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Opinion Document

Science for food safety and sustainable availability in conservation techniques.

I. Preservatives and antioxidants

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Presentation

The UNESCO Chair "Science and Innovation for Sustainable Development: Global Food Production and Safety", a joint effort of the TRIPTOLEMOS Foundation and the National Distance Education University (UNED), is a very suitable platform for working on sustainability from a scientific perspective and with a very specific cross-cutting focus on the world of food.

A foundational goal for both UNED and the TRIPTOLEMOS Foundation is for all outputs to be based on scientifically proven facts, especially given the universal responsibility conferred by the UNESCO Chair in question.

This opinion document, "Science for food safety and sustainable availability in conservation techniques: I. Preservatives and antioxidants" attempts to analyse from a multidisciplinary perspective the real-life issue through the joint opinions of lecturers from various universities who are members of the Foundation.

We hope that the result is a useful document because of its accuracy, always subject to updating with new scientific contributions, both in specific technical and social aspects, and usable by advocates, opinion leaders and the general reader interested in the topic. We would thus contribute to building society's trust towards the various ways in which science is working to boost food availability, crucial for future harmonious development.

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From past to present. Natural? Artificial?

Modern society is very receptive to new technologies [1]. Consumers expect and even eagerly await technological advances, such as innovations in automotive devices and new information and communication products. However, general behaviour as regards food is somewhat at odds. Most people openly declare that they prefer natural to industrial foods (often classified as artificial in certain spheres), but they also recognise that without food processing technology today's society — the world as we know it, in fact — would not be what it is.

It is a well-known and accepted fact that without the food processing industry many of the things we take for granted would not be possible, such as ensuring food supply for the planet [2], food product safety, proper nutrition, the comfort and convenience with which we now have access to all the foods for a proper diet, and the pleasure associated with food. The food processing industry is thus, of all industries in many parts of the world, including Spain, the top-performing industry in terms of turnover [3]. Spain is also one of the leaders in scientific publications of international impact on food science and technology, the scientific discipline which, along with health sciences, covers the advances being made on food issues.

Although these arguments should be given weight, they do little to dampen the intensity of the discussion around the suitability of food processing which has raged for many years [4]. The controversy is not limited to the field of processing, but also affects — and rather intensely — primary production.

Food preservation is essential to keep food safe for as long as possible. Safety is one of the features most requested by food consumers, so it is striking that very often they give greater value to the similarity of processed foods with natural foods. Minimal food processing technology thus emerged a few decades ago, based on what for many years were called "emerging conservation technologies". These processing technologies aim to change products as little as possible with regard to their natural state [5]. There is considerable research activity along these lines in Spain [6].

A significant part of the global chemical industry is engaged in manufacturing food ingredients. The "natural" claim is a widespread marketing catchphrase for both technological ingredients (preservatives, colourings, flavourings, etc.) and functional ingredients (i.e., those that enhance health benefits of food) because it attracts consumers [7]. It is all rather contradictory because even though ingredients may come from natural raw materials, they always require processing before application.

Strategies for industrial preparation of food ingredients are therefore incorporating technologies that avoid high temperatures and organic solvents. These strategies include supercritical fluid extraction and molecular distillation, often combined with enzymatic reactions in less traditional applications [8].

In short, on the one hand, to a lesser or greater extent all the foods on our table have undergone industrial processes which include mechanisation, field treatments, process treatments, etc. On the other hand, there are no "artificial foods". Currently, photosynthesis is the only source of edible organic matter for humans.

Regardless of consumers' preference for an idyllic vision of "natural" food, the use of technology cannot be circumvented. Cooking in a home kitchen is in itself a technological process that is inherent as well in many industrial processes. Technologists are responsible for boosting people's trust by convincing them that industrially processed foods can deliver optimal levels of nutritional value and safety, obviously depending on the adequacy of technologies applied. Since food technology has reached high levels of development, it can be applied rationally to provide people with quality food while generating added value in the industry and contribute to ensuring food supply to future generations, generously exceeding the negative connotations of the term "industrial". However, the collaboration of an independent body to clarify concepts is essential.

People look for "natural" food, an ambiguous term that everyone adapts to their own desires or ideals. There are, in fact, very few food scandals on record resulting from fraud or accidents considering the scale of food production and consumption. However, their immediate and constant result is to confirm the bad image of food in general and industrial-origin food in particular, especially with people already predisposed to this vision of the food world. The impact of these events in the media and society fuels the idea that to have safe and high-quality food we must use only what some understand as natural processes, obtaining foods that are designated as biological, ecological or organic. But we should define our terms. All foods are biological, since they result from processes linked to life, even if pesticides or fertilizers are used in their production. Only salt and water belong to the mineral world. In strictly scientific terms, nobody should be able to claim the exclusive use of the terms "organic" or "ecological" for their products (food), as indeed is currently the case in the European Union. That said, legislators are sometimes more sensitive to "politically correct" ideas than to scientific data and yield to pressures when supported by significant portions of society. The term "ecological", strictly speaking, is debatable when applied to foods, because the utmost respect for nature would imply obtaining them by simple gathering or collection in the wild, meaning that there would not be food for everyone in the world. A crop field, even an "ecological" one, is a smart modification of nature (and therefore the environment) to produce food. Natural biodiversity is lost in any crop field to the extent that productivity is gained. In effect, defenders of "natural", "organic" or "biological" foods have applied the criteria upheld by Lewis Carroll's Humpty Dumpty: "When I use a word it means just what I choose it to mean — neither more nor less".

Clearly, agriculture, livestock and fishing must respect the environment, focus on what sustainability is truly all about and leverage available technologies in the right measure, and this is not always the case. Moreover, consumers have a right to know how a product has been obtained and its composition. So-called ecological or biological agriculture and livestock breeding claim to ensure a socially, environmentally and financially economically sustainable productive system, using less aggressive practices than conventional methods. Promoters of these productive systems emphasise that they avoid the use of synthetic chemicals (fertilisers, pesticides, hormones and additives) used in intensive agriculture, livestock farming and the food industry. Albeit true that these products, used without control, can threaten the balance of natural ecosystems, when properly applied (always with restricted criteria), as is usually the case, they improve the quality and safety of production. The issue is to determine to what point these approaches are compatible with supplying food for all humanity.

If we compare high-quality conventional foods — for example, seasonal fresh fruit — with biological or ecological versions, differences in aroma, flavour and composition are virtually non-existent. Quite a different matter is fruit preserved in cold storage which has an appropriate nutritional value and allows us the luxury of enjoying fruit year-round at a reasonable price, but its aroma and flavour, though acceptable, are not the same as real fresh produce. What is not appropriate is to compare conventional mediocre products with the best biological or ecological products, which obviously also expose users to dangers in the event of fraud or failure.

There are not very many rigorous experimental studies that allow comparing the nutritional value and safety of conventional vs. ecological foods. Likewise, the diversity and heterogeneity of data does not make it easy to reach general conclusions. Regarding the nutritional value, as expressed by Bourn and Prescott (2002), "There is no strong evidence that organic and conventional foods differ in concentrations of various nutrients". With respect to pollutants, organic foods may have less chemical residues but more biological residues. For example, a 2011 report published by the Food Standards Agency in the UK on the presence of mycotoxins (toxins produced by microscopic fungi or mould) in cereals, flours and derivatives revealed the presence of alkaloids in ergot (a problem regarded as a thing of the past) in 12% of samples, and organic farming samples revealed the highest levels. A recent study on cheese contamination in the Canary Islands has found that in some cases the presence of contaminants was higher in organic cheeses. It is also worth noting that the use of animal manure, if not properly controlled, increases the potential risk of contamination by virulent strains of Escherichia coli. These data should not generate any widespread distrust of organic foods, but simply confirm that they are as subject to risks as conventional foods.

Nutritional data may have a relative value depending on product conditions. For example, the vitamin C content of a food is indicative of its nutritional value, its freshness and conservation status. But vitamin C is unstable and its content depends on the degree of maturation of the plant, storage conditions and other variables that affect both conventional and organic products. In short, although no significant differences can be noted and the variability range is significant, as noted, in some instances organic foods can contain somewhat less water and therefore more nutrients and other components, including for example polyphenols (antioxidants), than conventional foods (although other data indicate that's not always the case). The differences are fewer if organic food is compared with really fresh and high-quality conventional foods. It is important to underscore that the data considered, from the scientific standpoint, come from peer-reviewed journals. Much of the literature on organic agriculture and products (books, brochures and popular magazines) is subject only to the scrutiny of the author and publisher, and lack the same value as truly scientific literature, although it can also be rigorous.

For environmental and health reasons, crop production should no doubt be geared towards a controlled and minimal use of pesticide and fertiliser (the ideal would be to do without them) and that more research is needed to improve biological pest control beyond synthetic pesticides. But in this case also “the best can be the enemy of the good”. To abruptly and generally forego all current resources that ensure strong productivity would trigger higher prices and reduced food availability, to the detriment of people with less economic resources. In *Feeding the World: A Challenge for the Twenty-First Century,* Smil states: “The only way to feed 10 billion people (a plausible medium-term perspective) with the traditional farming system, based exclusively on recycling organic matter and legume rotations, would be to double — or even triple — the extent of crop land used today. This would require a complete elimination of all tropical forests, the transformation of a large part of tropical and subtropical grasses to cropland and the return of a substantial part of the workforce to agriculture... which makes this option a mere theoretical conception.” He adds: “In a world without synthetic nitrogen fertilisers, the number of inhabitants in the planet would have to be two to three billion less than the current population, depending on the quality of the diet we are willing to accept”. We must keep in mind that a preferably vegetable diet, as advocated by the guidelines for a balanced and healthy diet, allows producing food with less land than a diet overly based on animal products, which are obtained at a greater environmental cost. However, we should not forget that meat, among other things, is the best source of iron and that milk is the best source of calcium. These are foods with a positive role in our diet, when consumed with due moderation (like all foods) and as part of a varied diet. Moreover, we know that agricultural chemistry substances at authorised levels do not appear to have harmful effects on the soil or on human health. We would do well to remember that we enjoy the food that pests leave us.

An "intermediate" category between conventional and organic products is integrated production, which uses additives and other chemical agriculture resources minimally and strictly and in as controlled a manner as possible. At the end of the day, organic farmers do likewise, since the law allows them to use certain resources of this type, though they make a point not to flaunt it. A careful reading of labels, especially the small print, can be very illuminating. For example, the label of a wine clearly marked as obtained from "organic farming" in small print states that it "contains sulphites". Likewise, EU regulation on organic farming allows a limited amount of nitrates and nitrites in cured meats because otherwise a proper safety guarantees are difficult to ensure.

