GOODFOOD Methodology

Learning to become sustainable food consumers

Guidelines for secondary school teachers

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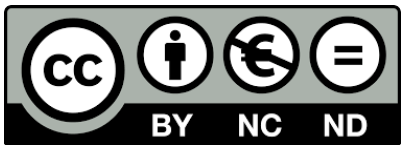


Content




Introduction

Introduction

Within the GOODFOOD project, we aim to involve the students of secondary school (from 13 to 19 years old) into a series of activities that will help them to learn more about food issues but also to communicate their experience and ideas about healthy and sustainable eating. GOODFOOD provides teachers and students with tools and materials on a spectrum of food themes to increase their knowledge and skills on a variety of topics and aspects related to food, make youngsters' aware of their food habits' impacts on health and environment, responding the need for a responsible citizenship (SIS network, 2016), reinforce the relationship between schools and stakeholders (including those from production systems such as farms and transformation and waste management such as urban utilities), but also encourage teachers towards an interdisciplinary approach between STEAM and collaboration and the application of attractive and effective learning methodologies that enhance hard and soft skills.

Food is a fundamental part of our life, with a major impact in our body health, our feelings and wellbeing, as well as in our social life. Food is pleasure and there is always something to say around food. In the more developed societies, people love speaking about food, and recently, it has been observed that young people love reproducing famous chefs' recipes, taking photographs, and sharing results and comments on social media.

Why is food an important theme for the students' learning program?
Food is a complex theme, connected to a wide range of aspects related to our life, essential for human health and for the future of our planet. A summary of these issues follows:

- **Food is essential for our health.** Food provides **essential substances (nutrients)** for the growth, repair, and maintenance of body tissues, for the regulation of vital processes as well as for the energy our bodies need to function. The main nutrients are **carbohydrates, fats, proteins, minerals, vitamins,** and **water** which are present in larger or smaller quantities in most foods. In addition, some foods also contain a variety of compounds with additional benefits for health (**bioactive compounds**).
  Foods can be divided into different groups:
  1. Fruits & vegetables: rich sources of vitamins, minerals, fibre and bioactive compounds. Fruits also contain important quantities of sugars; 2. Starchy foods: cereals (grains and derived foods: bread, rice, pasta), tubers (potatoes), and roots (carrots) rich in carbohydrates which constitute an important source of energy; wholegrains are also a source of fibre; 3. Dairy foods (milk, cheese, yoghurt) rich in calcium and phosphorus but also in protein, fatty acids, carbohydrates; 4. Protein foods:

Fruits and vegetables in a local market.

legumes, seeds, nuts, meat, fish and eggs. Some of these foods can also have a low fat content (legumes) or a healthy fat composition (nuts). Meat, fish and eggs are also rich in minerals like iron.

- Food is an essential part of our **culture** at all stages, i.e. when it is produced, created, prepared, transformed, chosen and consumed. Agriculture, fishing, livestock farming, hunting, are the main activities for producing food and they have become traditional in specific regions or countries based on many factors: climate, landscape, human experience etc. Even food preparation is also an important part of our culture: it is based on a selection of products (based on availability, traditions and(or) beliefs) and the transformation of these products into a recipe, according to one's own needs or economic constraints, diet, preferences, or identity (country, religion, living environment). Therefore, a recipe becomes traditional thanks to a specific way of cooking following traditions and practices of a place, specific foods and drinks, even specific meals or components or courses. Cuisine has surely also been influenced by trade and globalisation which made available foreign products, religious laws and historical traditions which exercise a strong influence on culinary practices.

Source: Atlas of world dishes https://www.tasteatlas.com/

- Since the big explorations, food has entered a **global system**. Species have been introduced into different continents and nowadays the transportation and distribution allow food to be available at larger distances between producers and consumers. The world food system includes all the activities such as production, transformation, transport, distribution, and consumption of food products, thus strictly related to globalisation. This network of activities and systems involve a variety of actors such as multinational companies, national companies, public and private subjects, including farmers (about half of the world's population), and then consumers. These systems are constantly changing to adapt to meteorological and environmental events, but also political and war events, and then to adapt to demographic forecasts. They follow economic and customs policies, fiscal, institutional, and regulatory mechanisms, coordinate with technological innovations and

Food is transported across oceans and continents and within countries through different transport means: air and sea freights, trail, trucks.

respect or address consumer preferences.

- **Food production** is obviously essential and includes farming for producing vegetables, fruits and livestock, fishing and hunting as main sources of food. The food on our table is the result of a complex production system which involves the relationship between man and natural resources (land, water and air). The alteration of the equilibrium between inputs (e.g., soil capacity to regenerate own fertility) and outputs (products) brings to the deployment of the natural resource. **Agriculture is one of the main causes of land degradation and loss of fertility** due to the exploitation of soil and the use of chemical inputs in the form of pesticides and fertilisers. In addition, soil and water pollution threatens biodiversity. These issues are exacerbated by climate change with extreme weather events that pose several damages and challenges to the production systems as well as to the natural resources. Intensive livestock and farming, food disposal in landfills are direct and indirect sources of greenhouse gases, that in turn are the main causes of global warming and climate change. Even a beautiful landscape hides problems of soil fertility, intensive soil erosion, leaching of nitrates from fertilizers or intensive cattle farming producing water pollution.

Severe soil erosion in an intensively cultivated area (left) and calves in the stable of an organic farm (right).

Another important issue is the introduction of new crop varieties, which on one side might be increasingly resistant to drought and pests or be highly productive, on the other side they threaten local biodiversity and varieties. Then, overfishing as well as fishing protected species endanger the equilibrium of the sea life and chain, which ultimately has consequences for fishing itself.
New paradigms in food productions should be supported, as food production, especially when it aims to maximise the production, is a threat to the environment. Alternative sustainable farming practices and the introduction of alternative food products are needed now.

