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for Public
Policy

Sustainable and Healthy Nutrition

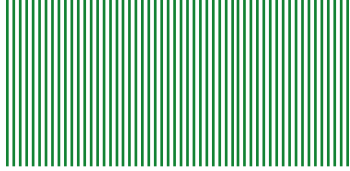
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Report



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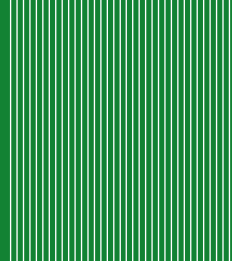
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The CSIC's functions include informing, assisting and advising public and private entities on science and technology, as stated in article 5 of its Articles of Association. Undertaking this task, we present the report on *Sustainable and Healthy Nutrition*, from the Science for Public Policy series, as a document targeting public administrations and society in general. This issue explains the challenge of establishing globally responsible nutrition and food consumption, working to reduce the risk of malnutrition, aggravated by environmental and geopolitical crises and the consequent inflation and food shortages. Lastly, we present some of the organisation's most important lines of research and innovation aiming to solve the challenges posed.

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Malnutrition and Undernutrition



FOOD is one of the most basic needs of any human being. The function of food is to supply the body with the nutrients and energy necessary for proper physiological and biochemical functions. Since nutrients provide what is necessary for the proper functional development of the individual, food is intrinsically related to the maintenance of health. But the scope of food's influence is much broader, and scientific evidence today has demonstrated the specific relationship of food components to beneficial effects on both human and community health. In addition, food must be safe, free from toxic substances or pathogenic micro-organisms and their toxins, which could harm consumers.

The right to adequate food is recognised in various instruments of international law and appeals to the legitimacy of having continuous access to resources to produce, obtain or be able to buy sufficient food, not only to prevent hunger but also to ensure health and well-being. In article 11 of the **International Covenant on Economic, Social and Cultural Rights** (adopted by the United Nations General Assembly on 16 December 1966), member states recognise the need to guarantee “the fundamental right of everyone to be free from hunger and malnutrition”.



The right to food is recognised in various instruments of international law. There are means to obtain food for everyone / iStock

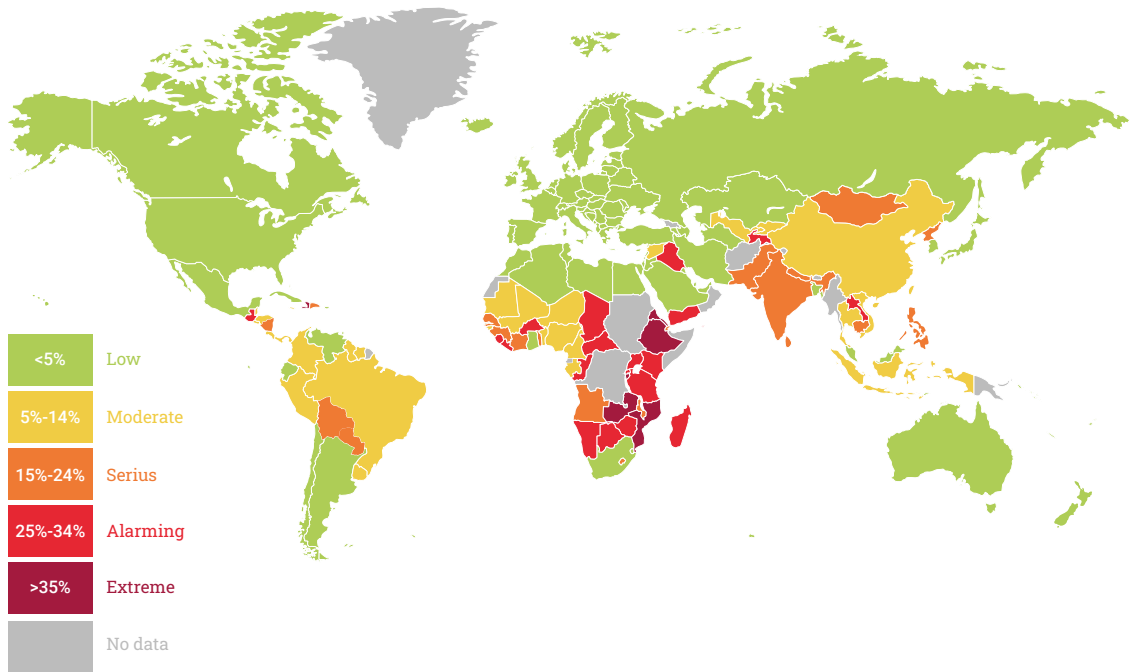


Article 11 of the International Covenant on Economic, Social and Cultural Rights:

1. The States Parties to the present Covenant recognize the right of everyone to an adequate standard of living for him/herself and his/her family, including adequate food, clothing and housing, and to the continuous improvement of living conditions. The States Parties will take appropriate steps to ensure the realization of this right, recognizing to this effect the essential importance of international co-operation based on free consent.
2. The States Parties to the present Covenant, recognizing the fundamental right of everyone to be free from hunger, shall take, individually and through international cooperation, the measures, including specific programmes, which are needed:
 - a. To improve methods of food production, conservation and distribution by making full use of technical and scientific knowledge, by disseminating knowledge of the principles of nutrition and by developing or reforming agrarian systems in such a way as to achieve the most efficient development and utilization of natural resources;
 - b. To ensure an equitable distribution of world food supplies in relation to need, taking into account the problems of both food-importing and food-exporting countries.

Although hunger is often associated with malnutrition in all its forms, it is essential to understand the context and possible solutions in each case. **Malnutrition** refers to the condition that results from an unbalanced diet in which certain nutrients are lacking, have excess nutrients (through over-consumption) or are not consumed in the correct proportions. A malnourished individual may even overeat, but does not eat enough healthy foods. **Undernutrition** is a form of malnutrition in which there is a deficient food intake and not all the necessary nutrients

Figure 1.1 Percentage of the population suffering from undernutrition.



HUNGER MAP 2013

(macro- and micro-nutrients) are consumed. Thus, **malnutrition, understood as a lack, excess or deficiency in calorie and nutrient intake**, affects not only poor countries, but also developed countries. Malnutrition harms the world's population far beyond the widely disseminated impact of word hunger. It has profound consequences on people's health and well-being, on their physical and cognitive development, and on their livelihoods. In addition, all its forms of severe social, economic and health impacts are transmitted from one generation to the next.



Crop shrivelled up by drought. / ISTOCK

The 2030 Agenda of the United Nations' Food and Agriculture Organization (FAO), in its Sustainable Development Goal (SDG) number 2, zero hunger, aims to end *hunger*, ensure food for all and improve nutrition. Currently, the international goals of ensuring healthy and nutritious food for all are far from being met. No country is exempt from this failure. Malnutrition is spreading around the world, obesity is increasing in almost all countries, while undernutrition persists in the poorest locations. The malnutrition study in the *Global Nutrition Report*, funded by public and philanthropic organisations around the world, shows that at least 57 of the 129 countries surveyed have high levels of undernutrition (especially stunting and anaemia) as well as obesity and overweight in adults.

The international community must act more proactively and effectively if we are to end malnutrition by 2030. Today, the global food system faces a number of challenges that have a direct impact on people's access to food and nutrition, which en-



Undernutrition: a lack of calories or one or more essential nutrients.

Malnutrition: a lack or excess of certain nutrients, having negative impacts on health and development.

Food security: when all people have access to sufficient, safe and nutritious food at all times.

Food poverty: a situation that does not allow for sufficient, safe and healthy food.

Food inequity: lack of food stocks that respond to nutritional needs, diversity, culture and food preferences.

sure their health and well-being. The rapid advance of climate change, the degradation of ecosystems and the overexploitation of natural resources have an impact on the reduction of resources on which food production depends. Increasing risks associated with disasters such as droughts and floods have a significant influence on food resources. These factors have been analysed in depth in the report *Producing food without depleting the planet* in this Science for Public Policy series. In addition, one-third of all global agricultural production is wasted, there is a highly unequal distribution of food, and the number of people suffering from hunger (measured by the prevalence of undernutrition) has increased slowly again in recent years, despite the steadily increasing farm yields. Current estimates indicate that 8.9% of the world's population suffers from hunger. If recent trends continue, the number of people affected by this crisis will exceed 840 million by 2030.

11.