In short, consumption of products called organic or biological is an option for enhanced quality of life, and it is interesting to promote within its real possibilities. However, it is not available to everyone and is not sustainable for the whole planet, at least for the time being. Clearly, we need to prevent the abuse of fertilisers or pesticides or incorrect animal farming methods. However, it cannot be claimed that consumers of organic products are better nourished than those consuming conventional quality products if both follow a varied, balanced and sufficient diet. A very recent extensive review concluded that "published literature does not provide consistent evidence that organic foods are significantly more nutritious than conventional foods" and adds that "eating organic foods may reduce exposure to pesticide residues and antibiotic-resistant bacteria". We might add that the available data indicates that in Spain the average intake of pollutants from food usually does not exceed tolerable limits.

As Professor Francisco Grande Covián said, there are many right dietary choices. What is objectionable is for supporters of a particular option to become "apostles" who look down on others, and this is often the mistake of organic product defenders.

Additives — in their many forms and functions — are some of the components under the media spotlight.

***Additives** are natural or synthetic substances used in food preparation for a number of technological purposes, all of which should involve improvements and benefits for the consumer*. In particular, the European Union legislation defines them as "any substance not normally consumed as a food in itself and not normally used as a characteristic ingredient of food, whether or not it has nutritive value, the intentional addition of which to food for a technological purpose in the manufacture, processing, preparation, treatment, packaging, transport or storage of such food results, or may be reasonably expected to result, in it or its by-products becoming directly or indirectly a component of such foods".

Among other things, we have **preservatives** (for protection against microorganisms, to extend the expiration time), **sweeteners** (to sweeten foods), **colours** (to dye or enhance colour), **antioxidants** (to fight rancidity, loss of colour by oxidation), etc. and for up to a total of **26 technological functions stipulated in the legislation**. Moreover, the law establishes that additives have to serve one or more of the following purposes: preserving the nutritional quality of food; supplying the ingredients or food components for groups of consumers with special dietary requirements (regulations under amendment); improving the quality, stability and conservation of food; improving its organoleptic properties (as long as this does not mislead the consumer); aiding in the manufacture, processing, preparation, treatment, packaging, transport and storage of food, including food additives themselves, food enzymes and food flavourings; provided that the food additive is not used to mask defective raw materials or unhygienic practices.

Some additives have been used for more than 2000 years. For example, in Europe, salt and smoke to cure meat have been instrumental in improving food safety, although it is doubtful that under current safety requirements (given the long-term use and increasingly stringent safety guidelines) it could pass the authorization process for current use. This reasoning applies also to other practices considered traditional and accepted by society, whether natural or synthetic products. In general, our society is more ready to accept known risks (smoking, traffic, etc.) which, in principle, people think they can handle. Thus, despite scientific evidence indicating that a particular risk associated with a food is very low, consumers may not take it into account and choose not to accept the risk. This may be because it is a food alien to our interest; because we do not appreciate benefits when it comes to innovations; because the danger factor is artificial and not natural and we believe the difference to be relevant; because we do not trust the information source; because we believe that innovation leads to injustice or unwanted side effects or for other reasons, cultural or otherwise. It is common, for example, for an artificial substance (a pesticide, for example) to be deemed a higher risk than a natural substance or hazard factor (bacterial, for example), although scientific evidence proves otherwise. Specifically, the combination of uncertainties or inadequate communication with the lack of perception of benefits for innovation underscores the rejection of possible risks, however small.

The next chapter develops this aspect of safe use of additives, exploring the concept and information about currently used scientific and legal mechanisms.

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Collective responsibility and risk analysis. Science and transparency. Future strategies.

INTRODUCTION TO RISK ANALYSIS.

Food safety in developed societies includes everything related to the issue, beyond the certainty of food availability, a problem faced by less developed regions. In our society the stress is placed on the responsibility of establishing the best conditions, procedures and controls to ensure that the consumption of food is safe and healthy. This is carried out with criteria and mechanisms that are fairly similar in the more developed regions of the world. Internal market improvements (in the case of the European Union) and the exchange of products globally, allowing free movement of safe and healthy food products, should lead to the preservation of health and welfare for citizens and their social and economic advantage. In order for this convergence of views and interests to be increasingly a reality, some ground rules must be accepted. Scientific knowledge should be the basis for adopting criteria, decisions and policies for food safety in a context of utmost transparency, providing access to businesses, consumers, academia, all stakeholders and the public in general.

Risk analysis is the methodology underlying the development of guidelines, standards and other food safety recommendations. It is an emerging discipline that comprises three elements: risk assessment (based on scientific criteria, involving risk identification, features, mechanisms, possible alternatives, etc.); risk management (involving the weighing of alternatives mentioned in the evaluation, together with other technical, social and economic considerations, which together and transparently lead to decision-making); and coupled with transparent, rigorous and professional communication (all information should be available on the Internet, with expert summaries attached to detailed documents) at all stages of the process.

Food-related decisions in modern democratic societies should be grounded in a rationale for decisions taken, based on scientific analysis and communication or publication of all essential data, and this scheme tends to extended to other sectors.

Understanding the association between a reduction in hazards or possible hazards that may be associated with a food item, and reducing the risk of harm to consumers' health, is key in developing appropriate food safety guidelines and standards (maximum permitted levels, acceptable daily intakes, etc.). In general, we can obtain evidence on the health effects of certain foods or components thereof, under certain conditions and to a certain extent, but it is not realistic to appeal to total food safety in absolute terms. The risk manager must often make decisions without scientific assessment, extensively clarifying the danger and/or the risks involved, and they should be made taking into account the uncertainties involved in scientific evaluation. Twenty-first century managers must be aware that their decision will be valued and criticised "after the fact" once the consequences of the various possible options are already evident to all. The utmost transparency is therefore required.

Some practices and standards implemented in recent years, mainly in Europe, are very helpful in managing problems. The food safety slogan — "from the farm to the table" — is now applied reasonably and in general to all sectors and all sources of food. The food chain through which food reaches consumers is of great complexity, and safety must be guaranteed throughout, from primary production, farmers and breeders (including the production of feed for animals, and animals that could be used as feed or as food for people), processing, conservation and transport, distribution and sale of food, and ending in consumption.

Traceability — already implemented in almost all areas in the developed world — is a complex and expensive system, but it proves vital, especially in alarm conditions. Traceability allows recalling from the market anything which poses a risk to consumer health, identifying the source of materials, knowing the processes applied in each case based on raw materials and, where appropriate, allowing accurately informing the parties concerned and consumers in general and thus preventing further disturbances in case of food safety problems.

Moreover, the precautionary principle is a mechanism that allows selecting risk management measures to protect consumers' health in the event of new products, processes or circumstances for which not enough scientific information has been gathered with regard to its safety. The impression is that this principle is very attractive for politicians, especially when its application does not affect their close regional areas, and the fact is that governments tend to be increasingly cautious and conservative, based on the above principle of precaution. It is difficult to ensure proper use of the same, especially if placed in the hands of people who are not food and risk management experts because, actually, the application of this precautionary principle must also be scientifically justified.

In addition, the concept of food safety extends today to meet consumer expectations related to nutritional quality and nutritional and physiological properties of food, including new knowledge of the effects of certain foods and components on improvements of certain physiological functions, in the field of health and wellness and disease prevention, including major illnesses affecting us. Thus, the conservation of these properties throughout the shelf life of a food has already become an added objective, beyond ensuring safety in the most basic sense.

DEVELOPMENTS IN EUROPE AT THE FOREFRONT OF FOOD SAFETY.

In Europe, the January 2000 food safety report or white paper already established the steps to be followed in the new food policy in order to achieve the objective of establishing a coherent and transparent set of rules, reinforcing controls from the farm to consumers' table and, most importantly, boosting the effectiveness of the scientific advisory system (1), all to ensure a high level of health and consumer protection compatible with the single market reality and the promotion of innovation and progress. Thus, the "general law" on food which crystallised in 2002 (2) has been a major milestone in the modernisation of the European system, which is now at the forefront of the most advanced countries. The law established a comprehensive framework for coherent legislative developments both at the EU and member state levels. It also outlined general principles, requirements and procedures that support decision-making in matters of food and food safety, covering all stages — from food production to distribution. And it created the European Food Safety Authority (EFSA), an independent agency responsible for scientific advice and support for governments, an essential step forward. In addition, key procedures and instruments for acting in emergency and crisis situations were established, as well as the Rapid Alert System (RASFF) (2). The RASFF provides an effective tool for member states to exchange information on any action taken in response to significant food risks discovered, which helps all governments to act more quickly and in a coordinated manner.

The creation of the EFSA (European Food Safety Authority) in 2002 is an essential part of this process. We should not ignore that the choice of the term “Authority” (rather than Agency) is due to the fact that what precipitated changes in Europe were the food crises of the 90s and, in particular the mad cow disease and the crisis stemming from the presumable but poorly documented chances of transmission to humans, which occurred in 1996. Recovering consumer confidence became unavoidable and it was agreed — probably the most essential component of the change — to make independent and transparent scientific research the basis of food-related decisions. The separation between risk assessment processes (by EFSA) and risk management processes (by the European Commission and EU Member States) is more transparent in Europe compared with the US and other regions of Southeast Asia, New Zealand and Australia.

AN INTEGRATED APPROACH TO ENSURE FOOD SAFETY BASED ON SCIENTIFIC KNOWLEDGE.

The integrated focus on food safety in Europe and in developed countries is based on the principle that citizens have a right to know the food they eat, how they are produced, processed, packaged, labelled and marketed (3). In addition, the system should ensure a high level of protection for human health, considering that the food industry is the largest productive industry and source of employment, and that food safety should be addressed in a comprehensive manner, covering all steps in the food chain. The system should ensure close links with independent and high-quality scientific advice (EFSA objectives) and should likewise take into account both connections with EU member states and possible interactions in the international context (3) in an increasingly interconnected word. The system should be sufficiently robust and flexible to align with scientific advances and technological development, and therefore should be well connected with the scientific community and with its best experts, which is a major challenge. In practice, the key pillars are the programmes for scientific and technical safety assessment affecting all food ingredients, including additives, enzymes, flavourings (flavour and smell enhancers), assessment of novel foods, and assessment and monitoring of pollutants, residues and any other food-related components. The availability of standards and general scientific assessments for food components and processes, and the experience gained in the process and analysis of all cases is what ensures the existence of a coherent and stringent application of standards, controls and other vital developments in terms of food safety.

FOOD-RELATED BIOHAZARDS.

These hazards may include mainly bacteria, viruses, parasites and prions, which can pose serious risks to public health, such as Salmonella in poultry, Listeria monocytogenes in dairy products, meat and fish farm products; biotoxins in live molluscs; Trichinella in pigs; and bovine spongiform encephalopathy in cattle. After the food crises of the 1990s, new measures were taken to increase the level of food safety and restore consumer confidence in Europe (and later in other countries). These actions, based on very solid scientific opinions, include coordinating hygiene measures affecting all food chain operators, pathogen source monitoring programmes including specific programmes for germs such as Salmonella and others, safety and quality assessment of all kinds of food products and establishing microbiological criteria in all links of the chain, from the production site to the market, effective control of transmissible spongiform encephalopathies, etc. (4) All measures are reassessed periodically and updated based on new knowledge and data. At the same time we study potential new risks, stemming from changes such as environmental, social or procedural conditions.