- When food arrives at the table, it has often gone through a complex process (e.g., washing, selection, transformation) which include the implementation of a diversity of technologies. **Food processing is the transformation of raw products** (vegetables, fruits, meat, fish, milk) **or already processed products into other forms of food** (e.g., bread, cheese, sauces, ready

to eat food)**.** Food processing is generally used to preserve food, increasing food security, and reducing food waste. Food processing can be of three types: the primary one transforms the product into something edible (e.g., grinding wheat kernels or butchering animals for meat, drying vegetables, fruits, fish and meat, pasteurising milk); the secondary one transforms the primary processed food into another food (e.g., bread, cheese, sausages, wine and beer), and tertiary type of food processing produces ready-to-eat or heat-and-serve foods, which are usually rich in preservatives, salts and sugars and are considered unhealthy.

Bread and pasta are transformation products of wheat and durum respectively.

- Another important aspect connected to food, is the **food loss and waste which is generated at all stages.** Globally, around 14% of total global food production is lost between harvest and retail, 18% is wasted in retail when selection follows aesthetic criteria and size, and at the consumption level (11% in households, 5% in the food service and 2% in retail) food waste is generated by leftover, when there is an over-amount. This means that together with such food loss and waste, all the resources (water, land, energy, labour, and capital) used to produce it, go to waste. There is an important need for reducing them, increasing the sustainability of food consumption: optimising the production and maximising the consumption of produced food. Nowadays technologies can be of aid, by allowing storing, transformation, e-commerce, and good practices to manage food quality and reduce food loss and waste.

In the EU, over 58 million tonnes of food waste (131 kg/inhabitant) are generated annually and at the same time, over 37 million people cannot afford a quality meal every second day (Eurostat, 2023).

- As the world population is continuously increasing (UNDESA, 2022) (estimated to reach 9.7 billion by 2050), there are important **question marks and challenges about the amount of food to be produced, the challenges to reduce inequalities and to maintain Earth capacity to renew resources**. As bioresources required for food production are diminishing, new approaches are needed to feed the current and future global population. In the last decades, scientists have developed novel strategies to reduce food loss and waste, improve food production, and find new ingredients (e.g. insects, microalgae, wood-derived fibres), design and build new food structures through a blockchain technology, and introduce digitalization in the food system even using augmented and virtual reality.

GOOODFOOD
Themes

GOODFOOD Themes

GOODFOOD aims • to create a sensitive community of stakeholders keen to develop more responsible citizenship about the Food Cycle (Sustainable & Healthy Eating), but also, • to make school and STEM (Science, Technology, Engineering, Maths) subjects attractive to students and teaching methods more effective through adding Art activities into the projects.

To achieve these goals, GOODFOOD has developed teaching and learning materials based on a structured methodology that is described in this book. This methodology also has been developed on the basis of the findings obtained from an initial survey aimed to understand the knowledge and the interest on methodological approaches and the attitude towards the themes of the project. The methodology facilitates the collaboration between teachers in different subjects, promotes knowledge and skills on the application of an integrated STEAM approach among the community of Secondary School teachers, but also promotes the use of innovative tools/products that may serve the community and others as teaching/learning materials to spread the knowledge on Sustainable & Healthy Eating.

GOODFOOD has grouped food aspects into four main **Thematic Modules** and for each theme, a collection of **Learning Units**, digital resources, videos and posters from the piloting experience, as teaching materials, regarding several aspects of food, aiming to make school subjects such as Science, Technologies, Engineering and Maths (STEM) more attractive. This is achieved through the implementation of activities that stimulate student's creativity (e.g., cooking), discoveries (e.g., cultural aspects), curiosity through experiments and research on a wide range of topics following a structured methodology.

Thematic module	Description	Learning Units
 **Sustainable Food Production**	The module aims to provide students with the knowledge on the **food production methods** and the environmental threats of food production, and to familiarise with sustainable methods such as conservative agriculture, agroecological practices and precision agriculture for the optimisation of irrigation water.	**Sustainable farming methods** **Is your food sustainable?** **Calculate your food Carbon Footprint** **Sustainable fishing**
 **Sustainable Food Availability and Food Selection**	This module includes two aspects: i) **Sustainable Food Supply** aims to provide students with the knowledge on sustainable **food supply in terms of transportation, packaging, and conservation,** stimulating even the invention of solutions that reduce consumption and food transportation, and support the use of green packaging; ii) **Sustainable Food Selection** aims to enhance the students' understanding of the different **cultural, social, and environmental factors that influence our daily food choices**. Knowing and understanding these factors, students may come up with ideas to overcome cultural limitations and change their food choices towards sustainability and health.	**Short food supply chains** **Dietary choices and habits of adolescents**
 **Nutritious and Healthy Food Consumption**	This module aims to increase the students' knowledge/understanding of the **impact of our food habits/choices on our health and how to improve them**. A lifestyle that includes excessive eating and(or) the abuse of highly processed foods (high in fats, sugars, salt, etc) favours the development of overweight/obesity as well as of a range of chronic metabolic disorders which can lead to several serious diseases. Some of these problems already start at a very young age. It is thus very important that everyone, but especially younger people become more knowledgeable of the nutrition properties of food and of the health benefits of our food choices.	**How much salt do we eat?** **The fat component of the diet – the importance of the quality and the quantity of fat in our food** **Improving our knowledge about the concept of antioxidants**
 **Sustainable food waste management**	This module aims to provide students with the knowledge on **different ways to reduce the food losses and waste, by using and transforming bad-looking food and avoiding the disposal of wasted food to landfill.**	**Packaging** **Reuse of leftover food**

Sustainable Food Production

By Francesca Ugolini

This chapter is about agriculture as the main food production activity and provides a brief overview on its evolution and the environmental impacts of the productions, but also the description of sustainable practices and techniques dealing with the intensification of sustainable agriculture.

