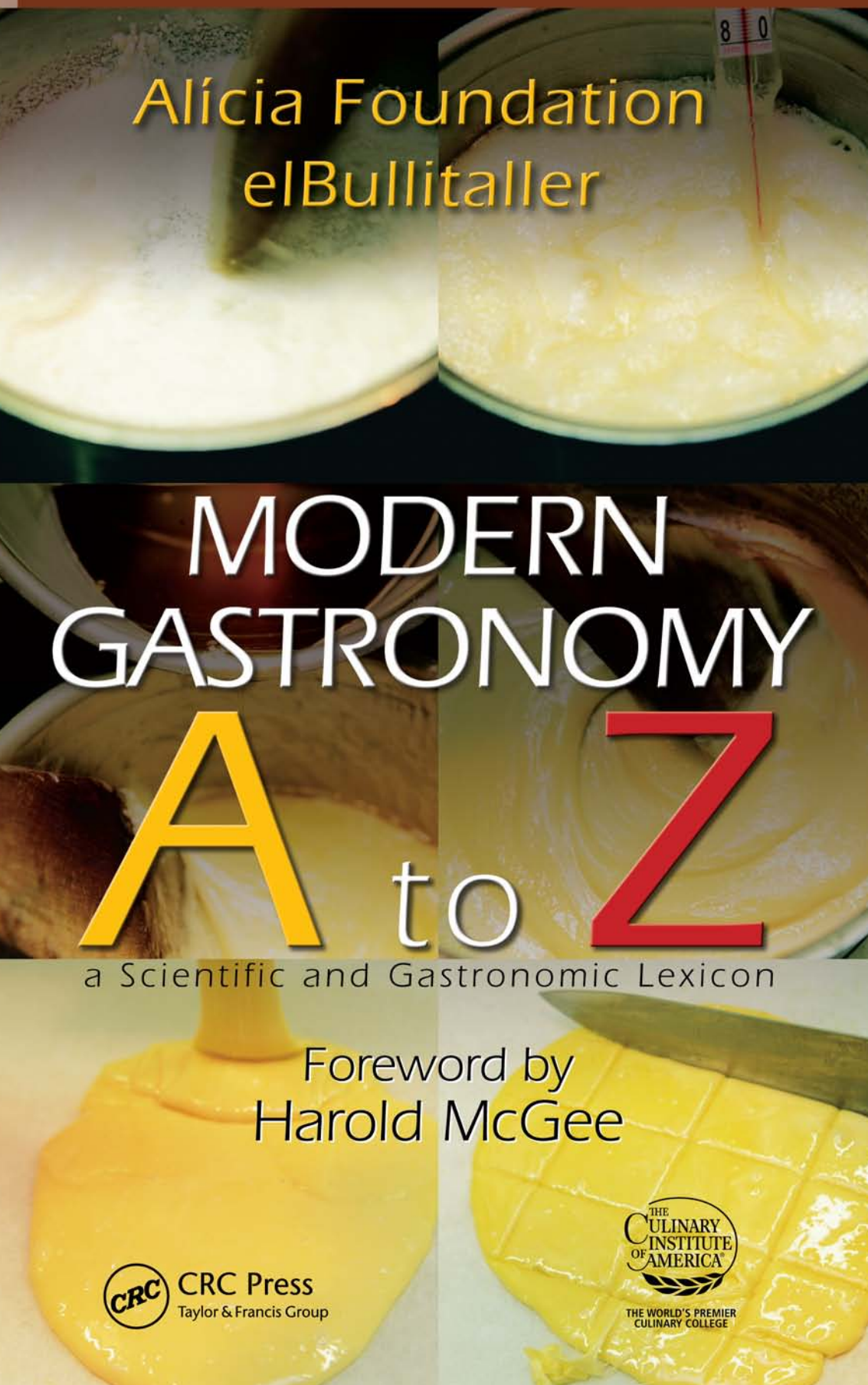
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elBullitaller
MODERN
GASTRONOMY
A to Z
a Scientific and Gastronomic Lexicon
Foreword by
Harold McGee
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Modern Gastronomy A to Z

a Scientific and Gastronomic Lexicon

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Alícia Foundation
elBullitaller

Alícia Foundation founded by famed chef Ferran Adrià of el Bulli

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Foreword

This book, the *Modern Gastronomy: A to Z*, is a landmark in the history of cooking.