CHEMICAL SAFETY OF FOOD INGREDIENTS.

Chemical safety is guaranteed with specific evaluation and monitoring programmes (5), including, on the one hand, the unintended presence of substances such as contaminants, residues, pesticides and hormones (in meat). Moreover, foods also contain substances that are intentionally added because of their important technological function in the production and distribution of food, such as additives that prolong food shelf life and colourings and flavourings that can make food more attractive. Other chemicals are used to fight diseases in farm animals and crops and should also be controlled. Materials (plastics and otherwise) in contact with food, which on the one hand are hygienic, should also be assessed and controlled to minimise possible side effects and derived residues.

With regard to the numerous chemical substances which, due to their presence in the environment, cannot be avoided as contaminants in food, food law aims to identify thresholds which exceed the balance between risks and benefits and establish measures for reducing these pollutants, based on risk analysis stemming from scientific evaluation. In some cases which, for example, affect essential food products, the programmes may only include measures for a progressive reduction in the presence of these pollutants and exposure to them, as can be the case with dioxins and PCBs in fatty products or acrylamide in carbohydrate-based products cooked at elevated temperatures.

Moreover, additives legislation is based on the principle that only additives that are explicitly authorised may be used, and in the quantities (often limited) established for various food products based on scientific assessments required to ensure food safety.

In the case of flavour and smell enhancers, the pre-existence of a large number of these compounds in the market — thousands of chemicals used but most present at very low concentrations — has required the launch of extensive risk assessment programmes, ongoing since 2003. Smoked derivatives are treated separately, since smoking is a traditional process for the conservation of certain foods (fish, meat, dairy products) which also alters the taste. Smoked product derivatives are produced by thermal degradation of wood and are used as an alternative to traditional smoking, added to many different foods to give them a "smoked" flavour (http://www.efsa.europa.eu/en/topics/topic/flavourings). Most of the products tested have been whitelisted, with defined conditions for use, but a few (basically those considered genotoxic in animal studies) have been banned from the market. Contaminant legislation is based on scientific evaluation and the principle that contaminants should be kept as low as reasonably possible by implementing best practices for production and use. More precisely, maximum levels have been set for some contaminants such as mycotoxins, heavy metals, nitrates and chlorine propanols. As far as veterinary medicine residues is concerned, scientific assessment is required before authorising their use and, where necessary, their presence in foods has been strictly limited by setting maximum permitted residue levels. In some cases, they are absolutely prohibited (which generates conflicting situations and requires practitioners to exercise caution due to the development of increasingly powerful analytical methodologies).

Legislation on materials in contact with food involves guarantees that these materials should not transfer their components to food in quantities which could affect health or change the composition, taste or texture of food.

The new Regulation on New Foods (6), effective only recently, will boost the efficiency in all matters relating to the entry of innovative foods into the European market and. For example, it will facilitate the entry of novel foods with interesting health properties. It opens new possibilities for using other, better performing food sources (including insects and parts thereof already widely consumed in other parts of the world) and will allow some control of nano materials, etc., while ensuring the highest possible standards of food safety for European consumers. In general, it also opens more possibilities for the exchange of products worldwide, providing access to the European market for products (hopefully many) which already have a long history of safe use in traditional foods in other regions of the planet.

At a global scale, each new action involving the scientific assessment of potential problems ensures higher levels of food safety, as in the case of novel foods. Until 1997 (when the Regulation on novel foods was implemented) novel foods or ingredients that were incorporated into consumers' diet were never systematically evaluated as to their safety. They were simply considered suitable based on their sensory appeal and the evidence that they provide energy and/or nutrients in the absence of signs of more or less short-term adverse effects. Similarly, previously we referred to the evaluation programme (the first ever) of thousands of flavourings, addressed both by the Joint FAO/WHO Expert Committee on Food Additives (JECFA), the EFSA and other agencies.

BEYOND TRADITIONALLY CONSIDERED RISKS.

Beyond safety, the emphasis is being placed on ensuring that the information advertised about the beneficial health effects of a given food is accurate. Until recently this was left up to the anarchic and heterogeneous measures of the various EU member states, who in general lacked enforcement rigour, as still happens in many other regions of the planet. Currently, EU rules on nutrition and health claims are established in Regulation (EC) 1924/2006 (7), probably one of the most controversial and complicated pieces of legislation adopted in the EU (even beyond the food field), and refers to voluntary declarations of functional health benefits and preventing the risk of diseases in food, provided that such benefits have passed a very rigorous evaluation. Currently only about 260 health claims have managed to pass the EFSA scientific assessment and have been authorised in the EU, accounting for approximately 10% among more 2,700 evaluations, most of which were outside the law from 14 December 2012 (8). These 260 claims are the only ones that can be used in advertising foods that meet the conditions referred to in Regulation 1924/2006. We have gone from a situation in health-food advertising in which everything was allowed except what was banned to a new situation in which food can only show the expressly permitted claims. For the time being, and facing the prospect of poor results, botanical extracts have been left outside the evaluation scope, pending some EC initiative which is expected in the coming months or years.

Provisions planned in the same Regulation are also pending stipulation, with a delay of more than six years, such as defining what "nutritional profile" food should have in order to feature health claims (Art. 4 of the Regulation stipulates that only foods with an appropriate nutritional profile may advertise health claims). This specification is being delayed due to the great impact it implies (delineation between good and bad foods?) and uncertainties in the application of property rights (analogy with patents) of data which the EFSA has considered essential to scientifically substantiate the veracity of a health claim, for example, research findings funded by a certain company, to certify a new health claim in their product. Undoubtedly, the introduction of these rights is an incentive for R&D in an industry that still invests very little in R&D. The 2002 directive on food supplements (9) addressed (in a first phase) vitamins and minerals that can be used in the preparation of supplements, but should be extended to other bioactive substances with some legislative developments which presumably may take place in connection with other issues (botanicals) which, in practice, also involve harmonisation difficulties, such as the application of the Regulation on health claims for foods to botanicals. With regard to essential nutrients and faced by the predictable tendency to increase consumption, an extensive evaluation has been undertaken aiming at determining the maximum amounts of daily intake that can be tolerated (10).

In parallel, Regulation (EC) 1169/2011 on consumer information to be provided in food (11) is worth noting. It includes rules for labelling which, in addition to making it more accessible (font size, etc.), include the obligation of providing the so-called nutritional information (energy content and six other key nutrients). Possible developments are also being considered on the use of new forms of information associated with new communication technologies.

Undoubtedly, the EU has chosen to pursue health protection at the highest level in the developed world, applied in a non-discriminatory manner, applicable to food and feed in the internal and international market. Trust has been built which must be consolidated, based primarily on respect for scientific principles, as well as in structuring and transparent functioning of risk analysis and independence of institutions.

RISK ASSESSMENT IN OTHER BODIES: FDA AND CODEX ALIMENTARIUS.

In general, agencies dealing with food safety at the global or international levels (Codex Alimentarius) and in the most developed countries, such as the FDA (Food and Drugs Administration) in the United States, follow the same criteria as those described above in Europe. This is so regardless of differences in the specific organisation of tasks, certain priorities (e.g., EFSA has prioritised flavourings more than JECFA, based on a concern for genotoxic properties), the different groupings of certain legislative materials in specific pieces of legislation or regulations. For example, in Canada the assessment of food products derived from genetically modified organisms (GMOs) is encompassed under the legislation on “novel foods” while in Europe a specific Regulation (12) applies for GMO-derived products. In the case of the FDA, the launch to market of any novel food or intentionally added substance can follow the GRAS (Generally Recognized As Safe) procedure, including what is called a GRAS self-rating, based on the opinion of a certified Panel of Experts assembled ad hoc, usually at the request of the company interested in marketing the product in question. In short, in the US any substance intentionally added to food is considered an additive and thus, in principle, its marketing is subject to a possible evaluation and approval by the FDA before it can be sold, unless the substance is generally recognised as safe among qualified experts in intended use conditions, and except in the event that said substance is excluded from the definition of food additive (for example, if it is considered a drug). The system for authorisation of novel foods or components thereof by establishing a GRAS status is thus more permissive and open than the European system, except in regard to products that blur the line between food and medicine.

In any case, the essential principle is the same: when risk analysis is applied to a given issue, scientific evaluation must serve as the basis.

CODEX ALIMENTARIUS.

The Codex Alimentarius (13) or "Food Code" was established by the FAO (the UN Food and Agriculture Organization) and WHO (World Health Organization) in 1963 to develop internationally harmonised food standards that protect the health of consumers and promote fair food trade practices. It is made up of 187 members, 186 countries and one organisation (the EU) and it involves other collaborating organisations and observers. Codex provides science-based recommendations in all areas related to food safety and food quality: food hygiene; maximum limits for food additives; pesticide residues and veterinary drugs; as well as maximum limits and codes for the prevention of chemical and microbiological contamination (13). Beyond the well-established systems in some specific regions, the Codex food safety reports are the benchmark for many countries. They are also used in settling trade disputes in the WTO (World Trade Organization, which deals with the global rules governing trade between nations). Certain expert committees like JECFA (see below) enjoy a solid reputation and a long track record. In general, as is usually the case with prestigious organisations, the Codex Alimentarius standards, guidelines, codes of practice, reports, etc. are available online (13). In addition to the Codex Commission and Executive Committee, there are various active Codex Committees which deal with general matters (additives, contaminants, hygiene, labelling, inspection and accreditation systems, nutrition and foods for special uses, analysis methods, pesticide residues, veterinary drug residues) and six regional coordinating committees. The Codex Executive Committee corresponds to the global scope of the organisation and comprises the Chair and Vice-Chair of the Commission, the regional coordinators and other seven members elected by the Commission (Codex members), each from a different geographical region.

Codex Committees are based on scientific advice provided by the committees of experts and ad hoc expert queries organised to address specific concerns.

These expert committees are autonomous entities (not part of the Codex Alimentarius Commission) that have been established by FAO and WHO to provide specialised and independent assessment to the Codex Alimentarius Commission and its subsidiary bodies, as well as to Codex member governments. Worth highlighting are the Joint FAO/WHO Expert Committee on Food Additives (JECFA), the Joint FAO/WHO Meeting on Pesticide Residues (JMPR) and the Joint FAO/WHO Expert Meetings on Microbiological Risk Assessment (JEMRA). FAO and WHO publish separate websites that post the work of these joint committees from the viewpoints of the two sponsoring organisations. The risk analysis process is critical to the scientific basis of Codex standards developed to protect the health of consumers at the international level.

FDA (US FOOD AND DRUG ADMINISTRATION).