During human evolution, agriculture (as the production and processing of any food and non-food products for human consumption) has played an essential role in the development of societies. About 10,000 years ago, early humans gathered food from the wild and, in the process, learned to domesticate crops and animals. Eventually, they started selecting plant materials for propagation and animals for breeding with the intention of developing better food crops and livestock.
Almost all grains and vegetables available today have been altered by human hands.
Over the centuries, agricultural technologies have evolved from simple equipment to complex machinery, chemistry, seed management and information.

Wheat selection has been done over the centuries to increase productivity or stress resistance.

The Green Revolution also known as the Third Agricultural Revolution, in the 1960s contributed to the commercialization of agriculture, trade in agricultural products and consequently, in agribusiness. The green revolution represents the technological breakthrough in agriculture by:

- Development of high-yielding seed varieties,
- Use of chemical fertilisers,
- Chemical control of diseases
- Mechanisation of agriculture,
- Use of irrigation technologies.

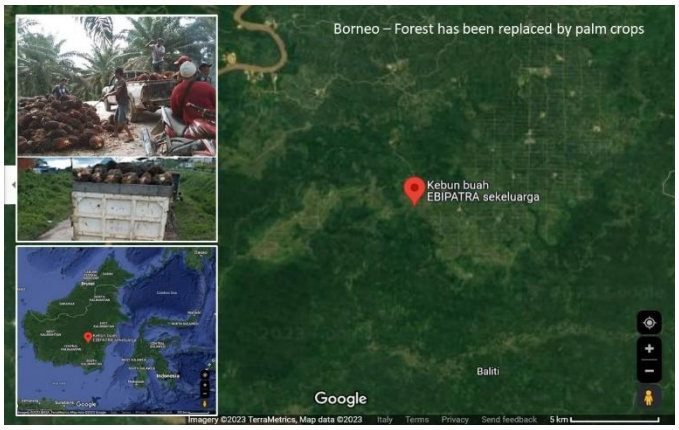
This led to the transformation of a small-scale agriculture into large-scale agriculture, even industrial scale, that increased the agricultural productions with advantages (e.g., simplification of the production system, Increased production efficiency of agricultural land, reduction of world hunger) and disadvantages such as the environmental unsustainability in the medium-long term to balance the reduction of the world hunger (e.g., loss of biodiversity, impoverishment of soil fertility, contamination of surface and groundwater, soil erosion). Today, the Internet of Things and machine learning are posing challenges but also simplifying the management of agricultural productions.

Environmental impacts of agriculture

Land use change and soil degradation

134,1 Mkm^2 is the total available surface on Earth (excluding ice regions) which over the past 300 years, globally, has faced drastic changes in cover and land use types.
Due to the population growth and the need for food production, forests, steppe, shrubs but also extreme environments such as deserts and tundra have witnessed a surface reduction, while agricultural areas have increased. Recently the appropriation of natural lands by land use systems has been estimated for the whole world and higher risk has been identified for temperate and Asian humid areas, besides wetlands (Hansen, 2022) as you can see in the Earth Engine App (https://glad.earthengine.app/view/global-land-cover-land-use-v1).

Deforestation is also an important threat, not only for the forest habitat disruption but also for eliminating the main carbon sink and causing greenhouse gases emissions with repercussions on the greenhouse effect. Nowadays we consume more natural resources than those available on Earth and the effects of climate change urge the identification of sustainable solutions for food production to guarantee the natural resources to future generations.



Deforestation of Borneo's tropical forest for the intensive cultivation of palm trees for oil productions. Source: edited Google Map.

Population's increase and soil threats

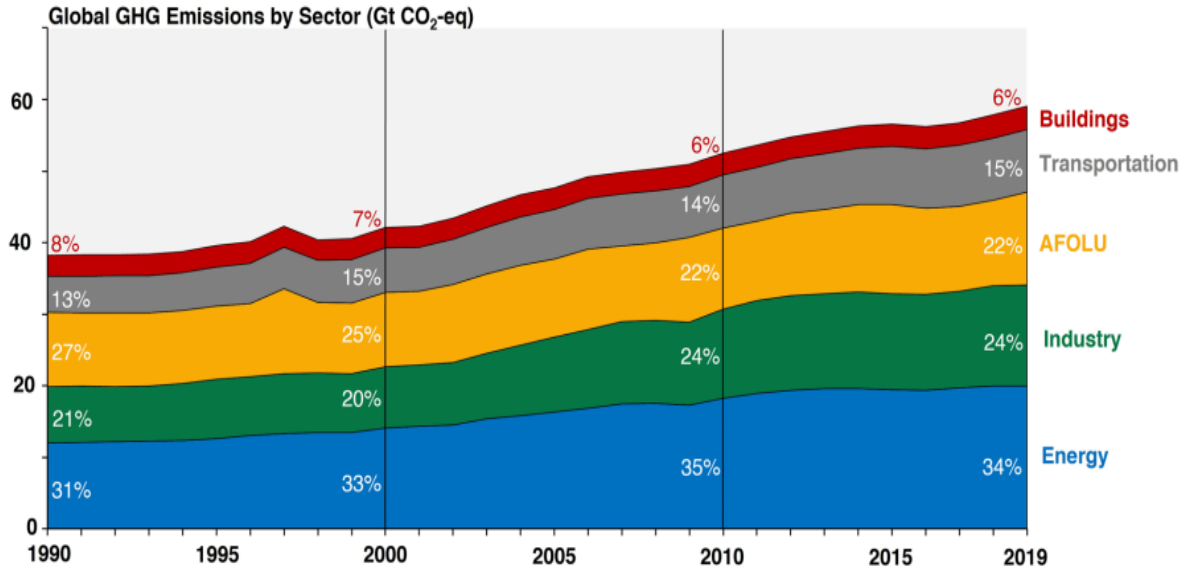
In addition, the continuous growth of the world population (UNDESA, 2022) (with an estimate of 9.7 billion in 2050, 2 billion more than today) is increasing the demand for food, threatening the agricultural area. In fact, from 1961 to 2016 it decreased from about 0.45 to 0.21 hectares per capita (FAO, 2020a) due to anthropic and environmental pressures: urbanisation, climate extremes, scarcity of water, pollution, exacerbate and increase the loss and degradation of the land. In 1994, the United Nations Convention to Combat Desertification (UNCCD, 1994) provided a binding definition of land degradation in Article 1.