It is not a grand monument. It's a concise, factual handbook. And it's not definitive. It will be superseded by improved editions of itself. But this modest book does mark the arrival of a new era for the culinary profession. In recent years, a few leading chefs have begun to take a fresh look at their craft and explore new ways of bringing nourishment, pleasure, and meaning to our lives. *Modern Gastronomy: A to Z* defines the chemical materials and processes that are the basis for the craft of cooking. It's not the first book to present this kind of information. But it *is* the first such book to be initiated and shaped by professional cooks themselves, and to be so forward-looking. Many of the entries describe materials and methods whose current use is "in experimentation." The book of cooking is now wide open.

Though the combination of cooking and science may seem fashionably modern, in fact these two disciplines go way back together. Cooks were among the first practical chemists on the planet. They discovered through trial and error that we could use tools, heat, and fermentation to transform natural foodstuffs into safer, more nutritious, and more interesting foods. When true experimental science developed in the 17th century, the early chemists learned important lessons from cooks and their water extracts of plant and animal tissues—their soups and stocks. As the knowledge of food chemistry grew, a number of scientists came to write about cooking and food preparation, among them Benjamin Thompson, Justus Liebig, and Louis Pasteur.

In the 20th century, the needs of the expanding industrial sector gave rise to the specialized field of food science. I began to survey the food science literature in 1978, and distilled the information relevant to cooks in a 1984 book, *On Food & Cooking: The Science & Lore of the Kitchen*. Then, in 1992, came the first of a handful of biannual workshops on "molecular gastronomy" in Erice, Sicily. The idea of an Erice workshop on the science of cooking was proposed by California cooking teacher Elizabeth Cawdry Thomas, and organized by her friend University of Oxford physicist Nicholas Kurti, who then invited Hervé This and myself to assist him. Though the term "molecular gastronomy," coined by Kurti and This, suggests precise, state-of-the-art analysis (as in its model, molecular biology), in fact the Erice meetings brought together a

very mixed group of scientists and chefs, and focused on the basic food chemistry of traditional dishes. The presentations and discussions were informal, and were never published.

Now, at the beginning of the 21st century, an experimental, open approach to cooking—often mistakenly named "molecular gastronomy"—has burst into prominence. This approach owes very little to particular books or meetings. It is the product of broad historical developments and a unique catalyst: the globalization of travel and commerce, the expansion of the Internet and rapid access to information, the infiltration of modern technology into all aspects of life—and the vision of Ferran Adrià.

In the past, cooks and their creations have been constrained by many factors—the limited local and seasonal availability of ingredients, limited techniques and tools for transforming them, limited understanding of cooking processes, and the necessarily narrow expectations defined by local customs. Of course, limitation can inspire inventiveness, and this is what has given us our great culinary traditions. But today there are many fewer constraints, and therefore unprecedented opportunities for the craft of cooking to grow and advance. Imaginative cooks are now able to work with the entire planet's ingredients, cooking methods, and traditions, and draw on all of human knowledge and invention to explore what can be done with food and the experience of eating.

Several remarkable chefs have been at the forefront of this new open cuisine, but its chief trailblazer is Ferran Adrià. In 1987, soon after rising to head the kitchen at El Bulli, a small restaurant hours north of Barcelona, he began a deliberate process of culinary exploration that has been dazzlingly productive and influential. He and his team became prolific creators of startling, beautiful, delicious dishes that brought worldwide renown to El Bulli and to elBullitaller, the Barcelona workshop that he set up in 1997. Science and scientists came relatively late to the workshop, but are now an integral part of its creative work. In 2004, Ferran Adrià agreed to direct a joint undertaking of the Manresa Savings Bank and the Catalan regional government, the new Alicia Foundation, whose name reflects the meeting of food (Catalan *alimentació*) and science (*ciència*). Alicia's purpose is to foster collaboration among culinary professionals, food scholars, scientists, and educators, to improve the quality of food—and so the quality of life—for as many people as possible.