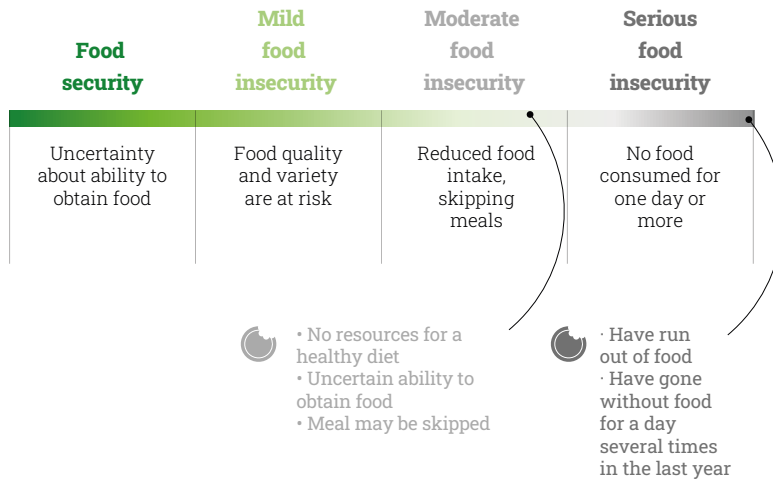
Food insecurity

LINKED to the definition of malnutrition is the term food insecurity. According to the FAO, it is the state suffered by people who are unable to maintain a healthy life due to inadequate dietary intake. Therefore, **food security** exists when people have social, physical and economic access to sufficient, safe and nutritious food at all times.

Food insecurity is endemic in many parts of the world. The main causes are scarcity of water resources, soil degradation, armed conflicts resulting from both, and numerous zoonotic and infectious diseases. We cannot forget the global consequences of the pandemic caused by the SARS-Cov-2 (COVID-19) coronavirus. Although infectious diseases caused by pathogens, epidemics and pandemics are not transmitted through food, they are a major cause of food insecurity, both in terms of their direct impact and the measures required to reduce their transmission. Since the pandemic, food insecurity in Spain has reached 13.3%; this represents 2.5 million households and more than 6 million people. Households most susceptible to food insecurity are located in urban slums and in areas dependent on mono-crops for export, and have medium and lower-middle socio-economic levels. The UN notes that the food security of the most vulnerable population is at serious risk of further deterioration.

The adoption of sustainable production models is essential to eradicate hunger and all forms of malnutrition, as well as to ensure food security. However, obtaining quality, healthy, safe and nutrient-rich food is a very complex challenge, which must take into account not only the steady population growth, but also current environmental, socio-economic and political issues.

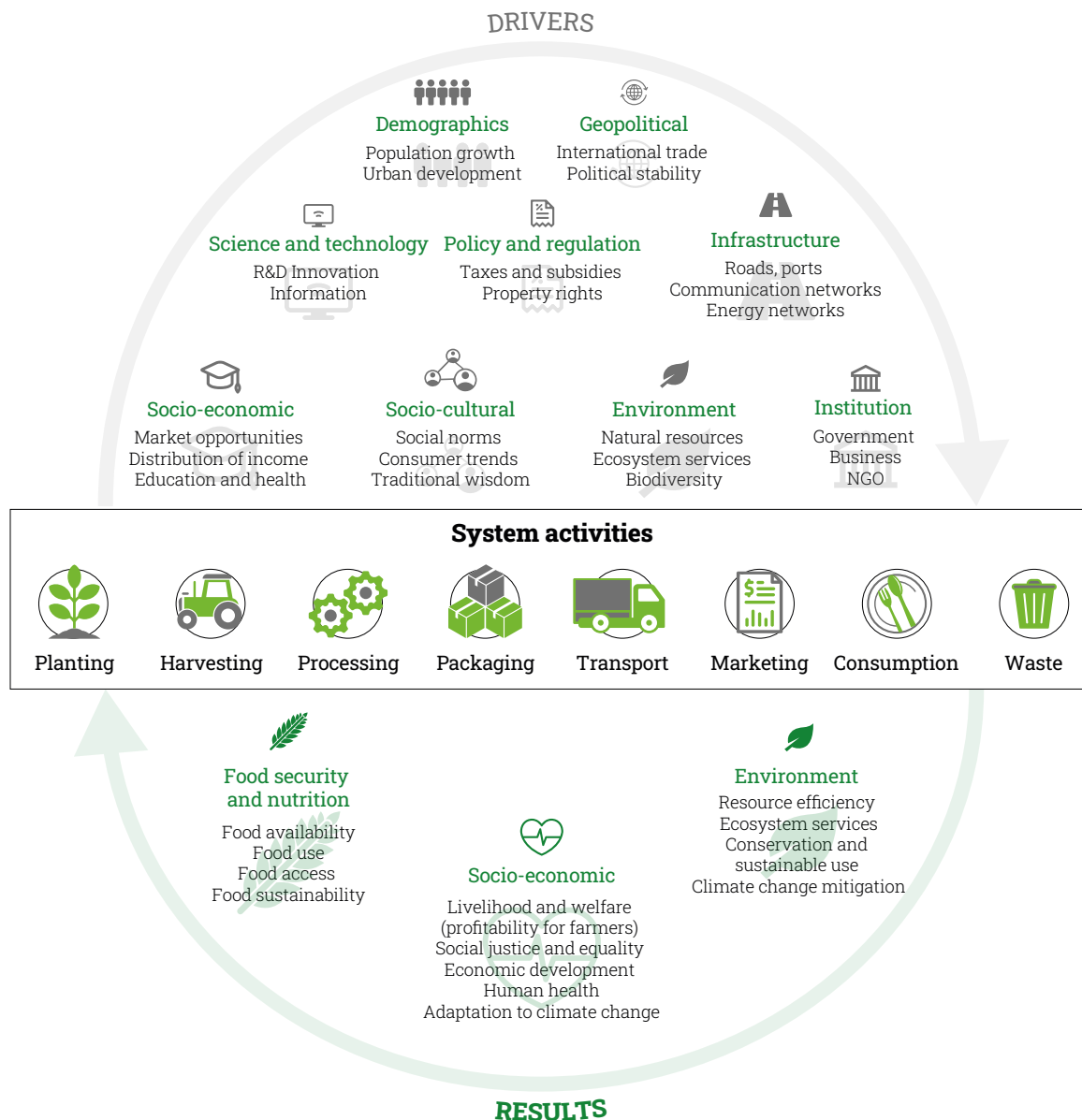
The COVID-19 pandemic and the current war in Ukraine have demonstrated the great importance of food supply chain functioning, and the need to make supply chains more resilient to emergencies and crises such as pandemics, climate change and geopolitical forces.

Figure 1.2 Food insecurity

As a result of the combination of these geopolitical, social, structural and climatic factors, the population is currently immersed in a pressing and unprecedented crisis in the food sector. Over the past year, consumer food prices have risen at the highest rate in decades. Globally, the year-on-year inflation rate for food, beverages and tobacco reached 13.8% in December 2022 in the euro area and 14.7% in Spain, measured in terms of the Harmonised Index of Consumer Prices (HICP), which combines and compares the national indices of European Union (EU) countries.

These figures exceed those recorded in the 2008 crisis, when the inflation rate closed at 1.4%, with a year-on-year growth in food prices of 1.6%.

Figure 1.3 How to improve the food supply chain?





The rise in prices has a direct impact on the risk of malnutrition, which is associated with not having enough food and limited access to healthy and sustainable food. It also reduces consumption of other goods and services, especially for lower-income households. Many families who cannot afford to pay the higher prices of fruit, vegetables, fish and fresh meat choose to buy cheaper but less healthy products. Spending on food is more frequent than other types of expenditure and, as a result, food price developments have a greater impact on consumer inflation and are a determining factor for monetary policy. All this combines social and economic imbalance with the risk of malnutrition, known as **food inequity** or **inequality**. This is because people in a situation of social vulnerability often live and eat unhealthily.