The FDA (14) comprises the Office of the Commissioner and four directorates overseeing the core functions of the agency (Medical Products and Tobacco, Foods, Global Regulatory Operations and Policy, and Operations). The Federal Food, Drug, and Cosmetic Act has recently been amended (21 USC 301 et seq.) on issues related to food supply safety (15). The FDA uses about 50 committees and panels for gaining independent expert advice on scientific, technical and managerial aspects. The Food Advisory Committee provides advice to the Commissioner of Food and Drugs and other appropriate officials, on emerging food safety, food science, nutrition, and other food-related health issues that the FDA considers of primary importance for its food and cosmetics programs.

The Committee may be charged with reviewing and evaluating available data and making recommendations on matters such as those relating to: (1) broad scientific and technical food or cosmetic related issues; (2) the safety of new foods and food ingredients; (3) labelling of foods and cosmetics; (4) nutrient needs and nutritional adequacy; and (5) safe exposure limits for food contaminants. The Committee may also be asked to provide advice and make recommendations on ways of communicating to the public the potential risks associated with food and cosmetics.

The Committee consists of 17 standing members including the Chair. Members and the Chair are selected by the Commissioner or designee from among authorities knowledgeable in the fields of physical sciences, biological and life sciences, food science, risk assessment, nutrition, food technology, molecular biology, and other relevant scientific and technical disciplines. Of the fifteen members who vote, two are technically qualified members identified with consumer interests. In addition to the voting members, the Committee has two nonvoting members who are identified with industry interests.

ACTIVITY OF INSTITUTIONS.

Most of the work carried out by committees or experts panels deals with issues raised by administrations or by companies and other entities through administrations. Most of the EFSA's work is at the request of the European Commission, the European Parliament and Member States, and business initiatives, if any. But they also deal with initiatives from the experts themselves, particularly on emerging issues, new methodologies, etc. In general, work programmes involve annual and multi-annual planning, organised by the committees themselves in response to EC and member state priorities, including periodic review of previously evaluated issues, and seeking complementarity with programmes carried out in member states inasmuch as, increasingly, collaboration relationships are established in the joint responsibility for risk assessment and taking into account available resources.

ADDITIVES, THEIR ROLE AND SAFETY. SOME EXAMPLES OF FUTURE DEVELOPMENT TRENDS.

Additives are natural or synthetic substances used in food preparation for a number of technological purposes, all of which should involve improvements and benefits for the consumer. In particular, European Union legislation defines them as "any substance not normally consumed as a food in itself and not normally used as a characteristic ingredient of food, whether or not it has nutritive value, the intentional addition of which to food for a technological purpose in the manufacture, processing, preparation, treatment, packaging, transport or storage of such food results, or may be reasonably expected to result, in it or its by-products becoming directly or indirectly a component of such foods".

Among other things, we have preservatives (for protection against microorganisms, to extend the expiration time), sweeteners (to sweeten foods), colours (to dye or enhance colour), antioxidants (to fight rancidity, loss of colour by oxidation), etc. and up to a total of 26 technological functions stipulated in the legislation. Moreover, the law establishes that additives have to serve one or more of the following purposes: preserving the nutritional quality of food; supplying the ingredients or food components for groups of consumers with special dietary requirements; improving the quality, stability and conservation of food; improving its organoleptic properties (as long as this does not mislead the consumer); aiding in the manufacture, processing, preparation, treatment, packaging, transport and storage of food, including food additives themselves, food enzymes and food flavourings; provided that the food additive is not used to mask faulty raw materials or unhygienic practices.

Some additives have been used for more than 2000 years. Salt and smoke to cure meat have been initially instrumental in improving food safety, without the current safety requirements The safety of food additives is currently guaranteed in the European Union. While granting that zero risk does not exist, the first guarantee is that they have been scientifically evaluated by the competent scientific panels in Europe (the SCF until 2002; the EFSA as of 2003) whose rigour and caution go beyond what is considered reasonable in other developed areas of the world (see examples below). The database of additives authorised in Europe is available online (https://webgate.ec.europa.eu/sanco_foods/main/?sector=FAD), as well as EFSA reports substantiating authorisation and details thereof. The EFSA currently has a re-evaluation process under way covering all the additives authorised until now.

The EFSA, its scientific panels (mainly the ANS Panel on Food Additives and Nutrient Sources Added to Food), is responsible for assessing the safety of food additives, generally based on a dossier of information normally prepared by the manufacturer or an operator interested in the same, which should contain all relevant information (chemical/physical features of the products, by-products, waste, etc., specifications allowing identification, production/manufacturing processes, analytical methods and general methodology, reactions/interactions, effects on food, needs to be covered by its use, proposed uses, and all toxicological data). **This toxicological information** must be very thorough, following the guidelines drawn up by the EFSA, with numerous requirements for regulated studies: toxicokinetics/metabolism of the substance, chronic and sub-chronic toxicity, carcinogenicity studies, genotoxicity, reproductive and development toxicity, and in addition, depending on the characteristics of each case, other specific studies may be required. In general, if the information is considered sufficient, the EFSA Panel may conclude the assessment estimating the amount of additive that can be ingested daily for years, i.e., the level below which it may be considered that the continued use of this substance is safe for human health.

Usually, this estimate is obtained by applying a safety factor determined, for example, by dividing times 100 the dose that has been shown not to have adverse effects in experimental animals. This is the so-called **Acceptable Daily Intake** (ADI). The ADI serves as the basis to calculate the maximum permitted uses and levels of the various products. **Daily intake, even if continued over years, is considered safe if it is below the ADI.** Two examples of additives evaluated in Europe in recent years (additives based on vitamin E and LAE®), can illustrate the practice of authorisation processes in Europe and prospects towards the development of ideal and functional additives.

VITAMIN E, A FUNCTIONAL ANTIOXIDANT.

Vitamin E is the collective name for a family of chemical compounds structurally related to alpha(α)-tocopherol. Vitamin E is found in nature in eight different forms, four tocopherols (α, β, γ, δ) and four tocotrienols (α, β, γ, δ) and in the EU there are several additive forms based on vitamin E, with the corresponding numbers of the E series: E306 (tocopherol-rich extract); E307 (α-tocopherol), E308 (γ-tocopherol) and E-309 (δ-tocopherol). It is usually expressed in α-tocopherol equivalents. The mixture of tocopherols was evaluated as early as 1989 (16) by the SCF (Scientific Committee on Food, an organisation assimilated into the EFSA structure in 2002). It was authorised as an antioxidant in foods in general, as an "ad quantum satis" (right amount) additive, also authorised for the preparation of infant formulas and follow-on milk.

Internationally, the safety of tocopherols was evaluated by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) which, based on the experimental data, deemed them NOAEL (no observable adverse effect, i.e., the maximum concentration or level of a substance, found by experiment or observation, that causes no detectable adverse changes in the test organism under defined exposure conditions). This NOAEL was established at 154 mg/kg of body weight of α-tocopherol, and applying additional safety factors, an acceptable daily intake (ADI) of between 0.15 - 2 mg/kg of body weight was calculated as α-tocopherol (WHO, 1986).

Tocopherols, as well as nutrients (vitamin E) or antioxidants in food or food supplements, are also considered GRAS (Generally Recognized as Safe) for human consumption according to the FDA (17).

Interestingly, after EFSA's evaluation of the health claims of this vitamin, the following statement specific to vitamin E has been authorised (8): "Vitamin E helps protect cells against oxidative stress". The conditions of use that a food must meet in order to show this statement (and the associated generic brands) is "may be used only for foods which are at least a source of vitamin E according to the statement SOURCE OF vitamin E", i.e., involving 15% of the recommended vitamin E recommended daily intake (12 mg), i.e., 1.6 mg.

Oxidative stress is an imbalance that occurs when there is an excess of oxidants that exceeds the capacity of our body to counter or repair the damage they produce. Thus, claims or general health benefit statements derived or specifically associated with vitamin E may extend to this area, depending on the benefit communication strategy adopted. It is therefore an additive that, in addition to its technological function, contributes beneficial functional health properties for foods.

LAE®, A PRESERVATIVE THAT GENERATES NATURAL COMPOUNDS AND NUTRIENTS USUALLY FOUND IN OUR METABOLISM.

LAE® (synonyms are Ethyl lauroyl arginate, Lauroyl ethyl arginate, lauramide arginine ethyl ester, ergo the acronym LAE®), is a substance that also illustrates what additives can be expected to be like in the future, while also showing the long path from primary scientific knowledge to its application. It should be noted that one of the major developments in additives, perhaps the main development in the past 25 years, has involved a Spanish company associated with an initial patent of the CSIC (Spanish National Research Council, Spain). For many years, the development of new food preservatives has been limited by the difficulties involved in finding appropriate molecules or ingredients, featuring safety, effectiveness, and biological plausibility in their mode of action that would offer improved characteristics, especially for their normal metabolic assimilation by our body, with respect to the preservatives commonly used for years.

These difficulties had not been addressed successfully, even though there was a pervading recognition that the range of preservatives currently available in food could, in some cases, be insufficient to cover the needs in today's society, that the levels of use of these preservatives could be close to the borders of what can be considered acceptable and, moreover, its effectiveness is recognised as very low in certain conditions of use. All this reinforced the need to discover new conservation strategies applicable to food, specifically new and improved preservatives that also had to meet the most stringent safety guarantees.

Thus, the development of LAE® is at the forefront of a new strategy of preservatives whose effectiveness is extensive in a variety of conditions and whose well-proven safety can be presumed or appear biologically plausible from the start. Since it is a lipoamino-type product, similar in structure to substances in the human body it therefore decomposes in our body into components or nutrients already in common foods (amino acid arginine, lauric acid and ethanol), as shown by experimental animal and human studies, and according to findings of the EFSA (18, 19) and the relevant JECFA (20) scientific panel. Following an investigation of nearly 20 years, the use of LAE® as food has been authorised first in the US in 2005 without any questioning regarding its GRAS status notification (recognition of safety), for use as an antimicrobial at concentrations of up to 200 mg/kg in the various categories of specified foods.

In 2007, in Europe it also received a favourable scientific evaluation that facilitates its application to initial uses, based on an ADI (acceptable daily intake) of 0.5 mg per kg of body weight. As far as its first application proposed in Europe for certain meat products, the relevant EFSA Panel has favourably reported that its consumption falls within the IDA range for both the general population and for different population subgroups (18).

In Mexico, it was included in the list of additives in 2006 and 2009. Australia and New Zealand approved its use in different food matrices. Other countries where it can also be used are Chile and Colombia. In addition to Europe, other countries listed, Israel and Turkey, it has been evaluated by JECFA (20) and is already registered in CODEX (INS 243) for numerous applications, given that the ADI (acceptable daily intake) established by JECFA in 2009 (up to 4 mg/kg of body weight daily or 240 mg for a 60 kg person) is 9 times greater than initially approved by EFSA in 2007.