This book is the first major project of the Alicia Foundation, a joint publication with elBullitaller. It is both a gift and a challenge. The gift is the book itself and the information it holds. The challenge is to make use of it creatively and generously, in the same spirit that has brought it to your hands.

Harold McGee

Preface

Despite the fact that most reactions and techniques in the kitchen have a scientific explanation, science and gastronomy have joined forces on very few occasions. Recently, there have been initiatives to establish a debate between both disciplines which, in principle, have very little in common with each other insofar as objectives and methods are concerned.

The reason for this is simple; these initiatives have arisen from an awareness that has gradually been taking shape in the world of gastronomy: knowledge of the processes that make culinary operations possible cannot but benefit all professionals who have hitherto used the traditional method of trial and error.

Modern Gastronomy: A to Z aims not only to give chefs a better understanding of the terminology that describes the nature of the ingredients they work with every day and to explain the reasons these ingredients produce certain reactions, but also to help them discover the potential of a wide range of products that can be used in a diversity of preparations.

This is a book that aims to enable catering professionals to research quickly, easily, and in plain language everything they need to know with regard to science in cooking. The choice of entries was above all practical; we hope, therefore, that chefs will find answers to some of their questions and broaden their understanding of a subject that they broach each day with their own hands.

However, when writing this book, the only tools at our disposal have been our thoughts, intuition, and continuous research in widely diverse areas, as there have been very few books to consult on this topic. Therefore, more than ever, we feel bound to state that this is a living work that sees itself as the foundation stone, so that in the future, all of us, the scientists who have been involved in the work, as well as the chefs who use it, will improve and adapt it to the real needs of the world of gastronomy.

Pere Castells
Director of the Scientific Department
Fundación Alícia

Albert and Ferran Adrià
elBullitaller

This Lexicon is a living work that aims to adapt and readapt to the real needs of chefs. Please help us to complete and improve it by sending your suggestions.

lexic@alimentacioiciencia.org

Acknowledgments

The contribution made by both science and gastronomy professionals has determined the shape of *Modern Gastronomy: A to Z*. First, we would like to thank the Roca brothers and Gabriel and Maria; also Salvador Brugués, Andoni Luís Aduriz, Quique Dacosta and Carme Ruscalleda, who agreed to proofread the first drafts. Their comments were of enormous value. The revision of the English version was by Wylie Dufresne.

We received invaluable help from Fernando Sapiña, Joaquín Pérez Conesa, and Raimundo García del Moral from the scientific world. Likewise, Robert Xalabarder and Claudi Mans edited the book and helped to correct the contents. The scientific adaptation in English was done by Ramon Trujillo (University of London) and Héloise Vilaseca. Josep Maria Pinto structured and gave shape to all the contents. And finally, we would like to thank Ingrid Farré, Elena Roura, and Toni Massanés at the Fundación Alícia, as well as all the team at elBulli for making possible this idea that we nurtured for so long.