Rising prices have an impact on the risk of malnutrition. / iStock

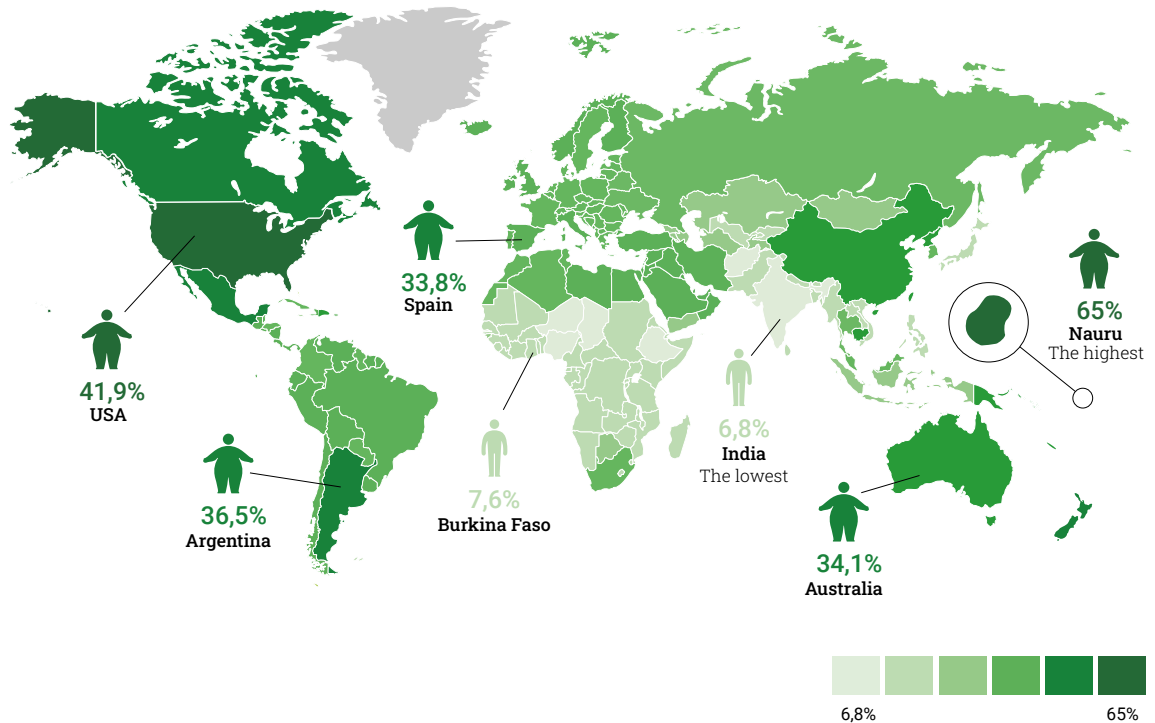
12.

Why we need to change our eating habits: diet-based diseases

UNDERNUTRITION coexists with overweight, obesity and other diet-related non-communicable diseases (NCDs), even in poor countries. In this respect, in 2020 the United Nations Children's Fund (UNICEF) reported that 37% of overweight children live in the developing world, in low and middle-income countries.

Among children, nutrient-poor diets and diseases that hinder the absorption of vitamins and minerals are responsible for one in three child deaths worldwide. The main nutrition objectives for pre-school and school-age children are aimed at ensuring growth and development in line with physical activity. Healthy dietary habits are also promoted to prevent the development of chronic nutritional diseases (atherosclerosis, hypertension, osteoporosis, constipation, diabetes) in the short and long term. However, overweight and obesity have become one of the most pressing problems in the pre-school and primary school population. Both phenomena (overweight and obesity and food insecurity) are closely linked and both are associated with the precarious socio-economic situation.

For the elderly, there is a whole range of ageing-related problems affecting the digestive tract, leading to problems of mastication, dysphagia, malabsorption or constipation, as well as sensory and sensory changes affecting taste, smell and sight. But their diet is also influenced by socio-economic aspects, such as social isolation and loneliness, low purchasing power and functional and mental impairment associated with eating disorders or depression. The underlying illnesses, medication and the risk of drug-nutrient interactions, together with hospitalisations, are determining factors in this group. It is therefore crucial to monitor their nutritional status.

Figure 1.4 Percentage of children and adolescents aged 5-19 years who are overweight

UNICEF 2016

There is a growing consensus that the intake of certain types of nutrients, specific food groups or general dietary patterns have a positive or negative influence on health. Scientific evidence shows that diet can play a role in the prevention of cardiovascular and chronic respiratory diseases, cancer, diabetes, obesity and cognitive impairment. These are among the leading causes of death and disability worldwide and affect people in both developed and developing countries. In the EU alone, these diseases account for more than 90% of all deaths and 85% of the entire disease burden. Each year they cause the premature death of more than 550,000 people aged 25-64. And they account for an annual expenditure of around €700 billion from health budgets.

To a large extent, many non-communicable diseases are preventable. Indeed, it is recognised that the food system has a broad and clearly modifiable impact on the burden of these diseases, including through its contribution to climate change, air pollution, occupational hazards and exposure to chemicals that can be harmful to health. In addition to these factors, an unhealthy diet is a major risk factor for the incidence of NCDs. For example, certain dietary choices are responsible for about half of cardiovascular diseases, which is the leading cause of premature mortality in Europe. These diet-related diseases, including the outstanding global increase in overweight and obesity (which in Europe affects almost 60% of adults and almost one in three children), have been causally linked to excessive consumption of processed foods that are high in saturated fats, sugars and salt, i.e. foods that are high in calories and low in nutritional quality. Currently, no country is on track to curb the rise of NCDs.

In order to achieve healthy lives through food, it is crucial to understand the impact of food on people's health, either positively or negatively. In this respect, scientific research to date shows that there is a need for a transition towards healthy diets that are also richer in plant-based foods, for better control of food production and preservation processes, and for improved European and national public policies on the consumption and production of animal-based food.

Nutritional and dietary monitoring is fundamental in most of the pathologies treated in primary care and hospital consultations, as well as in the different physiological states throughout our lives. Healthy nutrition is essential to ensure sustainable health in healthy individuals, at all stages of life, and for rapid recovery in the event of illness. Thus, critical consideration needs to be given to the influence that diet can have during the ageing process and how its modulation plays a key role in achieving healthy ageing. In this regard, it is important to remember that,



Diseases related to diet and nutritional status:

- Cardiovascular diseases and arterial hypertension Cardiovascular/cerebrovascular accidents, strokes Obesity, type 2 diabetes, dyslipidaemia
- Iron deficiency anaemia, pernicious anaemia, etc.
- Oral and intestinal infections, constipation, irritable bowel syndrome, inflammatory bowel disease, etc.
- Food allergies and intolerances Chronic respiratory diseases Eating disorders
- Cognitive impairment
- Cancer, at a preventive level and during drug treatments

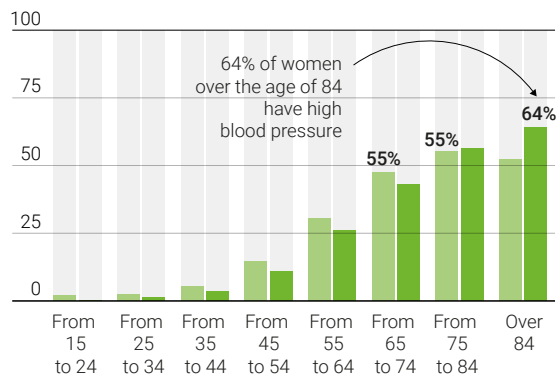
globally, the population aged 60 and over is expected to double in number by 2050, from 841 million to 2 billion. These figures represent clear challenges for our health care system as non-communicable diseases often develop during the ageing process.

Statistical data indicate an increase in the prevalence of diabetes, obesity and hypertension related to the age of the population. In this respect, 19.3% of people aged 65 and over are overweight in Spain while another 42.4% are overweight. Prolonging healthy life is therefore one of the major public health challenges. The World Health Organisation (WHO) proposes as a model of healthy ageing the optimisation of people's cognitive, psychological, sensory, vital and locomotor capacities. Healthy lifestyles promote the maintenance of cognitive abilities and strengthen the immune system. While a combination of lifestyle and genetic factors can speed up or slow down the ageing process, a num-

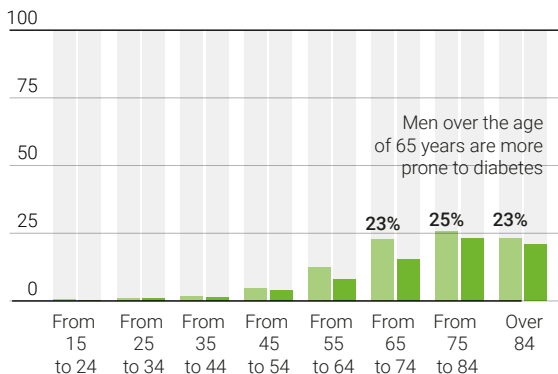
Figure 1.5 Proportion of people with chronic diseases by sex and age group in Spain in 2020