This additive can therefore be used with an assurance of safety, not only based on toxicological tests and other mandatory trials but also on the biological plausibility of its safety which can be inferred from the natural characteristics of products it breaks down into during the digestive process and in the metabolism in the short term. Future research could focus on possible functional properties, probably based on the health benefits of L-Arginine (semi-essential amino acid) or other products derived from the combination.

TRENDS IN FUTURE DEVELOPMENTS.

The above examples provide relevant signposts for future developments in the field of food additives and ingredients — what we might call the field of functional bio-additives. These are products that exist or that only result in naturally occurring compounds in our body, and in recommended quantities, so they boast optimal biological plausibility in terms of safety. Moreover, if it can be shown that in the recommended intake dose they may promote additional health benefits, they may be certified for specific health claims.

They also reflect the importance of supporting R&D and business/institutional innovation efforts. Worth noting are the recent legislative developments in Europe to protect investments for obtaining new knowledge, in addition to the patents that may exist, focusing both on the development of new foods or food ingredients (6) and the case of certifying foods or ingredients with specific health claim statements (7).

In both cases an exclusivity period of five years is established for authorisations where the scientific and technical information obtained by the applicant has been instrumental in obtaining a favourable report from EFSA required for authorisation, which is a very clear boost to research and development of safe and healthy ingredients.

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Semiquantitative evaluation of the effect of preservatives and antioxidants on durability.

Assessing the effects, from a general perspective, of the presence of specific components in the durability of processed food products is a two-fold challenge. On the one hand, it requires being able to integrate products and conditions, and on the other transmit the semiquantitative (not legal) vision we wish to give the proposal.

Durability is affected by specific factors — raw materials, their status, the technological process, development, packaging and transport and storage conditions — in a process similar to fatigue in materials science, and the Company has developed a legal system to protect citizens from all of this. This protective legislative system governs the use of components that increase durability, such as preservatives and antioxidants, stipulating specifications and use rates.

This overall study selected the following six large groups from the world of food production, possible targets for the use of preservatives and antioxidants:

1.Meat products

2. Processed fish

3. Non-alcoholic beverages (except

water)

4. Grated cheese

5. Refrigerated (vegetables, prepared dishes, etc.)

6. Edible fats and oils (including margarine)

The study explored the legal possibility of incorporating preservatives in these food groups, such as sorbic acid and sorbates (E200, E202, E203), benzoic acid and benzoates (E210, E212, E213), propionic acid and its salts (E280, E281, E282, E283) and sodium lauryl arginate ethyl (E243). In antioxidants, ascorbic acid and its salts (E300, E301, E302, E304) and the four tocopherols (E306, E307, E308, E309).

The criterion for this selection was to only consider the ingredients (preservatives and antioxidants) that meet the expectations detailed by Professor A. Palou in the previous point about the specification and features of future preservatives and antioxidants.

Taking into account the complex world of products within the six group classifications and the variety of packaging and environmental conditions, Table I provides a minimum estimate of shelf life for each group with and without the presence of preservatives and antioxidants for each group. The idea is not to determine or provide data on the shelf life of foods (which is stipulated legally by the manufacturer, at any rate) comprised in the various groups, but to establish a semi-quantitative assessment of the impact on increased shelf life resulting from the additives mentioned.

Table II, following the same approach and consistent with the above table, shows the estimated gap of time between manufacturing, distribution and the person’s home (pantry or refrigerator). To determine the period between manufacturing and distribution, the study accepted the agreement between producers and distributors on the maximum fraction of product shelf life that will be accepted at the time of delivery from the manufacturer to the distributor (1/3).

Table I

Estimated minimum shelf life (*)
(assessment of possible impact due to incorporating preservatives and antioxidants)

Product type	Shelf life without preservatives or antioxidants (months)	Shelf life with preservative and antioxidant protection (months)	Increased life (months)
Meat products	0.10	0.30	0.20®
Processed fish	0.09	0.29	0.20®
Non-alcoholic drinks (except water)	1.00	6.00	5.00
Grated cheese	0.24	1.00	0.76®
Refrigerated	0.20	0.60	0.40®
Edible oils and fats (incl. margarines)	3.00	12.00	9.00

(*) Actual figures depend on the composition of the product, manufacturing process the packaging and retail conditions.

® Refrigeration conditions

Table II

Estimated storage time from manufacture to home (in months)

Type of product	Manufacturing + Distribution	Home	Total
Meat products	0.07	0.15	0.22®
Processed fish	0.06	0.14	0.20®
Non-alcoholic beverages (except water)	1.98	1.00	2.98
Grated cheese	0.23	0.35	0.58®
Refrigerated	0.12	0.25	0.37®
Edible fats and oils (including margarine)	4.00	2.00	6.00

(*) approx. 1/3 estimated life

® Refrigerated storage

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Economic approach to increased availability

1. Introduction

The purpose of this chapter is to establish an economic approach to increasing food availability — or seen from a more current standpoint, to reduce waste — thanks to the effect of preservatives and antioxidants along the food chain.

Six food groups have been chosen according to the legal possibility of incorporating certain types of preservatives and antioxidants, all subject to rigorous scientific parameters and regulated by relevant legislation concerning their safety and conditions of use[1]:

- Group 1 - Meat products
- Group 2 - Processed fish
- Group 3 - Non-alcoholic beverages
- Group 4 - Grated cheese
- Group 5 - Prepared food
- Group 6 - Edible oils and fats

The territorial areas chosen have been the European Union (EU28) and the United States of America (USA). There are basically three reasons for this choice: the size of these markets (both economically and demographically), the availability and reliability of their official statistical databases and the scientific reliability of their food legislation and corresponding implementation. The time period to consider covers five years, from 2010 to 2014.

2. Data collection process

2.1. Statistical data sources and their limitations

The source of statistical data was Eurostat (European Commission) for EU28 [2] and the United States Census Bureau (U. S. Department of Commerce) for the USA[3].

The original intention was to work with sales volume data for each of the six food groups. However, this has not been possible for the USA, because the United States Census Bureau only provides monetary information and no volume information. Due to this disparity, the decision was made to work with units (thousands of kilograms and litres) in EU28 and currency units (thousands of dollars) in USA. This decision did not distort the final aim of the study because it allowed us to economically evaluate the increase in food availability due to the use of preservatives and antioxidants. The only difference is that for EU28 results are presented in physical units and for USA in monetary units.

[1] See rationale in the chapter on "Collective responsibility and risk analysis: Science and transparency. Future strategies" by Professor Andreu Palou and the chapter on "Semi-quantitative forecast of the effect of preservatives and antioxidants in technical durability" by Professor Josep Mestres.
[2] http://ec.europa.eu/eurostat (Eurostat home page).
[3] http://www.census.gov/ (United States Census Bureau home page).

A second difficulty stems from differing levels of detail in the information provided by Eurostat and United States Census Bureau data. Eurostat classifies economic activities since 2008 through the so-called NACE Rev. 2[4] which establishes the list currently known as PRODCOM 2013[5]. This list includes 384 different items to classify food and beverages. The United States Census Bureau, however, uses a list of economic activities called NAICS (the latest version is NAICS 2012)[6] that only provides 86 items for the same products. This has required a greater number of estimates in USA outcomes to determine the values for the six food groups chosen.

A third problem arose given the absence, in EU28 and USA, of specific statistics for the grated cheese food group. However, it has been possible to pinpoint the proportion of grated cheeses with regard to the total value of cheese imports and exports in Spain[7], so the 2010 percentage (6.8%) was taken as a benchmark for estimating the values for this group.

A final difficulty stems from the change made in 2012 from NAICS 2007 to NAICS 2012, which resulted in 2012 data not being published. These have had to be estimated from 2011 and 2013 data, taking into account GDP growth in the USA from 2011 to 2012 and from 2012 to 2013.

The PRODCOM and NAICS codes to be included or excluded in each of the six food groups described were selected by a team of experts from the Triptolemos Foundation, coordinated by Dr. Yvonne Colomer.

Eurostat provides Prodcom Annual Data since 1995 in Microsoft Excel[8] format, which makes it very convenient to work with the various values. Since Eurostat revises and updates its databases frequently, below we list the update dates for the tables used in this study:

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[4] http://ec.europa.eu/eurostat/web/nace-rev2 (Eurostat page for NACE Rev. 2 - Statistical Classification of Economic Activities).

[5] www.ine.es/en/daco/daco42/encindpr/lista_**prodcom**_en.pdf (pdf file of the PRODCOM 2013 list downloadable from the National Statistics Institute website).

[6] http://www.census.gov/econ/isp/ (NAICS 2012 United States Census Bureau home page).

[7] http://www.idepa.es/sites/web/idepaweb/productos/flashsectorial/Sector_Lacteo/Sector_Espania/quesos.jsp?menu=8 (Economic Development Institute of the Principality of Asturias-IDEPA, Development of foreign trade of cheese and curd, prepared by Alimarket with ICEX information).

[8] http://ec.europa.eu/eurostat/web/prodcom/data/excel-files-nace-rev.2 (Eurostat page containing annual production data based on NACE Rev. 2 since 1995).

- 2010 Food and Beverages (sold volume): updated 12/12/2014
- 2011 Food and Beverages (sold volume): updated 12/12/2014
- 2012 Food and Beverages (sold volume): updated 16/04/2015
- 2013 Food and Beverages (sold volume): updated 16/04/2015
- 2014 Food and Beverages (sold volume): updated 12/01/2016

United States Census Bureau provides statistical data on production since 2004 and also offers the possibility of downloading the data in Microsoft Excel[9] format. In contrast with Eurostat, it does not provide information on the update dates for their databases, so below we provide the dates on which we accessed the tables used in this study:

- 2010 Annual Survey of Manufactures NAICS 31-33: 09/02/2016
- 2011 Annual Survey of Manufactures NAICS 31-33: 09/02/2016
- 2012 Annual Survey of Manufactures NAICS 31-33: Not available
- 2013 Annual Survey of Manufactures NAICS 31-33: 09/02/2016
- 2014 Annual Survey of Manufactures NAICS 31-33: 09/02/2016

As already mentioned, the data provided by United States Census Bureau on US industry include no physical data on purchases, production or sales (units, litres, kilograms, etc.). They only report on financial data.

The tables provide two economic variables related to sales: Total value of shipments and Receipts for services ($1,000) and Value of primary and secondary product shipments and Receipts for services made in industry ($1,000). Both variables exclude taxes and freight. The second of these two variables was chosen for being deemed closest to the sales value of products produced, given that the first includes miscellaneous revenue such as income from installations and repairs by third parties, the sale of scrap metal and the sale of unprocessed products bought and sold, whereas the second variable excludes them.