Pere Castells
Director of the Scientific Department
Fundación Alícia

Albert and Ferran Adrià
elBullitaller

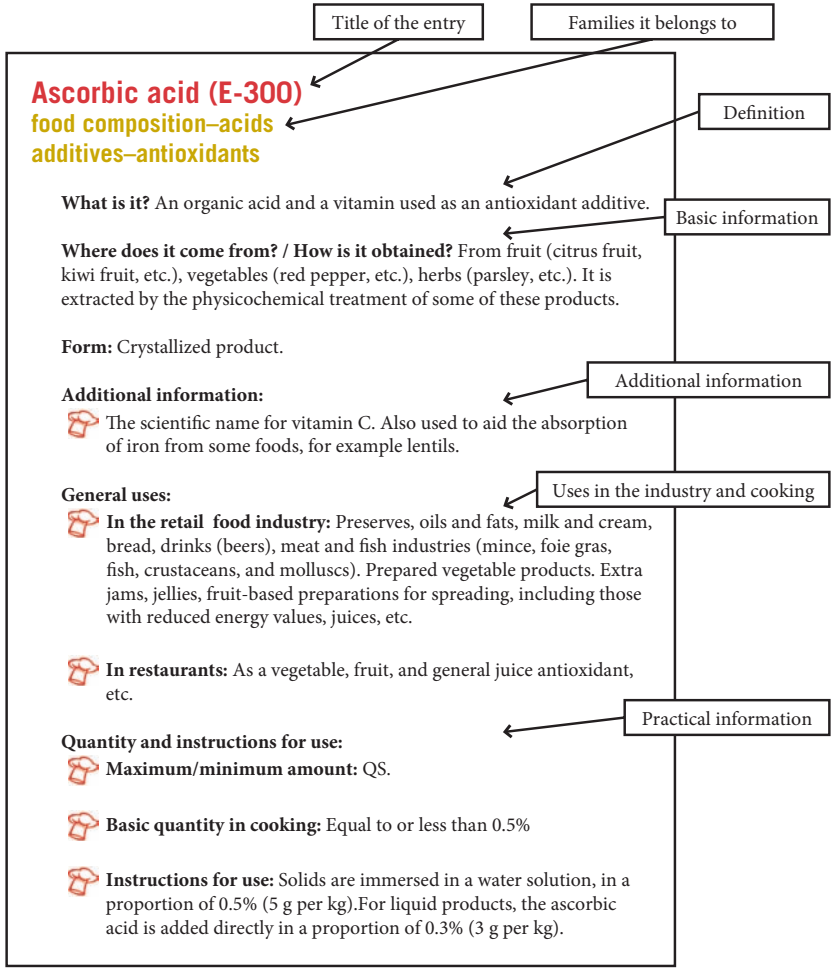
Scientific review and technical editing of the translated manuscript by

Darryl L. Holliday
Department of Food Science
Louisiana State University
Baton Rouge, Louisiana

How to Use *Modern Gastronomy*

How does *Modern Gastronomy* work?

1. As its name would suggest, the book has a lexical format with all the entries in alphabetical order.
2. A definition is given in each entry, which helps to establish each word quickly.
3. The "additional information" that accompanies the entries allows the reader to study the contents in greater depth and to understand the entry.
4. In the case of additives and other products, we offer practical suggestions for use in the food and catering industries, as well as instructions for dosage and use.
5. When it is indicated that a product is found "in experimentation," this does not mean that it is not yet used in cooking. In fact, many of these products have been used in restaurants, but we prefer not to deal with them in depth in this book until we have more information. We hope that they will be included in later editions.
6. So that each entry is situated in the right field, we have divided them into different categories (see table below). The category or family is included in small gold print just beneath the entry heading.
7. Naturally, some entries belong to more than one category. For example, acetic acid is included in the food composition—acids family, as well as in the additives—acidity regulators and additives—preservatives families.


Title of the entry
Families it belongs to
Ascorbic acid (E-300)
food composition–acids
additives–antioxidants
Definition
What is it? An organic acid and a vitamin used as an antioxidant additive.
Basic information
Where does it come from? / How is it obtained? From fruit (citrus fruit, kiwi fruit, etc.), vegetables (red pepper, etc.), herbs (parsley, etc.). It is extracted by the physicochemical treatment of some of these products.
Form: Crystallized product.
Additional information
Additional information:
The scientific name for vitamin C. Also used to aid the absorption of iron from some foods, for example lentils.
Uses in the industry and cooking
General uses:
In the retail food industry: Preserves, oils and fats, milk and cream, bread, drinks (beers), meat and fish industries (mince, foie gras, fish, crustaceans, and molluscs). Prepared vegetable products. Extra jams, jellies, fruit-based preparations for spreading, including those with reduced energy values, juices, etc.
In restaurants: As a vegetable, fruit, and general juice antioxidant, etc.
Practical information
Quantity and instructions for use:
Maximum/minimum amount: QS.
Basic quantity in cooking: Equal to or less than 0.5%
Instructions for use: Solids are immersed in a water solution, in a proportion of 0.5% (5 g per kg).For liquid products, the ascorbic acid is added directly in a proportion of 0.3% (3 g per kg).

