contributing to conservation. On the other hand, despite the proven antioxidant and antimicrobial action of these compounds, a study published by Patrick et al.[76] showed an interaction between saponins and proteins present in carbonated beverages forming acid flakes. These authors proved their theory by showing that saponins and proteins, when mixed in acidic conditions (pH 2), and of complex refrigerants, increasing the turbidity of these beverages and making them difficult to use together.

Flavonoids

As mentioned, several plant extracts contain biocontrol or bio preservative antimicrobial compounds and can be applied as natural food additives in various types of food. Some medicinal and aromatic plants are rich in compounds such as polyphenols, saponins, alkaloids and flavonoids.[77] Flavonoids are biologically active compounds with high antioxidant potential and numerous health benefits [78], is found in several plants (such as fruits, leaves and seeds) and many studies have sought their extraction for later applications as natural antioxidants.[79]

Flavonoids are the class of polyphenols most extensively studied in relation to their antioxidant and biological activities, having high antioxidant activity in vitro and being reactive with a wide range of reactive species of oxygen and nitrogen, such as superoxide, hydroxyl and peroxyl radicals.[80]

Peanparkdee and Iwamoto[81] published a review on the extraction and application of bioactive compounds from crop by-products and rice processing and its application in food and pharmaceuticals. According to this study, flavonoids are among these compounds and possess antioxidant capacity, so its use can improve stability in food storage. El-Maatiand co-workers,[82] due to the broad spectrum of biochemical and biological activity, including antiradical activity, studied the extraction of bioactive compounds from garlic cloves in relation to their phenolic content and antioxidant and antibacterial potential. These authors observed that water was the best solvent for extracting flavonoids (17.5 mg/g extract).

Final considerations

The reduced population time is one of the main factors for the fast-growing market for ready-to-drink juices and other non-alcoholic beverages. The market for teas and mates, for example, is another important segment in the non-alcoholic and recent impulse sector. The prospects are very promising and although this field is highly concentrated around a few participants, it is observed that new industries are investing in diversification, quality and price in order to reach those consumers who demand healthy and fast consumption drinks.

The intentional addition of substances for food industrialization is a critical factor for the Food Industry today. From the wide range of existing additives is dependent on a wide variety of foods and beverages available to meet the demand of the population. In the case of the non-alcoholic beverage industry, the additives are used especially for the purpose of maintaining sensory properties and ensuring food safety, making these products microbiologically stable.

Over the years there is a greater need, often driven by sociological and ethical questions, as well as the search for healthier foods, the use of substances considered natural instead of the chemicals that are conventionally applied. Soft drinks are among the most consumed beverages, however, due to the search for foods with lower amounts of sugars and considered natural, fruit juices and teas have typed its consumption increasing every year. In an extended form, the main groups of additives applied in these beverages can be visualized in Figure 2, either with the intention of maintaining the characteristics closest to those required by the consumers, either for conservation or nutritional purposes.

Among the main additives used in the beverage industry are those used as antioxidants, preservatives, acidulants and sweeteners. Generally, these additives are extremely necessary, used alone or in combination, to confer the microbiological stability of beverages and to achieve the sensory characteristics inherent to each beverage.

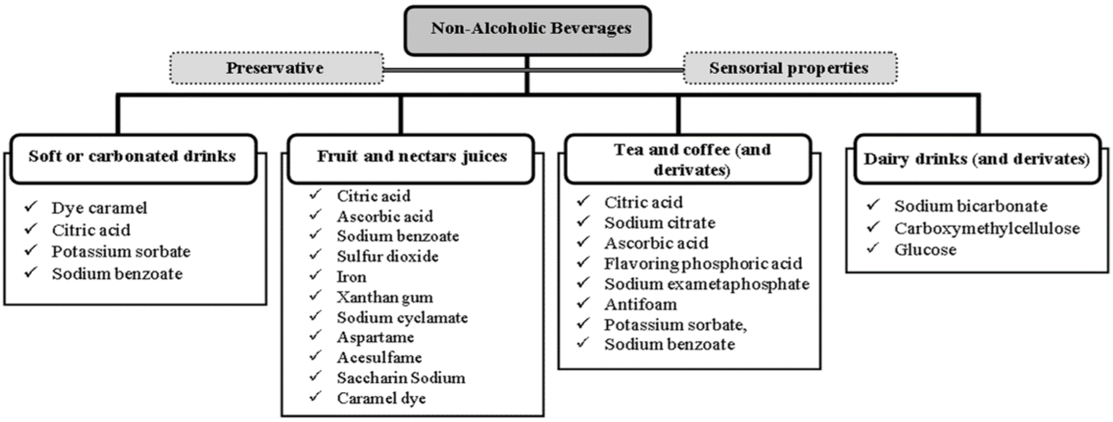

Figure 2 Main types of additives used in non-alcoholic beverages for the preservation and/or maintenance of sensory characteristics.