% of population in each age group

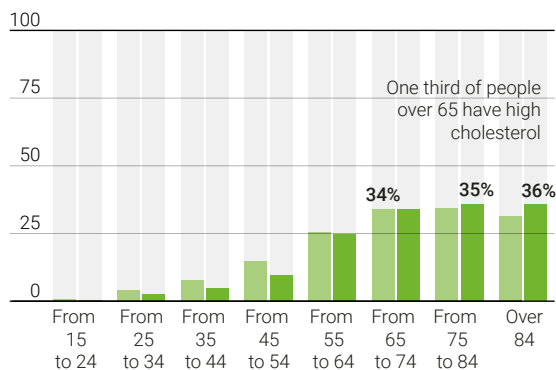
Blood pressure



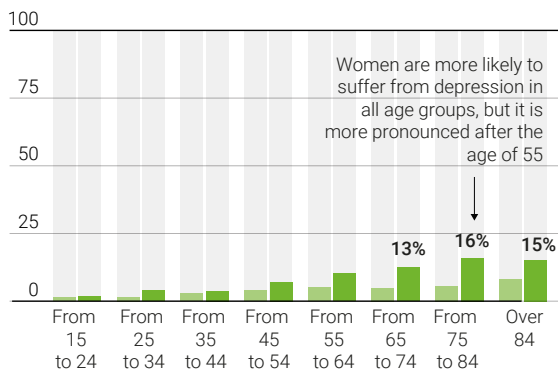
Diabetes



High cholesterol

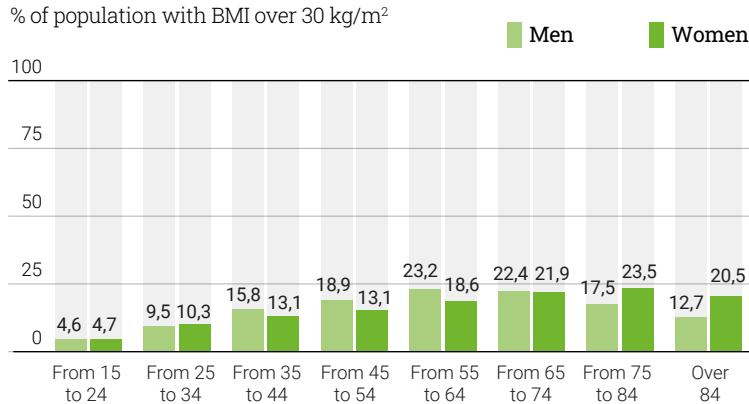


Depression



Instituto Nacional de Estadística (INE). Encuesta Europea de Salud de 2020. Consulta en febrero de 2022.

Figure 1.6 Adults with obesity by sex and age group in Spain in 2020



Instituto Nacional de Estadística (INE). Encuesta Europea de Salud de 2020. Consulta en febrero de 2022.

ber of mechanisms determine the rate of ageing. These mechanisms are relatively few and very well preserved among closely related species, such as mammals. Fortunately, simple dietary changes can go a long way to modulate these mechanisms and help people to live longer and healthier lives. We should also be aware that an increasing number of foods making nutritional and health claims are being marketed in the EU.

The microbiota and its role in diet-related diseases. Microbiota denotes the communities of micro-organisms that inhabit our skin and mucosal surfaces. The gene set of all the components of the microbiota is known as the microbiome.

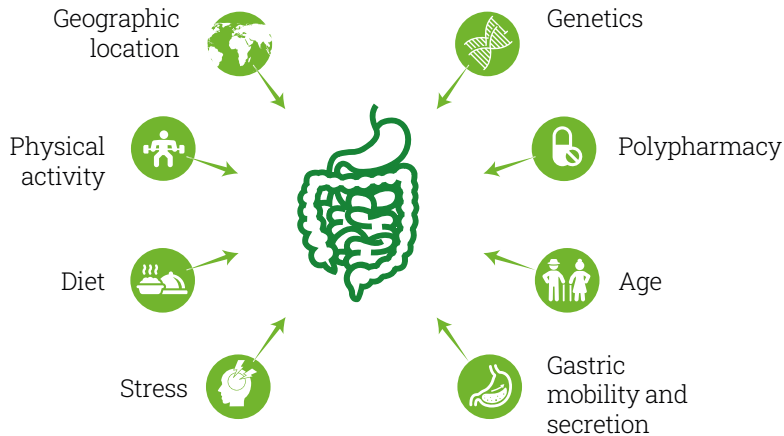
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“A nutrition claim is any statement that states, suggests or implies that: a food may be understood as having specific beneficial nutritional properties in terms of the energy, nutrients or other substances [contained or not, or contained in reduced or increased proportions]. Only authorised nutrition claims are allowed and only if they comply with the conditions laid down”. Spanish Agency for Food Safety and Nutrition (AESAN)

“Health claims are claims that relate a food or one of its components to health”. AESAN

In the human body, the gut is the ecosystem with the greatest microbe population, known as the gut microbiota. It is home to bacteria, archaea, fungi, protozoa and viruses that settle in from birth and evolve with us, undergoing changes during our lives. The main reasons for these changes are genetic, physiological and, in particular, variations in diet and lifestyle. The characterisation of the human microbiome is probably one of the major milestones of science in the 21st century. Thanks to a major international effort, we now know that the microbial ecosystem inhabiting the human body is much more complex and decisive than was thought 20 years ago. Because of its enormous metabolic capacity, the gut microbiota has been regarded as an organ essential for life and influential in health and disease.

Studies have shown that the gut microbiota plays an essential role in modulating the risk of several chronic diseases, such as inflammatory bowel disease, obesity, type 2 diabetes, cardiovascular disease, cancer, and other chronic diseases or even mental illness. Intestinal dysbiosis is an imbalance in the gut microbiota. In the event the gut microbiota is disturbed and the microorganisms are not present in the right quantities and proportions, there are alterations in their ability to carry out immuno-regulatory, muco-nutritional, protective, metabolic and regulatory functions in other organs, such as the brain.

Figure 1.7 Factors impacting on our gut microbiota

In this context, diet plays an important role in influencing the composition of the microbiota. Experimental results show that dietary changes can induce large temporary microbial changes within 24 hours. Given this association, the potential to alter microbial composition through diet can provide components that, when metabolised, give rise to metabolites with important protective actions, such as anti-inflammatory, antioxidant and immunostimulant properties, as well as neurotransmitters. All of these have an impact on our health throughout life, including the ageing process.

13.

Healthy diets for everyone

THE main tool in the fight against malnutrition is a healthy diet. The WHO defines it as a diet that helps protect us from malnutrition as well as NCDs. The exact composition of a diverse, balanced and healthy diet varies according to the individual characteristics of each person (age, gender, lifestyle and level of physical activity), cultural context, locally available foods and eating habits. However, the basic principles of what constitutes a healthy diet are the same for everyone. It consists of providing the necessary nutrients (without excess) and health-promoting substances from nutritious foods, and avoiding the consumption of substances that are harmful to health. A nutritious food “provides beneficial nutrients (e.g. protein, vitamins, minerals, essential amino acids, essential fatty acids, dietary fibre) and minimises potentially harmful elements (e.g. anti-nutrients, high amounts of sodium, saturated fats, sugars and contaminants)”.

Healthy foods are recognised as those that contribute to the promotion of health, since there is a component in their composition that has a positive effect on health. The relationship between food and health, both at the preventive level and in the recovery after illness, has been widely recognised since ancient times. Today, research aimed at clarifying the role of food in health and the mechanisms that underpin it is of interest not only for the advancement of knowledge and the possibility of making public health recommendations, but also for its application to the development of new foods and ingredients to improve our quality of life.

Certain dietary patterns, consumed around the world, are associated with beneficial health outcomes. Among these is the Mediterranean diet, which has become the foundation of heart-healthy eating. Scientific evidence shows that this diet has well-studied health benefits, such as lowering blood pressure and cholesterol. Studies also show a lower risk of type 2 diabetes, cerebrovascular disease, cancer and cognitive function. In Spain, the Prevention with Mediterranean Diet (PREDIMED) study, carried out in centres in several autonomous regions, showed that this diet supplemented with olive oil or nuts is associated with



a 30% reduction in the risk of suffering serious cardiovascular events and lowering blood pressure. Furthermore, higher intakes of dietary ingredients such as polyphenols, the main phytochemicals found in fruits, vegetables, tea and olive oil, were correlated with a 36% reduction in the risk of hypertension and improvements in inflammatory biomarkers related to atherosclerosis and cholesterol.

Other diets designed to reduce disease risk should also be mentioned, such as the Dietary Approaches to Stop Hypertension (DASH) or the Mediterranean-DASH intervention for neurodegenerative delay (MIND). These healthy diets, whether developed by tradition or design, share many common characteristics. In general, compared to a more traditional Western diet, they are

A healthy diet provides the necessary nutrients and health-promoting substances. / iStock



characterised by a higher content of plant-based foods, such as fresh fruits and vegetables, whole grains, legumes, seeds and nuts, and a lower content of animal-based foods, especially fatty and processed meats.

The big challenge for public-health administrations is to get the whole population to adopt healthy dietary habits. This is a difficult task given the powerful influences that currently promote unhealthy consumption choices, lower prices for unhealthy foods, and behaviours and lifestyles that do not promote healthy living. Indeed, there is a need for simple and inexpensive optimisation of dietary quality in populations of different social strata. More efforts are also needed to integrate healthy dietary and lifestyle choices into the daily lives of communities around the world. The goal is to make healthy eating accessible to all, as well as feasible and sustainable. Education in sustainable nutrition and responsible consumption will contribute significantly to this goal.