> *"Reduction or loss, in arid, semi-arid and dry sub-humid areas, of the biological or economic productivity and complexity of rainfed croplands, irrigated croplands or rangelands, pastures, forests and forests resulting from land use or from a process or combination of processes, including processes resulting from human activities and habitat patterns such as soil erosion, deterioration of the physical, chemical, biological or economic properties of the soil and the long-term loss of vegetation".*

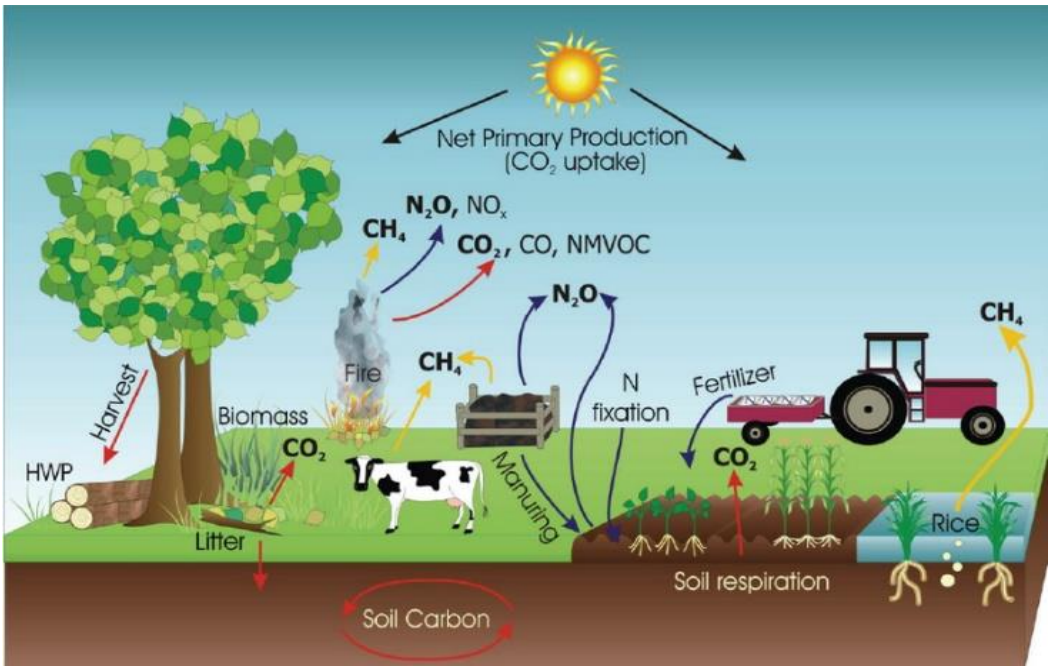
In the definition "soil" means a "terrestrial bio-productive system that includes soil, vegetation, other biota and the ecological and hydrological processes that operate within the system", whose main threats are water and wind erosion, nutrient depletion, salinity and contamination.

Greenhouse gases (GHG) emissions

According to the Intergovernmental Panel on Climate Change (IPCC, 2022), on a global scale, electricity and heat productions, industry, transportation, and buildings (due to burning of coal, natural gas, and oil) are the main sources of GHG (76%), and agriculture, forestry and land use change (AFOLU) are responsible for 22% GHG emissions mostly from the cultivation of crops and livestock and deforestation.



Global Greenhouse gases emissions by sector (Gt CO_2-eq) (IPCC, 2022).



Greenhouse gases emissions and uptakes in agriculture (Paustian et al., 2006; IPCC, 2006)