Conclusion

The profile of consumption of food and beverages has changed in recent years and it is observed that the consumer no longer only cares about the nutritional profile of the product and started to analyze the ingredients in their composition. Therefore, many companies, seeking to meet this new profile, have been concerned with developing products with cleaner labels, called clean label. There is a growing interest in non-alcoholic drinks and in those that contain ingredients considered to be non-harmful to health. The market for these beverages, such as carbonated, bottled water, juices, energy, teas and nectars, advances in relation to gigantic demand for alcoholic beverages. In view of the observations made in the present study, it is concluded that the diversification of non-alcoholic products supplied to consumers is increasing every day, pressing the Food and Beverage industry for the development of new products, which in turn directly influence the use of additives capable of providing the production of accepted beverages of nutritional quality.

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References

1. Márcio Carocho, Maria Filomena Barreiro, Patricia Morales, et al. Adding Molecules to Food, Pros and Cons: A Review on Synthetic and Natural Food Additives. *Comprehensive Reviews in Food Science and Food Safety.* 2014;13:377–399.
2. Branen AL, Davidson PM, Salminen S, et al. *J Food additives.* New York: Taylor & Francis, 2001.
3. Janina SGDiogo, Liliana SOSilva, Angelina Pena, et al. Risk assessment of additives through soft drinks and nectars consumption on Portuguese population: A 2010 survey. *Food and Chemical Toxicology.* 2013;62:548–553.
4. Joint FAO/WHO Codex Alimentarius Commission. General Standard for Food Additives. Rome: World Health Organization: Food and Agriculture Organization of the United Nations, 2016.
5. Roethenbaugh G. Trends in beverage markets. In: Chemistry and technology of soft drinks and fruit juices. 2nd edn. Blackwell Publishing Ltd; 2005;15–34.
6. Carter HE, Cannon PR, Kensler CJ, et al. Problems in the evaluation of carcinogenic hazard from use of food additives. *Cancer Research.* 1961;21(4):429–456.
7. Gao H, Yang M, Wang M, et al. Determination of 30 synthetic food additives in soft drinks by HPLC/electrospray ionization–tandem mass spectrometry. *J AOAC Int.* 2013;96(1):110–115.
8. Rothwell, J. A., Madrid-Gambin, F., Garcia-Aloy, M., Andres-Lacueva, C., Logue, C., Gallagher, A. M., ... & Dragsted, L. O. (2018). Biomarkers of intake for coffee, tea, and sweetened beverages. *Genes & nutrition*, *13*(1), 15.
9. Persistence market research. Global market study on non–alcoholic beverages: North America to Register a High–Value CAGR During the Forecast Period. 2017–2027.
10. Taylor B. Other beverage ingredients. In: Chemistry and technology of soft drinks and fruit juices. 2nd edn, Blackwell Publishing Ltd; 2005. p. 90–128.
11. German Jb. Antioxidants. In: Food additives. 2nd edition, New York: Marcel Dekker, Inc., 523–542, 2001.
12. Kregiel D. Review Article: Health Safety of Soft Drinks: Contents, Containers, and microorganisms. *Biomed Res Int.* 2015;2015:128697.
13. Joint FAO/WHO Codex Alimentarius Commission. Codex General Standard for Fruit Juices and Nectars. Rome: World Health Organization: Food and Agriculture Organization of the United Nations, 2005.
14. Daniel JW. Metabolic aspects of antioxidants and preservatives. *Xenobiotica.* 1986;16:1073–1078.
15. Reddy AC, Lokesh BR. Studies on spice principles as antioxidants in the inhibition of lipid peroxidation of rat liver microsomes. *Molecular and Cellular Biochemistry*. 1992;111:117–124.

16. Code Of Federal Regulations (CFR). 2018. Title 21. Food and Drugs, Part 170, Office of FederalRegulations, National Archives Records Services, General Service Administration, Washington, D.C.

17. DOORES, S. Organic acids. In: Antimicrobials in Foods, 2nd ed. Davidson P M, Branen A L. (Eds.). Marcel Dekker, New York, 95, 1993.

18. Zhang G, MA Y. Mechanistic and conformational studies on the interaction of food dye amaranth with human serum albumin by multispectroscopic methods. *Food Chemistry*. 2013;136:442–449.