It should be noted that the **Mediterranean diet**, based on traditional dietary patterns in European Mediterranean countries, encompasses much more than the types of foods consumed and their relative contribution to daily nutrient intake. It also includes how food is sourced (e.g. sustainability and respect for the environment) or how it is cooked and eaten, as well as lifestyle considerations such as regular physical activity, adequate rest and factors relating to participation in conviviality and companionship when preparing and enjoying meals.

Mediterranean diet characteristics:

The daily meals of the Mediterranean diet are based mainly on **cereals** and a variety of **fruits and vegetables**.

Fish, white meat and **eggs** are the main sources of protein whereas **red meat** and **processed meats** are consumed **less frequently**.

Legumes are also a preferred source of vegetable protein.

Olive oil is the main source of lipids in the diet and is supplemented with **olives, nuts and seeds**.



In 2010 the Mediterranean diet was declared an Intangible Cultural Heritage of Humanity as a valuable cultural heritage. / iStock

Recommendations are to consume **dairy products** in moderation daily to obtain calcium, which is necessary for bone and heart health.

Water (1.5–2 litres per day) is recommended as the main source of hydration.

Wine and other fermented alcoholic beverages, accompanying meals, should be consumed in moderation.

14.

Achieving global and sustainable food security

THE cost of malnutrition worldwide is around 3.5 billion euros per year. In order to progress in the eradication of hunger and malnutrition, fundamentally efficient production models must be adopted. Within this framework of action, and from a global perspective, countries' food policies **face the challenge of feeding more people over the next thirty years, with less water, less arable land and in an environment of globalised and urbanised societies.** But the transition to a safe and healthy food model must be socially and economically viable and sustainable. It must avoid social imbalances and contribute to reducing the social cost associated with the treatment of diet-related diseases.

For example, at present, just three crops (rice, maize and wheat) constitute the staple food for the entire global population. Recent crises, the COVID-19 epidemic and the war in Ukraine have highlighted the risk to food security of relying on too few crops. **Diversifying the food we eat** is one of the most effective solutions in a bid to reduce food poverty, tackle biodiversity loss and adapt to the climate crisis. Tools are therefore needed to help design and transform activities in the agri-food sector, food production and consumption from a multi-scalar approach. These activities have historically been dealt with in isolation and only recently has food been oriented towards what have been called **food systems.**

The concept of *food systems* refers to the set of interconnected activities, infrastructures and processes involved in feeding the population: growing, producing, processing, transporting, consuming and managing food waste. Food systems touch all aspects of human existence. The health of our food systems profoundly affects the health of our bodies and the health of the environment, our economies and our cultures.



A sustainable food system
must be a profitable business
and contribute to the sound
management of natural
resources

The European Commission, aligned with the Sustainable Development Goals (SDGs) of the 2030 Agenda, insists that the world's food systems must be transformed to make **"healthier diets more accessible to all, while increasing the sustainability and resilience of these systems"**. Scientists agree that transforming our food systems is one of the most powerful ways to change course and make progress towards the 17 SDGs. This will allow us to respond to the UN Secretary General's call to "build back better" after COVID-19. We are all part of the food system and only with a collective effort can we achieve the transformation the world needs.

Food sustainability is a concept that encompasses three dimensions: economic, environmental and social. A sustainable food system must be a profitable business that creates mutually beneficial relationships between workers and the surrounding community, and contributes to the sound management of natural resources. It should also seek to ensure that the people to whom it provides food maintain a long-term healthy state, thus promoting nutritional sustainability.

The fight against malnutrition and food insecurity will therefore involve tackling many challenges over the coming years. These mainly include those relating to primary production and the processing industry, which are essential for strengthening the agri-food sector, which is critical to the Spanish and European economies. As described at length in the report Producing food without depleting the planet, agricultural and food policies must be geared towards favouring food production in order to strengthen food supply, i.e. national food security.

Economic sustainability also extends to production processes, which must be designed in such a way as to ensure profitability for producers and affordable prices for the population. These policies must be combined with environmental sustainability,



Objectives of the Farm to Fork strategy related to healthy diets:

1. Education in nutrition and health for the general population, involving all population groups.
 2. Educate health professionals on the impacts of nutrition, sustainability and health.
 3. Improve the exploitation of natural resources and contribute to the consumption of traditional foodstuffs from third countries by European populations.
 4. Implement the strategy of co-creation of novel foods with the active participation of industry, scientists, nutrition and health professionals, and consumers.
-

reducing negative environmental impacts, particularly those related to greenhouse gas emissions. The Spanish agri-food sector accounts for 12% of the EU's gross domestic product in the sector, making Spain the fourth largest economy in the agri-food sector in the EU-27. It is essential to strengthen the agri-food sector through innovation, as it is critical to the Spanish and European economy.

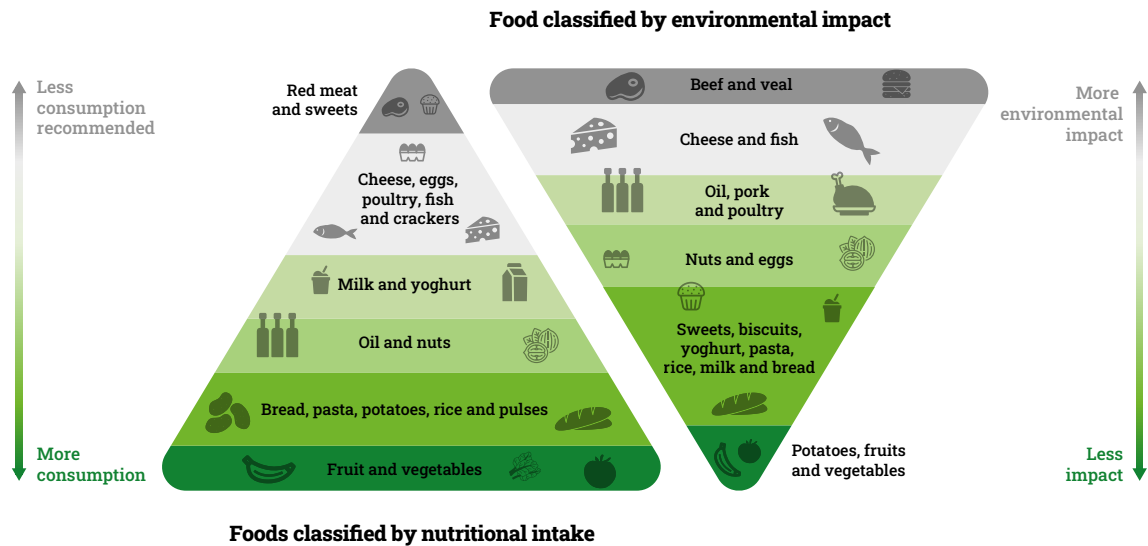
In its commitment to the environment and to the protection of the planet's health, the EU has established the Green Deal. As an integral part of this pact, namely the Farm to Fork Strategy has the overarching goal of addressing the serious problems facing global food production and the planet. Its ultimate goal is to integrate the links between healthy people, healthy societies and a healthy planet to achieve a fair, healthy and environmentally sound food system.

Initiatives aiming to achieve this goal include the following:

1. Create a food environment to make the healthy and sustainable choice the easy choice.
2. Label food to encourage consumers to choose healthy and sustainable diets.
3. Intensify the fight against food waste.
4. Invest in food research and innovation, bioeconomy, natural resources, agriculture, fisheries, aquaculture and environment.

Regarding potential risks in food production and supply, both nutrition and food security (the latter meaning that individuals and communities have access to adequate and nutritious food that meets their dietary needs) are inextricably linked to food **safety** in a more or less complex way. Diets must be healthy and must ensure that they are safe. *Food* safety refers to the absence of risks associated with the presence of contamination leading to the transmission of diseases caused by micro-organisms, viruses, prions, parasites and chemicals or other risks associated with the food supply chain.

Unsafe food creates a vicious cycle of disease and malnutrition, particularly affecting infants, young children, the elderly and the sick. Approximately 600 million people fall ill from contaminated food each year and more than 420,000 die annually, mainly children under five years of age, with 125,000 deaths per year. Food contamination also causes significant productivity losses and medical costs.