2.2. Association of PRODCOM 2013 (EU28) codes to the Group 1 - Meat products food group

Description	Code
Fresh or chilled cuts, of beef and veal	10111190
Fresh or chilled hams, shoulders and cuts thereof with bone in, of pig meat (including fresh meat packed with salt as a temporary preservative)	10111250
Fresh or chilled pig meat (including fresh meat packed with salt as a temporary preservative; excluding carcases and half-carcases, hams, shoulders and cuts thereof with bone in)	10111290
Meat of goats, fresh or chilled	10111400
Meat of horses and other equines, fresh or chilled	10111500

[9] http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ASM_2014_31GS101&prodType=table (United States Census Bureau - American Fact Finder website containing food industry production data, NAICS: 31-33, since 2004).

Edible offal of bovine animals, swine, sheep, goats, horses and other equines, fresh or chilled	10112000
Fresh or chilled whole chickens	10121010
Fresh or chilled whole turkeys	10121020
Fresh or chilled whole geese, ducks and guinea fowls	10121030
Fresh or chilled fatty livers of geese and ducks	10121040
Fresh or chilled cuts of chicken	10121050
Fresh or chilled cuts of turkey	10121060
Fresh or chilled cuts of geese, ducks and guinea fowls	10121070
Fresh or chilled poultry offal (excluding fatty livers of geese and ducks)	10124020
Hams, shoulders and cuts thereof with bone in, of swine, salted, in brine, dried or smoked	10131120
Bellies and cuts thereof of swine, salted, in brine, dried or smoked	10131150
Pig meat salted, in brine, dried or smoked (including bacon, 3/4 sides/middles, fore-ends, loins and cuts thereof; excluding hams, shoulders and cuts thereof with bone in, bellies and cuts thereof)	10131180
Beef and veal salted, in brine, dried or smoked	10131200
Meat salted, in brine, dried or smoked; edible flours and meals of meat or meat offal (excluding pig meat, beef and veal salted, in brine, dried or smoked)	10131300
Liver sausages and similar products and food preparations based thereon (excluding prepared meals and dishes)	10131430
Sausages and similar products of meat, offal or blood and food preparations based thereon (excluding liver sausages and prepared meals and dishes)	10131460
Prepared or preserved goose or duck liver (excluding sausages and prepared meals and dishes)	10131505
Prepared or preserved liver of other animals (excluding sausages and prepared meals and dishes)	10131515
Prepared or preserved meat or offal of turkeys (excluding sausages, preparations of liver and prepared meals and dishes)	10131525
Other prepared or preserved poultry meat (excluding sausages, preparations of liver and prepared meals and dishes)	10131535
Prepared or preserved meat of swine: hams and cuts thereof (excluding prepared meals and dishes)	10131545
Prepared or preserved meat of swine: shoulders and cuts thereof, of swine (excluding prepared meals and dishes)	10131555
Prepared or preserved meat, offal and mixtures of domestic swine, including mixtures, containing < 40 % meat or offal of any kind and fats of any kind (excluding sausages and similar products, homogenised preparations, preparations of liver and prepared meals and dishes)	10131565
Other prepared or preserved meat, offal and mixtures of swine, including mixtures (excluding sausages and similar products, homogenised preparations, preparations of liver and prepared meals and dishes)	10131575
Prepared or preserved meat or offal of bovine animals (excluding sausages and similar products, homogenised preparations, preparations of liver and prepared meals and dishes)	10131585
Other prepared or preserved meat or offal, including blood (excluding sausages and similar products, homogenised preparations, preparations of liver and prepared meals and dishes)	10131595

Group 2 - Processed fish

Description	Code
Fresh or chilled fish fillets and other fish meat without bones	10201100
Fresh or chilled fish livers and roes	10201200
Fish fillets, dried, salted or in brine, but not smoked	10202100
Flours, meals and pellets of fish, fit for human consumption; fish livers and roes, dried, smoked, salted or in brine	10202200
Dried fish, whether or not salted; fish, salted but not dried; fish in brine (excluding fillets, smoked, heads, tails and maws)	10202350
Smoked Pacific, Atlantic and Danube salmon (including fillets, excluding heads, tails and maws)	10202425
Smoked herrings (including fillets, excluding heads, tails and maws)	10202455
Smoked fish (excluding herrings, Pacific, Atlantic and Danube salmon), including fillets, excluding head, tails and maws	10202485
Prepared or preserved salmon, whole or in pieces (excluding minced products and prepared meals and dishes)	10202510
Prepared or preserved herrings, whole or in pieces (excluding minced products and prepared meals and dishes)	10202520
Prepared or preserved sardines, sardinella, brisling and sprats, whole or in pieces (excluding minced products and prepared meals and dishes)	10202530
Prepared or preserved tuna, skipjack and Atlantic bonito, whole or in pieces (excluding minced products and prepared meals and dishes)	10202540
Prepared or preserved mackerel, whole or in pieces (excluding minced products and prepared meals and dishes)	10202550
Prepared or preserved anchovies, whole or in pieces (excluding minced products and prepared meals and dishes)	10202560
Fish fillets in batter or breadcrumbs including fish fingers (excluding prepared meals and dishes)	10202570
Other fish, prepared or preserved, whole or in pieces (excluding minced products and prepared meals and dishes)	10202580
Prepared or preserved fish (excluding whole or in pieces and prepared meals and dishes)	10202590
Caviar (sturgeon roe)	10202630
Caviar substitutes	10202660
Prepared or preserved crustaceans, molluscs and other aquatic invertebrates (excluding chilled, frozen, dried, salted or in brine, crustaceans, in shell, cooked by steaming or boiling) (excluding prepared meals and dishes)	10203400
Fish heads, tails and maws, other edible fish offal: dried, salted or in brine, smoked	10204250

Group 3 - Non-alcoholic beverages

Description	Code
Tomato juice	10321100
Unconcentrated orange juice (excluding frozen)	10321220
Orange juice n.e.c.	10321230
Grape fruit juice	10321300

Pineapple juice	10321400
Grape juice (including grape must)	10321500
Apple juice	10321600
Mixtures of fruit and vegetable juices	10321700
Unconcentrated juice of any single citrus fruit (excluding orange and grapefruit)	10321910
Unconcentrated juice of any single fruit or vegetable, not fermented and not containing added spirit (excluding orange, grapefruit, pineapple, tomato, grape and apple juices)	10321920
Other fruit and vegetable juices n.e.c.	10321930
Non-alcoholic beer and beer containing ≤ 0.5% alcohol	11051010
Waters, with added sugar, other sweetening matter or flavoured, i.e. soft drinks (including mineral and aerated)	11071930
Non-alcoholic beverages not containing milk fat (excluding sweetened or unsweetened mineral, aerated or flavoured waters)	11071950
Non-alcoholic beverages containing milk fat	11071970

Group 4 - Grated Cheese

As explained in the previous section, given the absence of specific data relating to sales of grated cheeses, sales of this category are estimated as 6.8%, the sum of the following products:

Description	**Code**
Unripened or uncured cheese (fresh cheese) (including whey cheese and curd)	10514030
Grated, powdered, blue-veined and other non-processed cheese (excluding fresh cheese, whey cheese and curd)	10514050
Processed cheese (excluding grated or powdered)	10514070

Group 5 - Prepared food

Description	**Code**
Prepared meals and dishes based on meat, meat offal or blood	10851100
Prepared meals and dishes based on fish, crustaceans and molluscs	10851200
Prepared meals and dishes based on vegetables	10851300
Cooked or uncooked pasta stuffed with meat, fish, cheese or other substances in any proportion	10851410
Other prepared dishes and meals (including frozen pizza)	10851900

Group 6 - Edible oils and fats

Description	**Code**
Lard and other pig fat; rendered	10115060
Fats of bovine animals; sheep or goats; raw or rendered	10115070
Fats of poultry	10123000
Lard stearin, lard oil, oleostearin, oleo-oil and tallow oil (excluding emulsified, mixed or otherwise prepared)	10411100
Fats and oils and their fractions of fish or marine mammals (excluding chemically modified)	10411200

Other animal fats and oils and their fractions (excluding chemically modified)	10411900
Crude soya-bean oil and its fractions (excluding chemically modified)	10412100
Crude groundnut oil and its fractions (excluding chemically modified)	10412200
Virgin olive oil and its fractions (excluding chemically modified)	10412310
Oils and their fractions obtained solely from olives, crude (including those blended with virgin olive oil, refined) (excluding virgin olive oil and chemically modified oils)	10412330
Crude sunflower-seed and safflower oil and their fractions (excluding chemically modified)	10412400
Crude cotton-seed oil and its fractions (excluding chemically modified)	10412500
Crude rape, colza or mustard oil and their fractions (excluding chemically modified)	10412600
Crude palm oil and its fractions (excluding chemically modified)	10412700
Crude coconut (copra) oil and its fractions (excluding chemically modified)	10412800
Other vegetable oils, crude (excluding chemically modified oils)	10412900
Cotton linters	10413000
Oilcake and other solid residues resulting from the extraction of soya-bean oil	10414130
Oilcake and other solid residues resulting from the extraction of sunflower seed fats or oils	10414150
Oilcake and other solid residues resulting from the extraction of rape or colza seed fats or oils	10414170
Oilcake and other solid residues from extraction of vegetable fats/oils (including cotton seeds, linseed, coconut, copra, palm nuts or kernels; excluding soya beans, sunflower, rape or colza seeds)	10414190
Flours and meals of oil seeds or oleaginous fruits (excluding of mustard)	10414200
Refined soya-bean oil and its fractions (excluding chemically modified)	10415100
Refined groundnut oil and its fractions (excluding chemically modified)	10415200
Refined olive oil and its fractions (excluding chemically modified)	10415310
Oils and their fractions obtained solely from olives (including those blended with virgin olive oil, refined) (excluding crude oils, virgin olive oil and chemically modified oils)	10415330
Refined sunflower-seed and safflower oil and their fractions (excluding chemically modified)	10415400
Refined cotton-seed oil and its fractions (excluding chemically modified)	10415500
Refined rape, colza or mustard oil and their fractions (excluding chemically modified)	10415600
Refined palm oil and its fractions (excluding chemically modified)	10415700
Refined coconut (copra) oil and its fractions (excluding chemically modified)	10415800
Other oils and their fractions, refined but not chemically modified; fixed vegetable fats and other vegetable oils (except maize oil) and their fractions n.e.c. refined but not chemically modified	10415900
Animal fats and oils and their fractions partly or wholly hydrogenated, inter-esterified, re-esterified or elaidinised, but not further prepared (including refined)	10416030
Vegetable fats and oils and their fractions partly or wholly hydrogenated, inter-esterified, re-esterified or elaidinised, but not further prepared (including refined)	10416050
Margarine and reduced and low fat spreads (excluding liquid margarine)	10421030
Other edible preparations of fats and oils, including liquid margarine	10421050
Butter of a fat content by weight ≤ 85 %	10513030
Butter of a fat content by weight > 85 % and other fats and oils derived from milk (excluding dairy spreads of a fat content by weight < 80 %)	10513050
Dairy spreads of a fat content by weight < 80 %	10513070

2.3. Association of NAICS 2012 (USA) codes to food groups

Below are described the NAICS codes associated with the various food groups, as well as comments regarding the variables that have had to be taken into account.