19. Ioannou I, Ghoul M. Prevention of enzymatic browning in fruit and vegetables. *European Scientific Journal.* 2013;9:30.

20. Iyengar Radha, Mcevily Arthur J. Anti–browning agents: alternatives to the use of sulfites in foods. Trends in Food Science & Technology. 1992;3:60–64.

21. Fallico, B., Chiappara, E., Arena, E., & Ballistreri, G. (2011). Assessment of the exposure to Allura Red colour from the consumption of red juice-based and red soft drinks in Italy. *Food Additives & Contaminants: Part A*, *28*(11), 1501-1515.

22. Doell DL, Folmer DE, Lee HS, et al. Exposure estimate for FD&C colour additives for the US population. *Food Additives and Contaminants–Part A*. 2016;33:782–797.

23. McCann D, Barrett A, Cooper A, et al. Food additives and hyperactive behaviour in 3–year–old and 8/9–year–old children in the community: a randomised, double–blinded, placebo–controlled trial. Lancet. 2007;370:1560–1567.

24. Stevens LJ, Burgess JR, Stochelski MA, et al. Amounts of artificial food colours in commonly consumed beverages and potential behavioural implications for consumption in children. *Clinical Pediatrics*. 2014;53:133–140.

25. Scotter MJ. Methods for the determination of European Union–permitted added natural colours in foods: a review. *Food Additives and Contaminants*. 2011;28:527–596.

26. Sengar G, Sharma HK. Food caramels: a review. *Journal of Food Science and Technology*. 2014;51:1686–1696.

27. Codex Food Chemicals. 4th edn. Food and Nutrition FCC IV/ Monograph Specification for caramel colour. 1996.

28. Kamuf W, Nixon, A, Parker O, et al. Overview of caramel colours. Williamson. *American Association of cereal chemists.* 2003;48(2):65–69.

29. Xu XB, Liu DB, Yu SJ, et al. Separation and determination of 4–methylimidazole, 2–methylimidazole and 5–hydroxy– methylfurfural in beverages by amino trap column coupled with pulsed amperometric detection. *Food Chem.* 2015;169:224–229.

30. Demyttenaere JCR. The new European Union Flavouring Regulation and its impact on essential oils: Production of natural flavouring ingredients and maximum levels of restricted substances. *Flavour and Fragrance Journal.* 2012;27(1):3–12.

31. Kieling DD, Prudencio SH. Blends of lemongrass derivatives and lime for the preparation of mixed beverages: antioxidant, physicochemical, and sensory properties. *J Sci Food Agric.* 2019;99(3):1302–1310.

32. Li J, Liu H, Wang C, et al. Stable isotope labelling–assisted GC/MS/MS method for determination of methyl eugenol in food samples. *J Sci Food Agric*. 2018;98(9):3485–3491.

33. Faustino M, Veiga M, Sousa P, et al. Agro Food Byproducts as a New Source of Natural Food Additives. *Molecules.* 2019;24(6):1056.

34. Matta Z, Chambers E, Garcia JM, et al. Sensory characteristics of beverages prepared with commercial thickeners used for dysphagia diets. *J Am Diet Assoc.* 2006;106(7):1049–1054.

35. Singh S, Singh G, Arya SK. An overview of properties and application in food products. *Int J Biol Macromol.* 2018;119:79–95.

36. Hamdani AM, Wani IA. Guar and Locust bean gum: Composition, total phenolic content, antioxidant and antinutritional characterization. *Bioactive Carbohydrates and Dietary Fibre.* 2017;11:53–59.

37. Teimouri S, Abbasi S, ScanlonMG. Stabilisation mechanism of various inulins and hydrocolloids: Milk–sour cherry juice mixture. *Journal of Experimental Food Chemistry.* 2018;71:208–215.

38. Steinbach A, Guthrie B, Smith S, et al. Normal force–controlled tribological measurement of soft drinks and lubrication additives. *Journal of Food Measurement and Characterization.* 2014;8(2):142–148.

39. Sicińska E, Jeruszka Bielak M, Masalska K, et al. A survey of foodstuffs fortified with vitamins available on the market in Warsaw. *Rocz Panstw Zakl Hig*. 2013;64(4):293–298.

40. Marone PA, Birkenbach VL, Hayes AW. Newer approaches to identify potential untoward effects in functional foods. *Int J Toxicol.* 2016;35(2):186–207.