Figure 1.8 Food and environmental pyramids

FUNDACIÓN BARILLA CENTER FOR FOOD & NUTRITION (BCFN)

To foresee and prepare for new risks, collaborations between regulatory organisations such as the European Food Safety Authority (EFSA), WHO, FAO, the World Organisation for Animal Health (WOAH), Codex Alimentarius and the Organisation for Economic Cooperation and Development (OECD) need to be strengthened to promote standards in risk assessment and provide global food safety solutions.

two



How Science Contributes to Preventing Undernutrition and Malnutrition



A FUNDAMENTAL goal of science is to clarify the close relationship between diet and the reduction of risk of chronic diseases characterised by high morbidity and mortality. In this context, CSIC groups contribute as a national and international benchmark in issues related to food, health and personalised nutrition, through basic and applied science. Lifestyle and diet, as determining factors in the maintenance of health, have a decisive influence on the prevention of chronic and neurodegenerative diseases that develop throughout life and, in particular, those associated with ageing. Among the mechanisms that explain the development of these diseases, there are common aspects that include chronic inflammation and immunological and oxidative alterations, which greatly affect the evolution of mental (neurodegenerative and psychiatric) and physical (obesity, type 2 diabetes, cardiovascular pathology) pathologies. The CSIC has cutting-edge facilities, where researchers investigate these essential mechanisms with the aim of establishing preventive measures based on changes in diet and lifestyle that promote health and healthy ageing of the population.

21.

Healthy foods and why they can reduce or treat diseases

THE metabolism, bioavailability and bioaccessibility of food components are key factors for understanding their role in health and thus being able to propose new formulations. CSIC research stands out for the most advanced analytical and instrumental developments based on molecule identification methodologies (*omics methods*), which provide a comprehensive understanding of the functionality of food components. These tools require a high degree of specialisation due to their high degree of complexity. The main platforms for comprehensive omics analysis include transcriptomics (study of RNA molecules), proteomics (of proteins), lipidomics (of lipids) and metabolomics (of metabolites). These techniques are used at the CSIC to study the mechanisms of action of foods and their components, to propose new foods or new ingredients with healthy characteristics, or to optimise processing methods. In addition, CSIC groups address the challenges of digital science and develop computational tools including techniques for the massive handling of biological data (bioinformatics), adopting them in their work. The demand for an omics-based approach will continue to grow in food and nutrition science, and CSIC is committed to leading research that uses them in combination to provide more concrete information about what happens inside the body in response to food consumption.

Likewise, CSIC groups also study the nutritional status of the population and risk factors in nutrition-related pathologies. They also investigate the effect of compounds such as polyphenols, prebiotics, carotenoids, proteins, polyunsaturated fatty acids and minerals on the prevention of NCDs and the effect of functional foods on health. These studies are highly complex as not all people respond in the same way to the consumption of a bioactive compound. Therefore, research also focuses on their ability to absorb and metabolise these compounds, the individual's genetics and how the components of a food can cause changes in the nutri(epi)genetic DNA sequence.



Bioavailability: the amount or proportion of an ingested nutrient that reaches the bloodstream to reach our organs and tissues.

Bioaccessibility: fraction released from the food during digestion and available for subsequent gastrointestinal absorption.

Bioactivity: property of a food component to interact with our body and produce a physiological response.



The CSIC has cutting-edge technology to study food components and analyse their impact on health. / IIM-CSIC

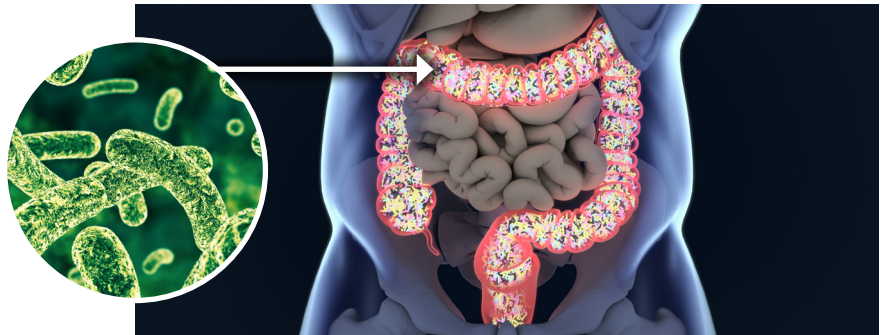
At CSIC, researchers also address the harmonisation and standardisation of protocols and methodologies of interest to the international scientific community. One example is the INFOGEST protocol, a consensus model of *in vitro* digestion used worldwide. This protocol is used, for example, to identify the bioactive molecules released in the gut during human digestion, as well as the bioavailability of nutrients. This information is necessary for a better understanding of the relationship between food and human health.

2.2.

Gut microbiota: key to dietary health and sustainable nutrition

FOOD components strongly influence the structure and composition of microbial communities. Currently, progress is being made in understanding whether changes in the microbiota are the cause or the consequence of disease. The modulation of the gut microbiota through dietary intervention has become an emerging therapeutic and preventive strategy to treat a wide range of diseases (digestive, metabolic, infectious, neurological, cardiovascular, allergic, oncological, etc.) in any medical speciality.

The CSIC is working to identify the mechanisms by which different food components influence the gut microbiota. Researchers also study the symbiosis of the gut microbiota with the individual at different stages of life, from infancy to old age. This is done both in healthy people and in different types of patients with pathological conditions that are clearly related to alterations in the microbiota, such as obesity, but also in situations of immune dysfunction or cancer, among others. In particular, the role of diet in the functions of the gut microbiota and its metabolites, and how this affects physical and mental health, is being investigated. Using machine learning algorithms, predictive models are being developed to plan healthy nutritional strategies based on the gut microbiota, from an early stage in life, and as a modulating factor in healthy ageing.





Specific CSIC infrastructures for nutrition and diet studies:

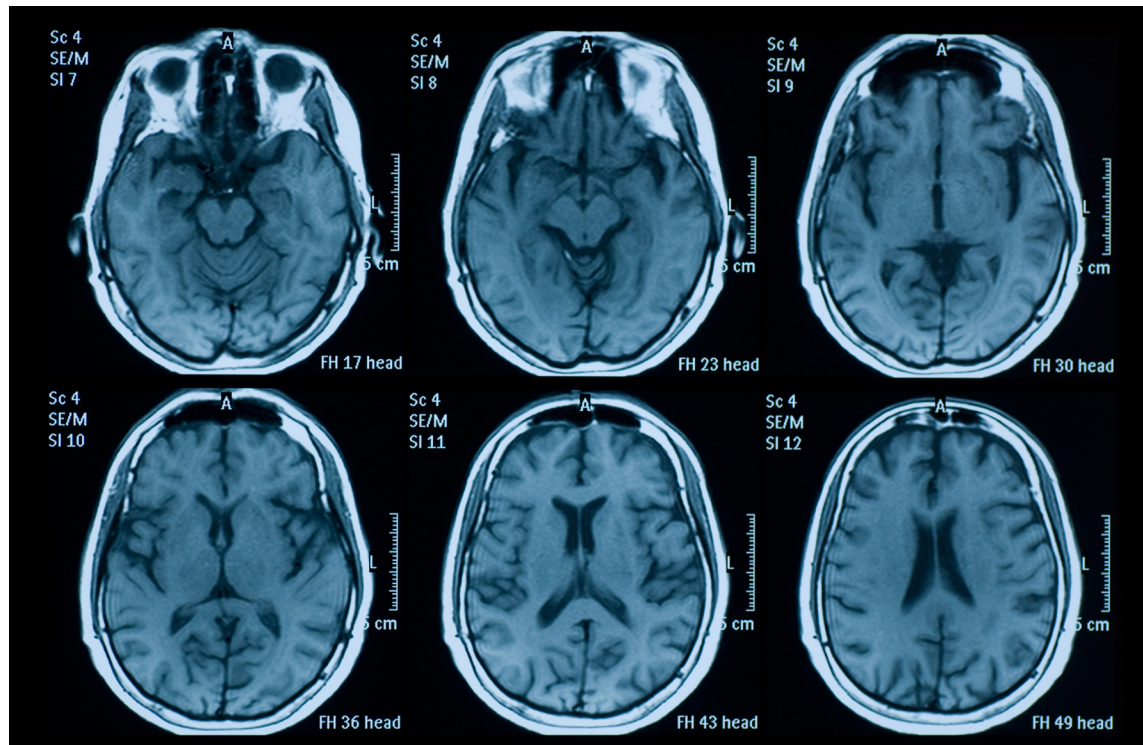
SIMGI®: human gastrointestinal tract simulation platform. Experimentation on this simulator allows progress to be made in important aspects such as: nutrient digestion and metabolism, interaction with the intestinal microbiota and new product formulation

Nutrition Unit: provides the support and means necessary to carry out short- and long-term clinical and nutritional studies with healthy volunteers and patients.