Group 1 - Meat products

Description	Code
Animal (except poultry) slaughtering	311611
Meat processed from carcasses	311612
Rendering and meat by product processing	311613
Poultry processing	311615

Group 2 - Processed fish

Description	Code
Seafood product preparation and packaging	311710

Group 3 - Non-alcoholic beverages

NAICS 2007 codes (2010 and 2011) only offer the *Soft drink and ice manufacturing* aggregate, which includes water and ice cream. Consequently, the study has had to estimate the value of soft drink sales in 2010 and 2011 based on the percentages for the years 2013 and 2014.

Description	Code
Soft drink manufacturing	312111

Group 4 - Grated Cheese

As in the EU28, given the absence of specific data relating to sales of grated cheeses in the USA, sales of this category are estimated as 6.8% of the sum of values in the following category:

Description	Code
Cheese manufacturing	311513

Group 5 - Prepared food

NAICS 2007 codes only offer the aggregate *Fruit and vegetable canning, pickling, and drying*, which includes dried and dehydrated foods. Figures for this group have had to be estimated for excluding them from 2010 and 2011 figures based on the percentages for years 2013 and 2014.

Description	Code
Fruit and vegetable canning	311421
Specialty canning	311422

Group 6 - Edible oils and fats

NAICS 2007 codes do not separate fluid milk and butter manufacturing. In addition, 2014 published statistics do not show separate sales data for butter. An estimate of the sales figure for butter has been made for 2010, 2011 and 2014 based on percentages from 2013.

Statistics for 2010 do not offer figures for soybean and other oilseed processing. These have been estimated based on 2011 percentages.

Description	Code
Soybean and other oilseed processing	311224
Fats and oils refining and blending	311225
Creamery butter manufacturing	311512

3. Results

3.1. EU28 sales in volume for the period 2010-2014

The sales by volume figures in the 2010-2014 period for each of the food groups selected are presented below. All variables are stated in thousands of kilograms, except for the non-alcoholic beverages group, expressed in thousands of litres.

Table 4.1: EU28 sales in volume for the period 2010-2014

Description	Unit	2010	2011	2012	2013	2014
Group 1 - Meat products	000 kg	41,091,805	42,798,229	42,665,598	43,990,579	44,650,613
Group 2 - Processed fish	000 kg	2,660,471	2,639,852	5,567,137	5,546,420	2,749,009
Group 3 - Non-alcoholic beverages	000 l	65,872,285	62,844,264	63,315,532	63,498,558	65,277,310
Group 4 - Grated cheese	000 kg	542,099	688,694	679,438	678,758	685,600
Group 5 - Prepared food	000 kg	5,043,272	4,948,195	5,040,867	5,062,915	5,220,264
Group 6 - Edible oils and fats	000 kg	62,489,717	59,717,235	61,284,424	58,506,756	66,730,084

Source: Eurostat and compiled by the authors

3.2. USA sales in value for the period 2010-2014

The following tables shows sales by value in the 2010-2014 period for each of the food groups selected are presented below. As already explained, data for 2012 which are not available due to the change made that year from NAICS 2007 to NAICS 2012 have been estimated taking into account the United States GDP growth from 2011 to 2012 and from 2012 to 2013. All variables are expressed in thousands of dollars.

Table 4.2: USA sales in value for the period 2010-2014

Description	Unit	2010	2011	2012 (est.)	2013	2014
Group 1 - Meat products	$000	173,033,024	192,617,279	198,379,996	203,499,737	219,147,483
Group 2 - Processed fish	$000	9,682,008	10,152,286	10,516,320	10,849,933	11,850,406
Group 3 - Non-alcoholic beverages	$000	34,020,936	35,510,306	36,741,055	37,862,752	34,821,257
Group 4 - Grated cheese	$000	2,380,030	2,737,685	2,829,982	2,913,716	3,348,497
Group 5 - Prepared food	$000	49,666,292	51,352,900	53,870,099	56,290,018	56,758,064
Group 6 - Edible oils and fats	$000	43,551,056	50,105,683	52,833,671	55,626,448	52,595,019

Source: United States Census Bureau and compiled by the authors

3.3. Evaluation of the increase in food use due to the use of preservatives and antioxidants

Once the sales data for the 2010-2014 period are obtained for each of the six food groups in the EU28 and in the USA, we can calculate the increase in food use thanks to the use of preservatives and antioxidants that prolong their useful life. For this we need an estimate of the increase in the useful time of each of the groups studied and an estimate of the time elapsed between food production and consumption in people's homes.

These estimates have been taken from the chapter of this study, "Semi-quantitative evaluation of the effect of preservatives and antioxidants in technical durability", authored by Dr. Josep Mestres, Professor of Quality Management and Food Security (Escola Superior d'Agricultura in Barcelona - Universitat Politècnica de Catalunya). The following table summarises these estimates.

Table 4.3: Estimate of the increase of useful life for food and of the time elapsed until consumption

Description	Months of life without preservative	Months of life with preservative	Month of consump	% Use without preservatives	% Use with preservatives	Increase
Group 1 - Meat products	0.10	0.30	0.22	45.5%	100.0%	54.5%
Group 2 - Processed fish	0.09	0.29	0.20	45.0%	100.0%	55.0%
Group 3 - Non-alcoholic	1.00	6.00	2.98	33.6%	100.0%	66.4%
Group 4 - Grated cheese	0.24	1.00	0.58	41.4%	100.0%	58.6%
Group 5 - Prepared food	0.20	0.60	0.37	54.1%	100.0%	45.9%
Group 6 - Edible oils and fats	3.00	12.00	6.00	50.0%	100.0%	50.0%

Source: Josep Mestres, "Semi-quantitative evaluation of the effect of preservatives and antioxidants in technical durability" in the present work and compiled by the authors

It is important to note that in this table the percentage of food use with preservatives and antioxidants is in all cases 100%, since, as can be observed, the months of life of the food incorporating these products exceeds in all cases the average months it will take to be consumed. In contrast, without preservatives and antioxidants, more than half of the food would spoil before being consumed.

Increase of food availability in the EU28

Taking the "% of use without preservatives and antioxidants" column as a reference, we can calculate in Table 4.4 the volume of food that would be usable and compare the results with the volume sold. The difference yields the estimate of total increase in availability thanks to the use of preservatives and antioxidants. For the entire five-year period considered, this increase in availability (assimilating 1 litre of drink to one kilogram) exceeds 500 million tons of food.

A clearer way of visualising the magnitude of these figures is to calculate the per capita increases for the 2010-2014 period. Eurostat provides population estimates on 1 January each year. The EU28 average for the period considered is 505,369,785 inhabitants. This allows us to calculate the values in Table 4.5, revealing that the possible increase in food availability (or waste reduction) exceeds two hundred kilograms of food per person, per year.

Table 4.4: Estimate of food availability in EU28

Description	Unit	2010-2014	% Use without preservatives	Foods that can be used without preservatives 2010-	Total increase
Group 1 - Meat products	000 kg	215,196,823	45.5%	97,816,738	117,380,085
Group 2 - Processed fish	000 kg	19,162,889	45.0%	8,623,300	10,539,589
Group 3 - Non-alcoholic beverages	000 l	320,807,950	33.6%	107,653,674	213,154,275
Group 4 - Grated cheese	000 kg	3,274,588	41.4%	1,355,002	1,919,586
Group 5 - Prepared food	000 kg	25,315,513	54.1%	13,684,061	11,631,452
Group 6 - Edible oils and fats	000 kg	308,728,216	50.0%	154,364,108	154,364,108

Source: Compiled by the authors

Table 4.5: Estimate of food availability per capita in EU28

Description	Unit	Per capita increase 2010-2014	Annual per capita increase
Group 1 - Meat products	Kg	232.3	46.5
Group 2 - Processed fish	Kg	20.9	4.2
Group 3 - Non-alcoholic beverages	l	421.8	84.4
Group 4 - Grated cheese	Kg	3,8	0.8
Group 5 - Prepared food	Kg	23.0	4.6
Group 6 - Edible oils and fats	Kg	305.4	61.1
Total		**1,007.2**	**201.4**

Source: Compiled by the authors

Increase in food availability in the USA

In the case of the USA, since the variables are expressed in thousands of dollars, using the same procedure we arrive at the estimate of total increase in availability thanks to the use of preservatives and antioxidants. For the entire five-year period considered, this possible increase in availability is close to 950 billion dollars of food.

Table 4.6: Estimate of food availability in the USA

Description	Unit	2010-2014	% Use without preservatives	Foods that can be used without preservatives 2010-	Total increase
Group 1 - Meat products	$000	986,677,519	45.5%	448,489,781	538,187,738
Group 2 - Processed fish	$000	53,050,953	45.0%	23,872,929	29,178,024
Group 3 - Non-alcoholic beverages	$000	178,956,306	33.6%	60,052,452	118,903,854
Group 4 - Grated cheese	$000	14,209,910	41.4%	5,879,963	8,329,947
Group 5 - Prepared food	$000	267,937,372	54.1%	144,831,012	123,106,360
Group 6 - Edible oils and fats	$000	254,711,876	50.0%	127,355,938	127,355,938

Source: Compiled by the authors

As we have done for the EU28, we can also visualise these figures by calculating the per capita increases for the 2010-2014 period. The United States Census Bureau publishes population estimates as of 1 July each year. The average for the period considered is 314,107,071 inhabitants. The data shown in Table 4.7 show that the increase in food availability (or waste reduction) in the USA exceeds six hundred dollars per person per year.

Table 4.7: Estimate of food availability per capita in the USA

Description	Unit	Per capita increase 2010-2014	Annual per capita increase
Group 1 - Meat products	$	1,713.4	342.7
Group 2 - Processed fish	$	92.9	18.6
Group 3 - Non-alcoholic beverages	$	378.5	75.7
Group 4 - Grated cheese	$	26.5	5.3
Group 5 - Prepared food	$	391.9	78.4
Group 6 - Edible oils and fats	$	405.5	81.1
Total		**3,008.7**	**601.7**

Source: Compiled by the authors

4. Summary

The purpose of this chapter is to establish an economic approach to increasing food availability — or seen from a more current standpoint, to reduce waste — thanks to the effect of using preservatives and antioxidants along the food chain.

The territorial areas chosen have been the European Union (EU28) and the United States of America (USA). The time period to consider covers five years, from 2010 to 2014. Six food groups have been chosen according to the legal possibility of incorporating certain types of preservatives and antioxidants[10]: meat products, processed fish, non-alcoholic beverages (except water), grated cheeses, prepared foods and edible oils and fats.

The minimum estimates of the shelf life of these food groups, as well as storage time between manufacturing and consumption at home, come from one of the chapters of this document[11].