Additives	
Antioxidants	Stabilizers
Coloring agents	Gases
Preservatives	Gelling agents
Sweeteners	Humectants
Emulsifiers	Flavor enhancers
Thickening agents	Acidity regulators
Food composition	
Acids	Lipids
Alkaloids	Minerals
Alcohols	Pigments and other compounds
Carbohydrates	Proteins
Food concepts	
Scientific concepts	
Organoleptic perceptions	
Physical or chemical processes	
Mineral products	
Technology	
Devices	Utensils

A

Acacia gum

See **Arabic gum**

Acesulfame-K (E-950)

additives—sweeteners

What is it? A potassium salt used as a sweetening additive, derived from an amide (an organic compound characterized by the presence of nitrogen).

Where does it come from? How is it obtained? Obtained by synthesis in the chemistry industry from petroleum derivatives (acetoacetamide).

Form: Powder.

Additional information:

- It is an intensive sweetener, also called potassium acesulfame or ace-K.
- Its sweetening power is some 200 times greater than sucrose (sugar).
- If stored in appropriate cold and dry conditions, it has a useful life of approximately 4 years.

General uses:

- **In the retail food industry:** Confectionery, drinks, chewing gum, jams. Sweetener for diabetics.
- **In restaurants:** Sugar-free drinks and desserts.

Acetic acid (E-260)

food composition—acids
additives—acidity regulators
additives—preservatives

What is it? An organic acid, a component of vinegar and an additive when it is used in its pure state. It is used as an acidity regulator and a preservative.

Where does it come from? How is it obtained? Produced by the fermentation of diluted alcoholic liquids, typically wine, cider or beer and other products (sake—rice wine, etc.).

Form: Liquid.

Additional information:

- It is found in a proportion of approximately 6% in vinegar. Pickling generally employs more concentrated solutions.

General uses:

- **In the retail food industry:** Vinaigrettes, sauces, cheeses, special breads, etc.
- **In restaurants:** No direct application. Used as vinegar when dissolved.

Acid

scientific concepts
organoleptic perceptions

What is it?

- **Scientifically:** A product with an organoleptic characteristic caused by its tendency to give off hydrogen ions.
- **Gastronomically:** The name given to one of the basic tastes.

Additional information:

- Acidic products have an acidity that can range from pH 0 to pH 7 (in food, from 2.5 to 7). *See* pH.

General uses:

- In cooking, the acidic taste can be accentuated by citrus fruits (citric acid), fermented products (acetic acid) or by malic acid from apples (tart tasting).

Most Frequently Used Acids in the Food Industry		
Fruit Derivatives	**Fermentation Derivatives**	**Others**
Citric acid (oranges, lemons, etc.)	Acetic acid (vinegar)	Ascorbic acid (vitamin C)
Malic acid (apples, etc.)	Butyric acid (cheeses)	Phosphoric acid (soft drinks)
Tartaric acid (grapes, etc.)	Lactic acid (yogurt)	

Acidification
physical or chemical processes

What is it? A procedure in which an acid is added to a product or a preparation.

Acidifier
food concepts

What is it? A product that increases the acidity of food and gives it an acid taste.

Additional information:

- Favorable conditions are created for some antioxidants when acidity levels are increased in a product. This has several repercussions, one of which is the delay in the loss of color in fruits and vegetables: Citric, malic, acetic, lactic acid, etc. Products with these components: lemon juice, vinegar, etc.

General uses:

- **In the retail food industry:** Citric acid, acetic acid, tartaric acid, etc. They are preservatives and enhance the taste of vegetables, sauces, jams, sorbets, ice creams, soft drinks, marinades, and acid preparations in general.
- **In restaurants:** Vinegar, lemon juice, etc. For making vinaigrettes, sauces, etc.

Acidity
scientific concepts

What is it? The indication of the acidic strength of a product.

How is it measured? Scientifically measured in pH units. The margin is from 0 to 14 for watery solutions. However, the acidity is relevant only for pH under 7. The range between 7 and 14 indicates the basicity or alkalinity of a product.