SIMGI® Platform. / CIAL-CSIC-UAM

The CSIC also addresses the design of foods and products adapted to maintain the health of our microbiota: prebiotics, probiotics, postbiotics and synbiotics. And it contributes to the understanding that, together with diet, other factors determining lifestyle need to be taken into account. Stress, physical activity, sleep, medication, smoking and excessive alcohol consumption are also important determinants of microbiota status and health. Projects are also underway on the interaction between diet and environment, environmental pollutants and xenobiotics, and the development of future microbiome-based dietary recommendations that take all these factors into account in an integrated way. The study of microbiomes in food systems is also addressed as a key challenge to improve productivity, sustainability, nutritional quality and food safety and security.



Research projects show the influence of gut bacteria on the brain. / istock



The CSIC is a pioneer in the understanding of key biological factors in the pathophysiology of ageing and brain function. The influence of the microbiota on communication between the gut and the brain (the so-called gut-brain axis), which connects the central nervous system with the gut microbiota, is one of the fields of research of greatest interest at present. Multidisciplinary approaches are being developed to identify early biomarkers and predictive models of healthy ageing. Research is also being carried out on the development of personalised preventive strategies based on the microbiota, diets and healthy foods in Alzheimer's disease, Parkinson's disease and other neurodegenerative diseases, such as autism, anxiety and depression. The CSIC's work to improve and protect the population's quality of life involves clinical studies in collaboration with hospitals and large international projects, as well as pre-clinical studies with different animal models and laboratory tests, including advanced models of human physiology.

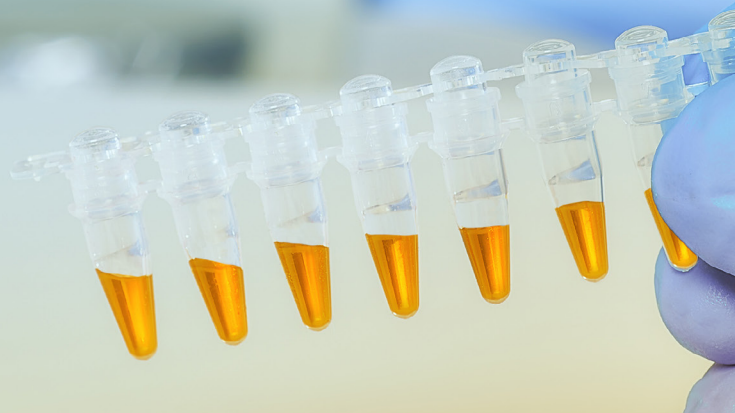


2.3.

**Precision
nutrition**

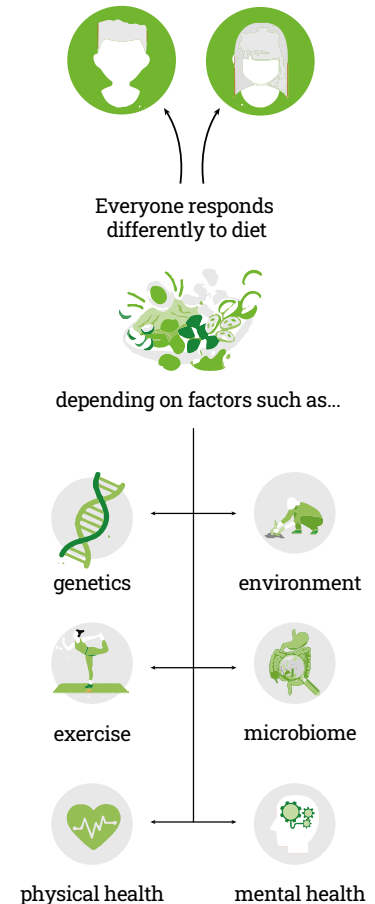
PRECISION nutrition has a major impact on reducing public health costs and improving the population's welfare. The CSIC recognises the metabolic, physiological and genetic diversity of individuals and, as such, they have different responses to food components. These responses can be measured through the integration of different health biomarkers that provide information which can be used to prevent or assist in the treatment of a disease.

For years, the institution has been assessing individual differences in response to different diets. This is done by comprehensively studying the interaction between food components, lifestyle, our genes and metabolic pathways, health history, the microbiome, social determinants of health and other individual factors. The development of tools using artificial intelligence helps to predict these individual differences and validate their clinical utility. This work aims to provide more specific recommendations based on each person's unique characteristics and environment.



Precision nutrition can particularly benefit populations with particular nutritional requirements (people with food intolerances and allergies, other specific pathologies involving nutritional failure or immune system depression, older adults, children, pregnant women, infants, special diets selected for ideological reasons) and a high genetic predisposition to specific high-incidence pathologies (colon cancer, among others). But precision nutrition can still be extended much further, including more holistic aspects that do not address disease, but also on wellbeing and other indicators of positive health. Studies focusing on the consumption of plant-based or marine and aquaculture products are examples of essential components of such targeted diets. Work is being done on the development and validation of foods and nutritional strategies for health, with proven efficacy from both a preventive and therapeutic perspective, and is therefore transferable and translational.

Figure 2.1 Precision or personalised nutrition



2.4.

Developing new healthy foods and ingredients

RESearch at the CSIC contributes to the adoption of traditional foods from third countries, which are considered novel foods in Europe. Legumes, wild cereals, coastal plants and seaweed are some examples. Alternatives for cereals are also being explored, such as roots and stems of foods not consumed previously by the European population (e.g. Ethiopian or “false” bananas), which are rich in starch for bread and other staple foods. Novel foods undergo stringent scientific evaluation by EFSA to demonstrate their safety, nutritional value and health benefits.

The rigorous benchmark of the scientific bases establishing the healthy role of food and its components is essential to increase consumer confidence in Spanish food production and consumption. The qualities associated with our foods and the ability of food companies to be innovative and adapt to consumer trends are important factors that determine consumers’ view of the Spanish food industry. Consumers make decisions largely in response to the information available about a food. One of the objectives of the CSIC groups is to help them make decisions when choosing between different food products.

CSIC groups are investigating the composition and health effects of ingredients obtained from fish and plant products (including seeds), by-products and underutilised species. These ingredients, when incorporated into a food, confer health-giving properties that can help reduce the risk of diseases such as high blood pressure or diabetes. Polyphenols, peptides and indigestible carbohydrates, among other bioactive compounds, have received attention in recent years, not only because of their potential health benefits, but also because of their ability to trigger benefits by modulating the microbiota. There is also growing interest in the use of lactic acid bacteria that produce compounds with a positive effect on consumer health. Another important issue is the substitution of unhealthy components, such as saturated fats, in industrial food processing. This is a necessity if healthy processed foods are to be achieved, and the use of new ingredients during processing, such as oleogels and oils rich in unsaturated fatty acids, is being explored.



ISTOCK

Culinary and industrial food processing processes have a crucial impact on food composition and effects on food safety, nutritional and sensory quality, and consumer health. Currently, as a priority line of research, many scientists at CSIC and other institutions around the world are studying the impact of formulation, food processing on food digestion, metabolism and health effects. Processes such as enzymatic hydrolysis, germination and fermentation are used to obtain innovative foods that can be consumed by people with particular nutritional needs, such as allergies and food intolerances. In this context, a great effort is being made to propose new nutritious, healthy and high sensory quality food and drink formulations for coeliacs and other population segments with food allergies.

One of the most promising strategies for achieving food security and reducing the risk of global malnutrition now and in the future is the so-called co-creation of food. This is a collaborative activity on which CSIC is working. Consumers and other stakeholders (entrepreneurs, researchers, producers, retailers, etc.) play an active role in the creation and selection of new products for the market. This allows consumers and producers to create heat (material and symbolic) and new market opportunities through collaboration.

Co-creation is a perfect tool for making better use of natural resources and meeting consumer demands, essential for repeat purchases, and useful for ensuring the viability of producers. Co-creation is a multidisciplinary innovation opportunity to add value not only to agri-food by-products but also to the food chain, to contribute to bio-economy and to transfer knowledge from the scientific community to industry.

Several CSIC groups are working in this field, which involves not only the sensory quality of new products, but also a response to consumer demands. It is also noteworthy that the CSIC is a strategic member of the EIT-Food, a leading European initiative in food innovation designed to transform our food system. Since its creation, CSIC has been a member of the EIT-Food South Advisory Board, created to build bridges between universities, research centres, institutes and the food market, with participants from Cyprus, Italy, Israel, Greece, Portugal, Spain and Turkey. EIT-Food is a large European consortium of more than 50 partners hailing from leading companies, research centres and universities in 13 countries. The consortium aims to transform the European food system by promoting innovation in food and health, sustainable and circular food systems and digital traceability. It also aims to engage consumers in making healthy and sustainable choices, and to promote education in this area through advanced training programmes.



CSIC research is
underway to obtain
healthier oils. / csic

2.5.