For reasons of statistical availability, data for the EU28 are expressed in physical units (thousands of kilograms and litres), whereas USA data are expressed in monetary units (thousands of dollars).

The final results of this economic approach, based on legal use and estimated storage and consumption times, allow us to determine the quantity of food that is not be wasted thanks to the use of preservatives and antioxidants in the EU28 at around 200 kilograms per person and year — a little more than half a kilogram a day. In the USA, the savings per person, per year stands at $600, little more than a dollar and a half daily, which represents a volume similar to the EU28 when translated to quantities.

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[10] See rationale in chapter "Semi-quantitative forecast of the effect of preservatives and antioxidants in technical durability", by Professor José Mestres.

[11] Tables I and II in chapter "Semi-quantitative forecast of the effect of preservatives and antioxidants in technical durability", by Professor José Mestres.

Science's difficult message on food issues.

The magic of words and conditioning factors in culinary choices in the early twenty-first century.

The witty acronym invented by Fischler (1995, 201), UFO (Unidentified Food Object) summarises well the problems we face in the early twenty-first century from not knowing what exactly is on our plates. Westerners are supposedly the most informed consumers in history, and yet we are seduced by the magic of words and the symbolic aura of product names, brands and label elements. In the past, the way food was produced and prepared conveyed closeness, knowledge and emotional attachment. Consumers knew the producers, products and culinary processes. People knew the lands where agricultural products grew, they knew where the animals whose meat they ate grazed, they even got to know — on a first-name basis — the farmers and ranchers who provided them with food as producers or as sellers in the market. And what's more, we also knew the hands that cooked those foods — a loved one, a family member or at the very least someone from our immediate circle. This knowledge was the basis our culinary confidence and emotion. We needed no marketing enhancements to make food appealing. Dish names were generally descriptive (soup, stew, beans, etc.) but even if they were metaphorical (toad in the hole, bubble and squeak...) the weight of tradition behind a name and recipe was a sufficient mark of its quality, safety and flavour — what we humans expect from our culinary experiences.

However, the changes brought about by the food industry (as a consequence of the radical displacement from the countryside to the city and the demographic boom) led to a clear alignment, a gap between food producers, preparers and consumers, the birth of gastro-anomie (in Fischer's own terminology) in contrast with the gastronomy represented by the previous order. The rift was not only geographical but also sentimental.

New foodstuffs that started arriving from factories or from unknown farms (UFOs) cause mixed feelings. Some feelings are positive, no doubt, such as those that have to do with the idea of modernity — with the connotations of healthiness and associated durability — or the taste for experimentation and novelty. But the situation also bred negative feelings associated with uncertainty and suspicion. Modern diners ask themselves several basic questions that condition their access to new products: How have they been produced? What unknown objects have come in contact with the food we are about to consume? What hands have stewed, packaged, transported the food on our table? What "artificial" ingredients do the new recipes include? What components distort their colour, texture, taste and durability?

Faced by this situation which affects the majority of modern consumers, at least the majority of Westerners, how can we inspire trust and emotional empathy? How can we safely and comfortably eat modern food? We know that the emotion elicited by a food or dish results from many factors that have to do with personal and social consumption circumstances, with sensory attributes such as colour, smell, taste and even sound — all of which can be given a positive or negative twist by cultural factors. And the role of culture in choosing or rejecting a food based on religious and moral values and the class, gender or ethnic position of the diners is likewise self-evident. We are well aware that all these elements make a dish look and taste better or worse. But there is one more circumstance that has not been studied properly and is linked with empathy in industrialised consumption processes or in the introduction of novel products. This circumstance has to do with the symbolic power of the name of the food or the descriptive semantics of the product on the label, the name of the food or the dish, the names of ingredients or additives, the words that define or descriptively enhance the food or dish. Choosing a name is no trivial matter and, as with the names of people and things, the name of a food or a product range is its cover letter.

What is new and unknown must be named and identified. Giving it a name, a brand and a label is the first step in making the food attractive and tasty. Thus, if a new product is launched under a successful brand, the battle for new diners' approval is half won. A brand that lasts over time — a name with a history behind it that gains increasing prestige — can become a symbol of quality. A single product name acquires magical power and smoothes all obstacles to the consumer's acceptance.

We know that the symbolic value of the brand inspires trust. Brands that survive and engage consumers emotionally over a period of time somehow replace, in the collective mind, the local farmers, the mothers and grandmothers who prepared meals. This knowledge of the brand's allure makes many new products try to enter the market using this magic of words, also seeking to eliminate or dwarf the common names — which pack very little emotional punch — on product labels. The importance of this magic among Western consumers in the twenty-first century proves contradictory.

The attractive or reflective magic of a name (brand, specific product, accessories, etc.) is linked to cultural contexts and fads. In the West we are witnessing a swerve towards naturalisation in our culture. It seems that being more natural is our way of recovering that lost mother, those allegedly unpolluted, pristine products of our past. “Natural” products are magically imbued with a field of meaning that includes everything wholesome, nutritious and complete. By naturalising a name we feel we can escape the ghosts inherited from the industrial framework. Natural vs. Artificial, Healthy vs. Poison; Complete in itself vs. Needing additives. These are three dichotomies which most often influence how we select products in the current market. In the span of a few decades we have seen how products are launched (and succeed) with prefixes or suffixes such as -plus, vita- (or vital), mega-, nutri-, sani, natur-, pur- and sometimes compounds like nutriplus, complevita, etc. Sometimes, rather than prefixes, marketers deploy adjectives like “local”, “organic”, “handmade” — words that fascinate us and arouse our obsessions — as the metonymy of paradise lost, our return to our mother. Whoever names a new jam as “Old Factory Handcrafted Jam” may know a lot about jams, but certainly knows a lot about sociology too. In this context, the emergence of “craft” beers is not surprising, or the whole arsenal of catchwords such as “original”, “homemade food”, “Grandma's kitchen”, “Grandma’s-style” canned goods, etc. What is rather puzzling is that we are well aware of the deception and yet allow ourselves to be hoodwinked.

In such a scenario, it’s no wonder that food industry chemistry is not well-regarded, associated as it is with the other side of the dichotomy — Artifice and Poison. To make matters worse, additives appear on the label with laboratory names unenhanced by the social warm-and-fuzzy name factory. What emotional engagement can we expect from additives that start with E-? Obviously not much. We know that behind many E- ingredients there are no hidden cancer germs, impotence triggers or lurking capitalist evils, but the chemophobia permeating our society also points to a widening gap between the laboratory and society. In Spain, the Permanent Chemistry and Society Forum seems to have noticed this divergence process. They published a booklet titled *Chemistry and Food* that begins with a striking proposal: “What would you do if you were offered the following menu? First course: Denatured proteins, polypeptides, amino acids, polysaccharides, cellulose, cholesterol, and linoleic, propionic and oleic acids. Second course: Proteins with isoleucine, leucine, lysine, methionine, iron, phosphorus, magnesium, zinc, niacin and riboflavin. Dessert: Lactose, casein, lactalbumin, calcium, phosphorus and also malic acid, polysaccharides, amyl and formic esters and acetaldehyde.” As the book suggests, and readers will agree, we would look the other way ... without knowing that we are rejecting something that our cultural history has named differently: scrambled eggs with cheese, onions and tomatoes, a veal fillet, and for dessert a glass of milk and an apple.

The prospects do seem rather dim. Western consumers are subjected to two radically opposing advertising pressures that are more disorienting than ever. One message comes from a soul-less industry that ignores the planet, our cultural history and a sense of taste. The other comes from an equally detrimental glorification of nature. The true revolution for the contemporary consumer is to access detailed, accurate information worlds away from insidious marketing and obnoxious propaganda. This informed knowledge leads to true freedom of choice.

Prof. Julián López García
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Collective considerations.

In the effort to establish structured visions of complex subjects, as Professor E. Souto points out in the presentation of this document, the UNESCO Chair has chosen a complex subject open to debate and has attempted to give a scientifically sound view of the coherence between sustainability and technological development in food production.

We are grateful to professors Joan Carles Gil, Julián López, Abel Mariné, Josep Mestres, Andreu Palou and Guillermo Reglero who have contributed their expertise in the field at hand and have developed the issue in a way that combines scientific rigour with serious social outreach and dissemination on a subject that people are sensitive about. They have also been careful to apply their expertise in the framework of the food system. Professors Mariné, Reglero and López are involved in knowledge areas (academics, behaviour, culture), while professors Palou, Mestres and Gil develop the more technical areas of availability, economics and policies. Each of these areas exists in its own right, but we cannot determine if the food system operates properly or deficiently unless we are able to interpret the interrelationships between them, just as health cannot be accurately assessed based on exclusive knowledge of one organ without knowing the interactions with the rest.

Based on a reading of the authors' conclusions, open to all readers' interpretations and new scientific advances, four areas can be underscored for collective consideration.

- Natural is not synonymous with safe. For millennia, nature has been manufacturing potent toxins. The opposite is also true: processed (wrongly called colloquially "artificial") does not necessarily mean risky.

- Just like many areas of our lives, our food safety is in the hands of experimental science. Let us trust in its rigour — increasingly more demanding — and in ongoing advances. Food safety is an objective and measurable concept. Its advances demand a new interpretive culture. Nowadays we enjoy highly accurate analytical and measurement techniques. Social awareness of the concept of ADI (Admissible Daily Intake) of any chemical substance we ingest is essential to obtain people's confidence in science and in producers or processors.

- Food resources tend to be scarce. The use of preservatives (microbial growth inhibitors) and antioxidants (fat oxidation inhibitors) significantly increases actual availability by substantially decreasing food spoilage and consequently their waste.

Agri-food raw materials are perishable and seasonal. Humanity's development has been possible thanks to the assurance of food supply. The coordination between Professors Mestres and Gil has made it possible to quantify this intuition validly in efforts to increase availability and obtain better economic results.

- The future is aimed at obtaining additives formed by molecules with components already existing in human biochemical systems and therefore not extraneous, which in turn may have functional activity. Thus, what we understand today as additives will not only contribute to sustainability but will also positively affect health. The story of LAE® is a good example of science-business collaboration. Based on an initial CSIC patent (Spain), Laboratorios MIRET/LAMIRSA/VEDEQSA, focused on producing food ingredients, undertook further research and developed a new-generation preservative, already accepted by the EU, the USA and multiple administrations, which anticipates these future requirements.

Like any analysis document, it is developed on the basis of scientific knowledge and the functional organisation of this knowledge in society. One of the missions of the Triptolemos Foundation and the UNESCO Chair "Science and Innovation for Sustainable Development: Global Food Production and Safety" is to build links and generate evidence-based information so that opinion leaders and any concerned citizen can have access to independent, objectified and proven sources offering various perspectives of the complexity of the Global Food System to facilitate their informed criteria. This is one of our objectives.

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