41. Shahidi F, Naczk M. *Phenolics in Food and Nutraceuticals.* 2nd edn. 2019.

42. Blanco Morales V, López García G, Cilla A, et al. The impact of galactooligosaccharides on the bioaccessibility of sterols in a plant sterol–enriched beverage: adaptation of the harmonized INFOGEST digestion method. *Food Funct.* 2018;9(4):2080–2089.

43. Peerajan S, Chaiyasut C, Sirilun S, et al. Enrichment of nutritional value of Phyllanthus emblica fruit juice using the probiotic bacterium, Lactobacillus paracasei HII01 mediated fermentation. *Food Sci Technol*. 2016;36(1):116–123.

44. Kakitani A, Inoue T, Matsumoto K, et al. Simultaneous determination of water–soluble vitamins in beverages and dietary supplements by LC–MS/MS. *Food Addit Contam Part A Chem Anal Control Expo Risk Assess*. 2014;31(12):1939–1948.

45. Tennant DR. Screening potential intakes of colour additives used in non–alcoholic beverages. *Food Cheml Toxicol.* 2008;46(6):1985–1993.

46. Yamashita H, Matsuhara H, Miotani S, et al. Artificial sweeteners and mixture of food additives cause to break oral tolerance and induce food allergy in murine oral tolerance model for food allergy. *Clinical & Experimental Allergy*. 2017;47:1204–1213.

47. Song P, Wu L, Guan W. Dietary nitrates, nitrites, and nitrosamines intake and the risk of gastric cancer: a meta–analysis. *Nutrients.* 2015;7:9872–9895.

48. Maslova E, Strom M, Olsen S. Halldorsson T.I. Consumption of artificially–sweetened soft drinks in pregnancy and risk of child asthma and allergic rhinitis. *PLoS ONE.* 2013;8:5726.

49. Sullivan C, Sayre SS, Leon JB, et al. Effect of food additives on hyperphosphatemia among patients with end–stage renal disease: a randomized controlled trial. *American Medical Association*. 2009;301;629–635.

50. Mepham B. Food additives: an ethical evaluation. *Br Med Bull.* 2011;99:7–23.

51. Ju HeeChoia, Jin-YongKima, Eun Tak Jeong, et al. Preservative effect of Camellia sinensis (L.) Kuntze seed extract in soy sauce and its mutagenicity. *Food Research International.* 2018;105:982–988.

52. Radka Vrancheva, Ivan Ivanov, Ina Aneva, et al. Food additives and bioactive substances from in vitro systems of edible plants from the Balkan peninsula. *Engineering in Life Sciences*. 2018;18:799–806.

53. Donsì F, Ferrari G. Essential oil nanoemulsions as antimicrobial agents in food. *Journal of Biotechnology.* 2016;233:106–120.

54. Hammer Ka. Treatment of acne with tea tree oil (melaleuca) products:

a review of efficacy, tolerability and potential modes of action. *Int J Antimicrob Agents*. 2015;45(2):106–110.

55. Furneri PM, Paolino D, Saija A, et al. In vitro antimycoplasmal activity of Melaleuca alternifolia essential oil. *J Antimicrob Chemother.* 2006;58(3):706–707.

56. BabarAli, Naser AliAl-Wabel, SaibaShams, et al. Essential oils used in aromatherapy: A systemic review. *Asian Pacific Journal of Tropical Biomedicine.* 2015;5(8):601–611.

57. Neto ACR, Navarro B B, Canton L, et al. Antifungal activity of palmarosa (Cymbopogon martinii), tea tree (Melaleuca alternifolia) and star anise (Illicium verum) essential oils against Penicillium expansum and their mechanisms of action. *LWT – Food Science and Technology.* 2019;105:385–392.

58. Hammer KA, Carson CF, Riley TV. Antifungal effects of Melaleuca alternifolia (tea tree) oil and its components on Candida albicans, Candida glabrata and Saccharomyces cerevisiae. *J Antimicrob Chemother.* 2004;53(6):1081–1085.

59. Lin G, Chen H, Zhou H, et al. Preparation of tea tree oil/poly(styrene–butyl methacrylate) microspheres with sustained release and anti–bacterial properties. *Materials (Basel)*. 2018;11(5).

60. Seow YX, Yeo CR, Chung HL, et al. Plant essential oils as active antimicrobial agents. *Critical Reviews in Food Science and Nutrition*. 2014;54:625–644.

61. Rai M, Pandit R, Gaikwad S, et al. Antimicrobial peptides as natural bio–preservative to enhance the shelf–life of food. *Journal of Food Science and Technology. 2016*;53:3381–3394.