Food traceability and food safety

FOOD traceability allows food to be traced from its original point of production until it reaches the final consumer, in other words, it is an identification system throughout the whole food supply chain. At the CSIC, researchers are working on the design and industrial implementation of new strategies through multi-omics approaches. They are also using multisensors and nanosensors to guarantee the origin, authenticity and genuineness of the raw materials, ingredients and foods we consume. The incorporation of advanced predictive labelling systems and digitisation, capable of providing real-time information on the food label - including nutritional and composition data - as well as the best-before date are of great interest to consumers.



Advances in product labelling facilitate real-time food label information. / ISTOCK

It is also important to note that these tools are essential to ensure food safety. They are technologies with high analytical capabilities that help to prevent food fraud in mass- consumed products such as dairy, meat products or fish. They are crucial to identifying emerging risks and spoilage of products that can occur during food processing and production as well as during the supply system in a highly interconnected and competitive global economy.



Food safety control also implies the need to control the growth of micro-organisms such as bacteria, yeasts, fungi and viruses, which can proliferate and cause health problems for the consumer. The CSIC contributes to this field by identifying risk factors, implementing technologies or using bioprotective micro-organisms, bacteriophages or natural ingredients that control the growth of other micro-organisms. A clear example is the search for effective measures to prevent the growth of *Listeria monocytogenes* in foods such as fruit, vegetables, meat or fish. Research is also being carried out on cleaning and disinfection treatments that prevent the growth of these bacteria on the surfaces of processing facilities, where they form films that make them resistant to traditional cleaning processes.

Another task of the CSIC research staff is to reduce the prevalence and concentration of dangerous or emerging viruses in food and water by means of different technologies. Work is also being done on the control of mycotoxin production by pathogenic fungi and their detection by means of different strategies.

The CSIC's contribution to the development and identification of robust and highly sensitive differential markers to detect adulteration, biological and chemical contaminants in food, the presence of additives, pesticides, veterinary drugs and other industrial xenobiotics, pathogens, toxins or food-borne allergens is also highly relevant.

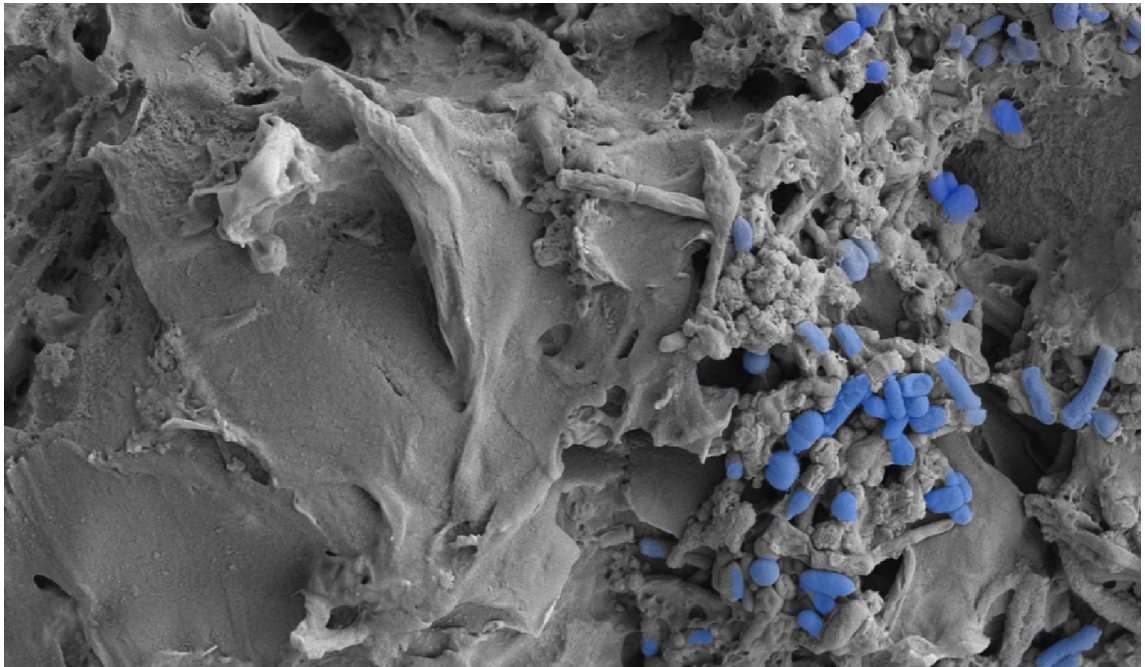
On the other hand, research into the development of innovative and environmentally friendly technologies that guarantee food safety, whether processed or fresh, or that are useful for the decontamination of processing facilities, is essential for the CSIC. The aim is to preserve the original characteristics of the food and to prevent microbial growth. It also aims to develop technologies that prevent the appearance of undesirable compounds in food during processing. These include acrylamide or oxidation products of unsaturated fatty acids.



The institution is working on strategies to protect consumers from pathogens such as anisakis in fish and food allergens of various kinds.

The work of CSIC researchers is also important in the study of the safety of foods that incorporate new ingredients in their formulation, either directly or protected in micro- or nano-capsules. Understanding the effects, from a multidisciplinary point of view, of the presence of microplastics in the food chain is also a CSIC objective.

Another relevant aspect is the design of new antimicrobials and antimicrobial strategies, both for direct use in food and as part of a natural alternative (and based on dietary approaches) to the use of antibiotics in clinical and veterinary medicine. The identification and prediction of the behaviour of foodborne pathogens, including viruses, bacteria, yeasts and filamentous fungi, as well as micro-organisms causing food spoilage, are other contributions related to food safety and security.



CSIC researchers have discovered that the digestion of microplastics can reduce the amount of beneficial bacteria present in the colon. /csic

three



Conclusions and Recommendations

Conclusions

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The CSIC is working in collaboration with other national and international research centres and universities to generate new knowledge and to develop food products which avoid malnutrition, promote good health and reduce the risk of diet-related diseases.

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Sustainable food production must consider social justice, as well as ethical and moral issues, which contribute to facilitating access to healthy food for the whole population, avoiding the risk of malnutrition.

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Sustainable food systems are those that provide sufficient, healthy and accessible food for all; they are environmentally friendly, culturally acceptable, equitable and resilient to crises.

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Food must necessarily be sensorially acceptable as well as being safe; healthy and sustainable food should be the easiest choice

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A healthy and sustainable diet will only be achieved if it is approached holistically as part of the food systems, considering all variables without one factor dominating another.

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The Mediterranean diet is a centuries-old tradition, which encompasses much more than the types of food consumed. It contributes to an excellent nutritional status, provides a pleasurable sensation and is a valuable cultural heritage, representing much more than just a simple rich and healthy nutritional guideline.

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The CSIC works in different fields related to the sustainable production of healthy food for all, aiming to become a national and international benchmark in issues related with food, health and personalised nutrition.

Recommendations



Education in food purchasing can play a key role in supporting sustainable practices throughout the food supply chain, for example by simultaneously promoting sustainable local products and healthy diets. The actions of local or regional authorities are as important as the efforts made at the national level.



Consumers must be aware of the power they have to drive change towards healthier diets and sustainable systems through the choices they make. However, this is only possible if there are affordable products that are sustainably produced and properly labelled, i.e. the information is trustworthy.



Dietary change is identified as a necessary global driver which will enable the widespread adoption of nature-friendly agriculture, livestock, fisheries and aquaculture.



Epidemiological studies are needed to better understand the relationships between a healthy diet, health and healthy ageing. Such studies should consider the intrinsic capacity of individuals in all domains and multidimensional concepts. When a sufficient number of epidemiological study results are available, the evidence can be synthesised and holistic nutritional studies can be designed, thereby advancing the translation of evidence into practice. and promoting health at all stages of life.



Responsible and sustainable consumption patterns need to be established as a guide to ensure adequate nutritional status. In this respect, education, research and the adoption of co-creation models in the modern food system are essential to meet this challenge.

four



List of Centres

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CENTRES	WEB PAGE	E-MAIL ADDRESS
Centro de Edafología y Biología Aplicada del Segura (CEBAS, CSIC)	www.cebas.csic.es	direccion.cebas@csic.es
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Instituto de Ciencias de la Vid y del Vino (ICVV, CSIC-UR-Gobierno de La Rioja)	www.icvv.es	direccion.icvv@csic.es
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Instituto de Productos Lácteos de Asturias (IPLA, CSIC)	www.ipla.csic.es	direccion.ipla@csic.es
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA, CSIC)	www.inia.es	direccion.general@inia.es

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Further Information

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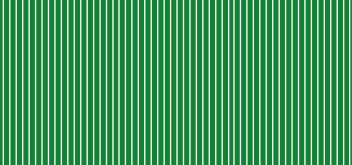
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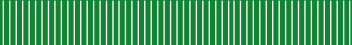
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Science for Public Policy



Knowledge Transfer
Report



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