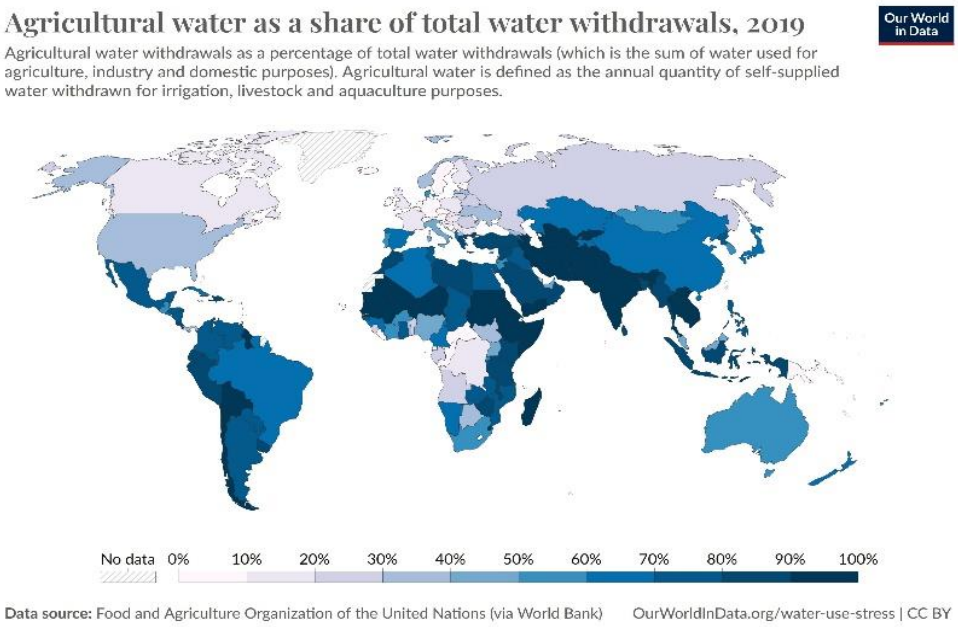
Although crops partly contribute to the absorption of carbon dioxide, farming is responsible for GHG emissions, as shown in the following picture (IPCC, 2006).
Agriculture and animal husbandry releases methane and nitrous oxide as well as conventional tillage and use of fertilisers which are responsible for N_2O emissions.
Deforestation not only releases CO_2 due to burning and rapid mineralization of the soil organic matter, but it counteracts the removal of carbon dioxide by trees' photosynthesis, reducing the carbon storage.
A more recent report (FAO, 2020b) states that in 2018, world agriculture and related land use emissions reached 9.3 billion tons of carbon dioxide equivalent (Gt CO_2eq) emissions mainly from crop and livestock (5.3 Gt CO_2eq), and land use/land use change activities (3.9 Gt CO_2eq).

GHG emissions (in CO_2eq) from agricultural sources			
Source of non-CO_2 emissions (e.g., CH_4 and N_2O) (5.3 Gt CO_2eq)		**Emissions from land use change (3.9 Gt CO2eq)**	
Enteric fermentation	39%	Deforestation	74%
Livestock manure	20%	Drained organic soils, CO_2	18%
Synthetic fertilisers	13%	Organic soil fires	5%
Rice cultivation	10%	Biomass fires	2%
Manure management	6%		
Burning savanna	5%		
Crop residues	4%		
Drained organic soils (non-CO_2)	2%		
CO_2 equivalent (CO_2eq) is a metric measure used to compare the emissions from various greenhouse gases (e.g., CH_4 and N_2O) on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential.			

Emissions of greenhouse gases due to agriculture. Global, regional and country trends 2000–2018 (FAO, 2020b).

Water withdraws and inefficient use

In addition, 70% water withdrawn from rivers and aquifers is used for irrigation in agriculture, while 10% is for domestic purposes and 20% in industry.
Agriculture is the sector with the lowest return of water into the underground water as part of it is lost by evaporation and part is used by vegetation for growing.
The countries with the greatest surface of irrigated land are those with the greatest agricultural area and intensive agricultural productions (e.g., China, US, India), and those where evapotranspiration is very high (e.g., drylands) (Ritchie and Roser, 2024; OWID, 2019).



Agricultural water as a share of total water withdrawals (OWID, 2019)

Other environmental impacts

Agriculture also is a source of soil and water pollution: leaching of fertilisers, use of pesticides and livestock effluents contribute to the pollution of waterways and groundwater. For instance, the herbicide atrazine, which was banned in many countries a few decades ago, is still found in surface and groundwater due to its high persistence in the environment, threatening the aquatic environment and the food chain. More recently, controversy has emerged regarding glyphosate, the world's most widely used commercial synthetic herbicide, that has been found to threaten the environment and human health after exposure to high doses for prolonged periods.

Carbon and water footprints

In order to assess the actual environmental impact of things and processes, **the carbon footprint is used.** The carbon footprint is a measure of the total amount of carbon dioxide (CO_2) and other greenhouse gases emissions such as methane (CH_4) and nitrous oxide (N_2O), that are linked to the object, person or system or activity. It considers all the relevant sources and sinks and storage and it is calculated as carbon dioxide equivalent using the relevant 100-year global warming potential (GWP100). The average carbon footprint for a person in the United States is 16 tons, one of the highest rates in the world. Globally, the average carbon footprint is closer to 4 tons.

The **carbon footprint can be calculated for food products**, by taking into consideration all the processes behind the production and the delivery of any single component and assessing the amount of carbon dioxide equivalent released to produce it. Food contributes 10-30% of a household's carbon footprint, mainly attributed to the **agricultural practices** used to produce it and the

transportation. For instance, meat products have large carbon footprints due to the large amount of feeding that is needed and the release of methane from manure. In contrast, plant products like vegetables and grains have lower carbon footprint because of the efficiency in absorbing CO_2 for photosynthesis, although the use of chemical fertilisers, tillage and other machinery that cause emissions. The Centre for Sustainable Systems of the University of Michigan has developed Food Footprints and Sustainability Indicators factsheets (https://css.umich.edu/publications/factsheets) which provide information regarding different food types, diets, and regarding other aspects of life habits .

Food habits and diets can be assessed in terms of carbon dioxide emissions. Some years ago, Scarborough et al. (2014) surveyed the real-life diets of British people and the average dietary greenhouse-gas emissions per day found in the study are reported in the following table.

Carbon footprint of dietary habits per day	Kg CO_2eq / day
High meat-eaters	7.19
Medium meat-eaters	5.63
Low meat-eaters	4.67
Fish-eaters	3.91
Vegetarians	3.81
Vegans	2.89

Carbon footprint of real-life diets of British people (Scarborough et al., 2014).