Additional information:

- Stomach acidity or heartburn is the name given to a sensation of pain in the abdomen. It is caused by excess gastric production of hydrochloric acid. It can be treated with products that neutralize this acid, such as bicarbonate.
- The following FDA definitions apply:
  (a) *Acid foods* means foods that have a natural pH of 4.6 or below.
  (b) *Acidified foods* means low-acid foods to which acid(s) or acid food(s) are added; these foods include but are not limited to beans, cucumbers, cabbage, artichokes, cauliflower, puddings, peppers, tropical fruits, and fish, singly or in any combination. They have a water activity (aw) greater than 0.85 and have a finished equilibrium pH of 4.6 or below. These foods may be called, or may purport to be, "pickles" or "pickled." Carbonated beverages, jams, jellies, preserves, acid foods (including such foods as standardized and nonstandardized food dressings and condiment sauces) that contain small amounts of low-acid food(s) and have a resultant finished equilibrium pH that does not significantly differ from that of the predominant acid or acid food, and foods that are stored, distributed, and retailed under refrigeration are excluded from the coverage of this part.
  (c) *Low-acid foods* means any foods, other than alcoholic beverages, with a finished equilibrium pH greater than 4.6 and a water activity (aw) greater than 0.85. Tomatoes and tomato products having a finished equilibrium pH less than 4.7 are not classed as low-acid foods.

General uses:

- **In the retail food industry:** Acidity is used to determine the extent of processing a food product needs, i.e., low acid foods need to be processed at a higher temperature for a longer period of time to ensure safety because the acid acts to inhibit some microbial growth.
- **In restaurants:** Acidity has a greater role in flavor than cooking.

Indication of the Acidic Strength of a Product		
Degree of Acidity	**pH**	**Examples**
Very acidic product	Less than 3.5	Lemon juice (2.5)
Acidic product	Between 3.5 and 5	Tomato juice (4.5)
Less acidic product	Between 5 and 7	Melon (6.5)
Neutral product	Equal to 7	Water
Base product	Between 8 and14	Egg white (8.9)

Additive (food)

food concepts

What is it? In the United States, *food additives* include all substances not exempted by section 201(s) of the Code of Federal Regulations, the intended use of which results or may reasonably be expected to result, directly or indirectly, either in their becoming a component of food or otherwise affecting the characteristics of food. A material used in the production of containers and packages is subject to the definition if it may reasonably be expected to become a component, or to affect the characteristics, directly or indirectly, of food packed in the container. "Affecting the characteristics of food" does not include such physical effects, as protecting contents of packages, preserving shape, and preventing moisture loss. If there is no migration of a packaging component from the package to the food, it does not become a component of the food and thus is not a food additive. A substance that does not become a component of food, but that is used, for example, in preparing an ingredient of the food to give a different flavor, texture, or other characteristic in the food, may be a food additive.

In the European Union, food additive means any substance not normally consumed as a food by itself and not normally used as a typical ingredient of the food, whether or not it has nutritive value, the intentional addition of which to food for a technological (including organoleptic) purpose in the manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food results, or may be reasonably expected to result (directly or indirectly), in it or its byproducts becoming a component of or otherwise affecting the characteristics of such foods. The term does not include contaminants or substances added to food for maintaining or improving nutritional qualities.

A substance with no nutritional value on its own that is deliberately added to a product or food preparation to ensure its preservation, to simplify or improve its preparation process, or to modify its physical or organoleptic properties.

Additional information:

- A nomenclature with an E followed by three or four numbers is assigned to additives in the European Union.
- Additives may be natural or artificial. The E nomenclature does not define this particular aspect.
- They are classified as intermediate food products.
- They have been used quite a bit in the retail food industry but not a lot in kitchens due to their rather bad reputation, except MSG.
- Every country across the globe has a list of authorized additives. In the European Union 365 have been catalogued and the industry regularly uses approximately 125.
- They are "licensed" with the letter E (for Europe) and a three- or four-digit number. When the number E-1420 is marked on a label, this does not mean there are more than 365 additives. Rather, there are many blank spaces on the list to separate the various functions.
- The following functions are the most common: preservative, antioxidant, thickening agent, emulsifier, coloring agent, etc.
- The use of additives, besides contributing to the evolution of the world of textures, is one of the key points in the dialogue between science, food, and gastronomy.

Aerosol
scientific concepts

What is it? A mixture composed of a solid or liquid included in a gas.