62. Laverty G, Gorman SP, Gilmore BF. The Potential of antimicrobial peptides as biocides *Int J Mol Sci.* 2011;12(10):6566–6596.

63. Nielsen SD, Beverly RL, Qu Y et al. Milk bioactive peptide database: A comprehensive database of milk protein–derived bioactive peptides and novel visualization. *Food Chem.* 2017;232:673–682.

64. van 't Hof W, Veerman EC, Helmerhorst EJ, et al. Antimicrobial peptides: Properties and applicability. *Journal of Biological Chemistry.* 2001;382:597–619.

65. Powers JP, Hancock RE. The relationship between peptide structure and antibacterial activity. *Peptides*. 2003;24:1681–1691.

66. Battey AS, Duffy S, Schaffner DW. Modelling yeast spoilage in cold–filled ready–to–drink beverages with Saccharomyces cerevisiae, Zygosaccharomyces bailii, and Candida lipolytica. *Appl Environ Microbiol*. 2002;68(4):1901–1906.

67. Wu Yuehan Li, Qi Zhang, Xingzhong Li, et al. Cellulose–based peptide polysaccharides as cationic antimicrobial package films. *International Journal of Biological Macromolecules*. 2019.

68. Johnson CP Santos, Rita CS Sousa, Caio G Otoni, et al. Nisin and other antimicrobial peptides: Production, mechanisms of action, and application in active food packaging. *Innovative Food Science and Emerging Technologies*. 2018;48:179–194.

69. Zanutto-Elgui MR, Vieira JCS, Prado DZD, et al. Production of milk peptides with antimicrobial and antioxidant properties through fungal proteases. *Food Chemistry*. 2019;278:823–831.

70. Noreddine benkerroum. Antimicrobial peptides generated from milk proteins: A survey and prospects for application in the food industry. A review. *International Journal of Dairy Technology.* 2010;63:320–338.

71. Abriouel H, Lucas R, Omar NB, et al. Potential applications of the cyclic peptide enterocin AS–48 in the preservation of vegetable foods and beverages. *Probiotics Antimicrob Proteins*. 2010;2(2):77–89.

72. Faizal A, Geelen D. Saponins and their role in biological processes in plants. *Phytochemistry Reviews*. 2013;12(4):877–893.

73. Man S, Gao W, Zhang Y, et al. Chemical study and medical application of saponins as anti–cancer agents. *Fitoterapia.* 2010;81(7):703–714.

74. Kim WeiChan, ShahidIqbal, Nicholas M.H.Khong, et al. Antioxidant activity of phenolics – saponins rich fraction prepared from defatted kenaf seed meal. *LWT – Food Science and Technology.* 56(1):181–186.

75. GajananGundewadi, Dhruba JyotiSarkar, Shalini Gaur Rudra, et al. Preparation of basil oil nanoemulsion using Sapindusmukorossi pericarp extract: Physico–chemical properties and antifungal activity against food spoilage pathogens. *Industrial Crops & Products.* 2018;125(1):95–104.

76. Morton PAJ, Murray BS. Acid beverage floc: protein–saponin interactions and an unstable emulsion model. *Colloids Surf B Biointerfaces*. 2001;21(1–3):101–106.

77. Al-Huqail AA, Behiry SI, Salem MZM, et al. Antifungal, antibacterial, and antioxidant activities of Acacia saligna (Labill.) H. L. Wendl. Flower extract: HPLC analysis of phenolic and flavonoid compounds. *Molecules.* 2019;24(4).

78. Navnidhi Chhikara, Hidam Roshree Devi, Sundeep Jaglan, et al. Bioactive compounds, food applications and health benefits of Parkiaspeciosa (stinky beans): a review. *Agriculture & Food Security.* 2018;7:1–9.

79. Mohdaly AA, Sarhan MA, Smetanska I, et al. Antioxidant properties of various solvent extracts of potato peel, sugar beet pulp and sesame cake. *J Sci Food Agric.* 2010;90(2):218–226.

80. Maqsood S, Benjakul S, Shahidi F. Emerging role of phenolic compounds as natural food additives in fish and fish products. *Crit Rev Food Sci Nutr*. 2013;53(2):162–179.

81. Peanparkdee M, Iwamoto S. Bioactive compounds from by–products of rice cultivation and rice processing: extraction and application in the food and pharmaceutical industries. *Trends in Food Science & Technology.* 86:109–117.

82. El–Maati MFA, Mahgoub SA, Labib SM, et al. Phenolic extracts of clove (Syzygiumaromaticum) with novel antioxidant and antibacterial activities. *European Journal of Integrative Medicine.* 2016;8(4):494–504.