There are tools that allow the calculation of the food carbon footprint, so that a dish, a food habits or diets can be assessed. **GOODFOOD library** available at this link https://goodfoodeplus.cebas.csic.es/educational-material-2/, offers a list of **free calculators in the form of Apps** (e.g., Myemissions; Zero Foodprint etc. – also see the Digital Tools chapter in this book) developed by acknowledged organisations.

The **water footprint** is defined as the total volume of fresh water used to produce the goods and services consumed by the individual or community or produced by the business.
When we buy a food product, we should consider that some water was needed to produce it (e.g. irrigation, animal beverage, washing, transforming the products etc.). The amount of water used to produce such a food is called **virtual water** which means hidden in the product, services and processes. Crops can grow only if rain or fresh water - which is underground water or river water, are available. Then, some crops can be used and sold after the harvest, some others enter into a process chain as livestock feeds or transformation processes that produce other products and may require more water. This is why animal products generally count higher virtual water than plant-based foods. Also other processes such as packaging require water for washing and processing some foods, so that the virtual water of the products enters into a wider geographical system due to the transportation of goods in the supply chains.

Water footprint of some foods (L / kg)	
Bovine meet	15415
Nuts	9063
Sheep-goat meat	8763
Pig meat	5998
Chicken meat	4325
Eggs	3265
Cereals	1644
Milk	1020
Fruits	962
Vegetables	322

Global averages of some food water footprint (Amstrong, 2023).

Look at the GOODFOOD library for the list of calculators (see also the references of this book) to calculate the food water footprint. Due to an increase in extreme events of climate change such as droughts, many agricultural areas are becoming extremely vulnerable especially as food demand and agricultural productions become necessary to a greater extent.

How to achieve sustainable food productions

In the broadest sense, sustainability:

- Is the ability to maintain or support a process over time.
- Concerns three core concepts: economic, environmental, and social.

In agriculture, there is the need to introduce innovations for a more efficient use of resources and improve environmental sustainability. When agricultural operations are sustainably managed, they preserve and restore critical habitats, help protect watersheds, and improve soil health and water quality. But unsustainable practices have serious impacts on people and the environment. At any scale and in many places, agriculture has reached a point in which natural resources such as soil and water are dramatically compromised, thus there is a strong need to reduce its impacts. Research has brought to the definition of practices that can make productions more sustainable even at large scale.

Conventional vs. sustainable farming

In summary, conventional, and sustainable agricultures can be summarised as follows:

Characteristics of conventional vs. sustainable agriculture	
Conventional agriculture	**Sustainable agriculture**
High Specialisation • Monoculture • Standardised production methods • Minimum genetic diversity • Separation of crops and animals • Highly specialised methods and machineries • Highly specialised science and technology oriented to optimise the production methods **Competition** • Lack of cooperation • Traditions and rural culture are not considered • The management of the company focuses on the profit • It emphasises quantity and profit	**None/less specialization** • Soil functions are maintained • Growth and decay are balanced • Production is maintained over long periods • Limited external inputs, mainly from organic origins • Harmony with nature • Humans are part of nature, natural systems are the main inspiration **Diversity** • Genetic diversity • Species diversity for productions and other weeds and soil fauna • Integration between crops, and between crops and trees or animals • Climate, landscape-based productions • Science and technologies applied for an interdisciplinary goal **Support to local community** • Cooperation • Traditions and culture • Landscape and environmental quality • Unprocessed and naturally nutritious food

Characteristics of conventional vs. sustainable agriculture (Baronti and Ugolini, 2020).

Regenerative agriculture

We speak about **regenerative agriculture** as an approach for food and farming systems that focuses on the regeneration of topsoil, the conservation of fertility and biodiversity, improving the quality of soil and ecosystems. Regenerative agriculture makes use of different systems for a sustainable agriculture such as the ones showed in the photos and described below.

Making efficient nutrient and water management, saving the natural resources allow to save costs of production, maximise crop yields, thus increase profit.

- **Sod seeding or no tillage (or low) agriculture** aims to produce without any soil tillage, by choosing the most appropriate crops in rotation in order to preserve the soil fertility, enhance soil aeration and carbon storage. This technique is considered **conservation agriculture** which aims to produce by enhancing the soil nutrients by minimum tillage, cover crops and diversification of the species and productions (FAO, 2022).

- **Agroecology** is based on locally available inputs and nutrients recycling, diversification of production, knowledge of the landscape and careful management of biodiversity and soil fertility. For instance, it uses cover crops and perennial crops to reduce invasive weeds by natural competition for resources, to enhance soil aeration, nutrients and to maintain soil moisture. **Use of legumes** as cover crops or associated to other crops as they have nitrogen fixing bacteria living in root nodules. These bacteria can convert the atmospheric nitrogen into ammonium and since they live in symbiosis with legumes, they allow these plants to be rich in nitrogen and valuable to enrich soils.
- **Permaculture (permanent agriculture)** is an approach that adopts species arrangements observed in flourishing natural ecosystems, since different species next to each other can have a mutual benefit.
- **Agroforestry** is a combination between trees and crops or livestock that allows the diversification of productions, prevents wind erosion and soil evaporation.
- **Use of organic fertilisers and amendments** (biochar, crop residues, manure, compost) enhances soil fertility, reduces soil erosion and preserves soil moisture. Organic matter is degraded by microorganisms, releasing nutrients to plants (e.g., mineralization produces ammonium which is then transformed by other microorganisms into nitrite and then nitrate which can be absorbed by plants.