Additional information:

For example, the smoke produced when food is cooked over a wood-burning grill contains solid and liquid particles that fly up into the air and come into contact with the food. This gives certain characteristics to this particular cooking process.

Types of aerosol:

- **Liquid aerosol** (L/G) "Water in gas." L indicates liquid and G represents gas. Example: fog, where air disperses little drops of water.
- **Solid aerosol** (S/G) "Solid in gas." The S indicates solid and G represents gas. Example: smoke, where air disperses carbon particles or ash. Smoked foodstuffs are an example of a cooking application of solid aerosols.

The name aerosol has been used to denote the device that generates this kind of dispersion, much used in perfumes, pesticides, etc. In food it is used to disperse aromas and also as a propellant for food additives and food, i.e., pressurized nitrogen or carbon dioxide for whipped cream, or nonstick spray.

Agar-agar (E-406)

additives–gelling agents

What is it? A fibrous carbohydrate that is used as a gelling agent. It has the properties of a hydrocolloid.

Where does it come from? How is it obtained? It is extracted by physico-chemical treatments from red algae *Gelidium* and *Gracilaria*.

Form: Product in powder or in filaments (dehydrated algae).

Additional information:

- It forms thermoreversible gels. *See* Thermoreversibility.

General uses:

- **In the retail food industry:** Baking, preserved vegetable products (preserves, jellies, jams, etc.), meat derivatives, ice cream, cottage cheese, coatings for fish preserves and semi-preserves, soups, sauces, marzipans, fruit-based preparations for spreading, etc.
- **In restaurants:** Jellies. Used for the first time to obtain hot jellies in 1998. Emerging uses include desserts and "noodles."
- **Other:** It is used in science as a solid medium to cultivate microorganisms.

Quantity and instructions for use:

- **Maximum/minimum quantity:** QS (minimum needed to obtain the desired effect), except in jams or industrial derivatives where a maximum of 10g/kg is specified (separately or in total). This means that the agar may be mixed with other hydrocolloids but the total may not surpass 10 g/kg.
- **Basic quantity for cooking:** 0.2–1.5%, i.e., 0.2–1.5 g per 100 g of liquid to be jellified (2–15 g per kg).
- **Instructions for use:** It is stirred and heated to 80°C (for ease it may be heated to boiling point). Jellification begins at between 50 and 60°C and once jelled it can be served hot. The gel withstands temperatures up to 80°C. If a more consistent gel is required, the dosage should be increased, and diminished if a more fluid gel is required.

Algae

Seaweed has been a part of human nutrition for many centuries, both for consumption and for its derivative products. Of the most commonly used algae, a distinction needs to be made between those used in restaurants (as well as in domestic cooking) and those used by the retail food industry to obtain gelling and thickening agents and stabilizers. Some of these algae, such as agar-agar or the carrageenans, are mainly used in the processing industry to obtain additive products (agar-agar or the kappa, iota, and lambda carrageenans), but in some parts of the world they are used for direct consumption.

Common Algae for Direct Consumption
Brown or Phaeophyta algae • Nori (*Porphyra*) • Wakame (*Undaria*) • Kombu (*Laminaria*) • Others: Hiziki, arame, alaria, etc.
Red or Rhodophyta algae • Dulse (alga *Palmaria*) • Agar-agar (alga *Gelidium*) • Carrageen, incorrectly called Irish moss (*Chondrus*)
Blue or Cyanophyta algae (micro-algae) • Spirulina (*Spirulina*) • Sea spaghetti (*Himanthalia*)
Green or Chlorophyta algae • *Caulerpa* • Sea lettuce (*Ulva*)

Common Algae Used to Obtain Additive Products
Brown or Phaeophyta algae • Extraction of alginates: Algae that contain algine or alginate (*Ascophyllum nodosum, Laminaria digita, Fucus serratus, Macrocystis pyrifera*, etc.)
Red or Rhodophyta algae • Extraction of agar-agar. *Gelidium*, in particular *Gelidium sesquipedale* • Extraction of the kappa, iota, and lambda carrageenans. *Chondrus crispus, Gigartina radula, Euchema cottoni,* etc. • Extraction of the furcellaran-type carrageenans. *Furcellaria fastigiata*