Then, other agricultural production practices that provide benefits are:

- **Agronomical adaptation practices** such as sowing shifts (e.g., anticipating the date of sowing) and use of more resistant cultivars to reduce the risks of failures for extreme droughts in summer.
- **Pest and disease biological control** by exploiting the relationships between plants and the soil microbial systems to enhance the plant vitality and growth.

Sustainable crop farming	
Sod seeding 	*Agroecology: legumes and corn* 
Permaculture (combination of species) 	*Agroforestry* 
Organic amendment with biochar 	*Organic mulching with straw* 

Sustainable crop farming systems considered as regenerative agriculture.

Precision agriculture

Precision farming through precision irrigation and fertilisation adopts smart and even low-cost technologies to manage the resources in a more efficient way: irrigation schedule and quantities are calculated and supplied based on the real needs (e.g., crop growth stage, climate, soil chemical and moisture). The information can be obtained from sensors installed in agrometeorological stations in the field, or from images taken from remote devices like drones or satellites.

Technologies for the sustainable use of water and fertilisers

Agrometeorological stations

Precision agriculture with drones

Technologies for the sustainable use of water and fertilisers in precision agriculture.

Sustainable livestock productions

In livestock productions, some sustainable practices include pasture management like:

- **Rotational grazing** in which livestock is moved to portions of the pasture, called paddocks, while the other portions rest, with the intent to allow the pasture plants and soil time to recover.
- **Silvopastoral systems** in which cattle graze in pastures with trees. These systems have been shown to increase the biodiversity of ground insects and birds compared to conventionally grazed pastures, but also the welfare benefits for the animals that use trees' shade and protect from winds.
- **Re-seeding** pastures to enhance grassland biodiversity, enhance the animal diet and recover and reduce soil compaction.

Sustainable livestock farming

Rotational grazing

Silvo-pastural systems

Sustainable livestock farming systems.

Agricultural biotechnologies

Recently, agricultural biotechnology has been introduced for a wide range of motivations. It includes a range of tools, including traditional breeding techniques, that alter living organisms, or parts of organisms, to make or modify products; improve plants or animals; or develop microorganisms for

specific agricultural uses. Modern biotechnology includes the tools of genetic engineering (USDA) to produce **Genetically Modified Organisms**. These are organisms **whose DNA has been altered using genetic engineering techniques**. Biotechnology provides farmers with tools that can make production cheaper and more manageable. For example, some biotechnology crops can be engineered to tolerate specific herbicides, which make weed control simpler and more efficient. Other crops have been engineered to be resistant to specific plant diseases and insect pests, which can make pest control more reliable and effective, and/or can decrease the use of synthetic pesticides (USDA, 2024).

Contrasting aspects of biotechnologies are connected to the introduction of new varieties and Genetically Modified Organisms. For thousands of years, humans have used breeding methods to modify organisms. Corn, cattle, and even dogs have been selectively bred over generations to have certain desired traits. Methods such as selective breeding and crossbreeding take a long time and may often produce unwanted traits. Instead, specific targeted modification of DNA has allowed scientists to avoid this problem and improve the genetic makeup of an organism without unwanted characteristics.

However, the introduction of these cultivars in the environment constitutes a threat to local varieties that may cross with these GMOs and lose the original genetic diversity. The most famous activist fighting for sustainable agricultural productions is Vandana Shiva (1952-) who has been fighting against biotechnology, genetic engineering besides intellectual property rights. She supports the protection of diversity and integrity of living resources, especially native seed, the promotion of organic farming and fair trade, educating farmers to the benefits of maintaining diverse and individualised crops rather than accepting offers from monoculture food producers. In the area of intellectual property rights and biodiversity, Vandana Shiva challenged the biopiracy of neem, basmati and wheat, supporting the idea of seed freedom, and the rejection of patents on new plant lines or cultivars as they have ties with the corporate sector.

Sustainable food labels

Many businesses and governments have committed to sustainable goals, such as reducing their environmental footprints and conserving resources, but whether some are actively embracing sustainability investments, known as "green investments", some others are practising the "greenwashing," the practice of misleading the public to make a business seem more environmentally friendly than it is.

However, there are **labels that certify the environmental sustainability of production processes** such as the most known logo of “organic agriculture”.

> *"a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasises the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system."* (FAO, 1999).

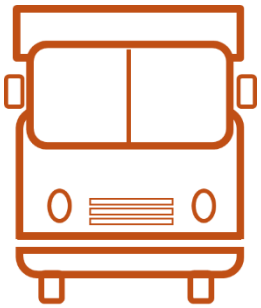
Logo of organic agriculture in Europe.

In Europe, the green logo certifies a product from organic agriculture thanks to a system of certification and labelling. This means that consumers are aware about how the food they buy is produced, processed, handled and marketed. Organic agriculture aims to reduce the use of chemical inputs, thus reducing groundwater pollution or creating a more biologically diverse landscape.

Certifications for sustainability are many as you can see at the Ecolabel Index website, at this link https://www.ecolabelindex.com/ecolabels/?st=;category=food;region=europe, among which, well know certifications are:

- *Rainforest Alliance* which aims to conserve biodiversity by promoting sustainability and sustainable farming for cocoa, coffee, tea and hazelnuts to "maximise positive social, environmental, and economic impact, offering farms an enhanced framework to improve their livelihoods while protecting the landscapes where they live and work."
- *Fairtrade International* born in 1997. Fairtrade International "ensures minimum prices and demands that producers are paid a premium to be invested back into the community" (https://www.fairtrade.net/).

Sustainable Food Availability and Food Selection



By Demetris Mylonas and María-Teresa García Conesa

This chapter includes two aspects:

i) **Sustainable Food Supply** which regards transportation, packaging, and conservation, and
ii) **Sustainable Food Selection** that concerns different cultural, social, and environmental factors that influence our daily food choices.

Sustainable Food Supply

Transportation and short food supply chains

"Food supply chain" is the term we use to describe the process of bringing the food from the producer to the consumer. Often these processes involve a great number of intermediaries (e.g. distributors, wholesalers, retailers, food service operators, etc.) and the travel of food from the producer to the supermarket shelves or the consumers is rather long, resulting in higher costs for food, higher energy consumption (for transport, storage, packaging, etc.), higher CO_2 emissions especially regarding the transportation of food, and issues regarding food's traceability and safety given the absence of interaction between producers and consumers.

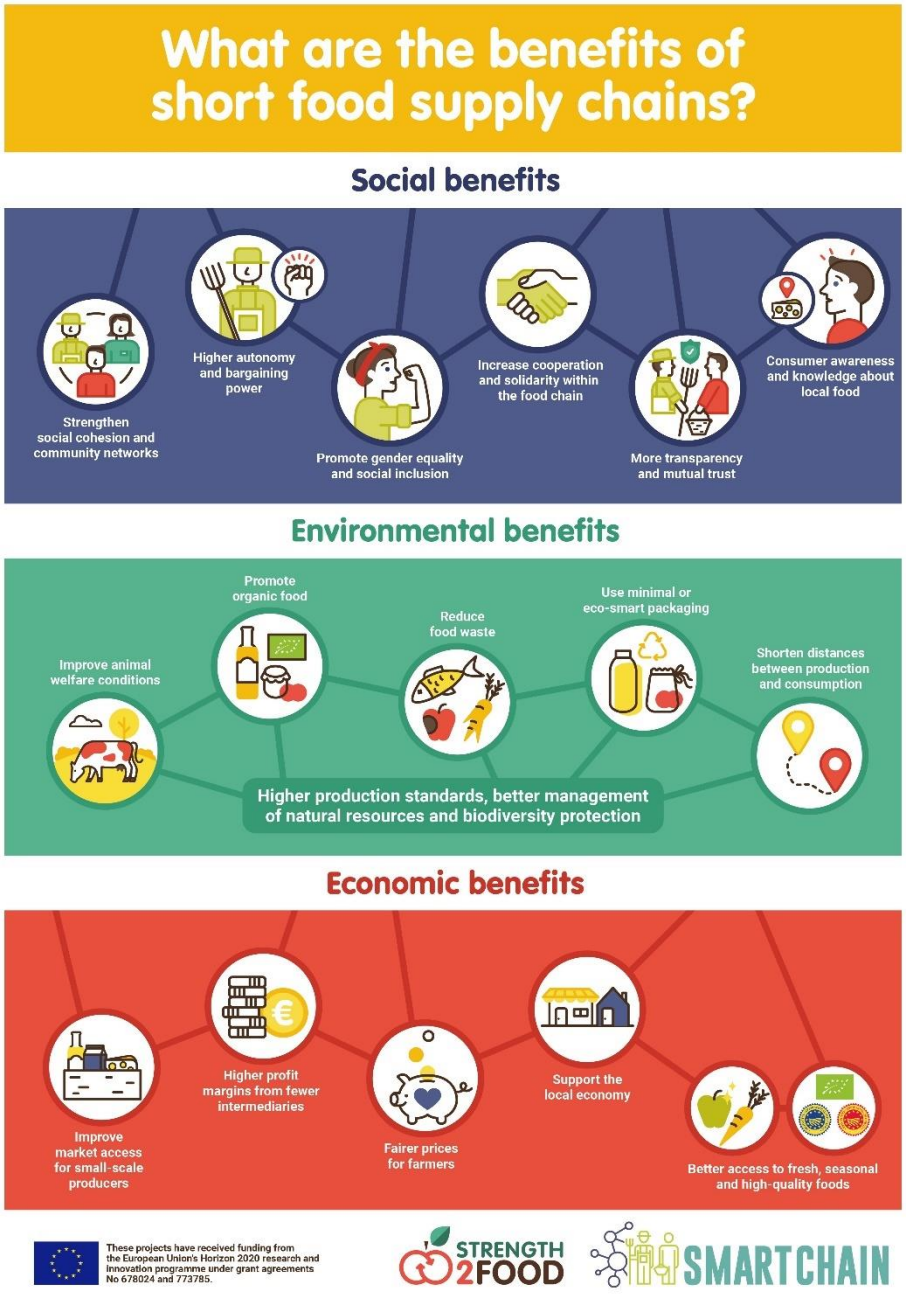
In an effort to promote more sustainable food supply systems, the concept of **short food supply chains was born** in the European Union's rural development regulation (1305/2013):

> *"a supply chain involving a limited number of economic operators, committed to cooperation, local economic development, and close geographical and social relations between food producers, processors and consumers"* (EU, 2013).

In essence, a short food supply chain is defined as **involving a short physical distance** and/or having **as few links as possible** between the food producer and the consumer/citizen who eats the food. What are the benefits of Short Food Supply Chains?

- **Environmental benefits** – Reduction of CO_2 emissions due to shorter distances of food transportation, reduction of energy consumption for storage, transportation, packaging etc., reduction of food waste, contributing to the fight against climate change.
- **Economic benefits** – Reduced costs of energy and transportation, improvement of the producers' negotiating position by giving them a more direct access to the market, increased income for the producers while keeping food end-prices at the same levels for consumers, opportunities for jobs creation especially in rural areas.
- **Social benefits** – Increased communication/interaction between the producers and consumers who have a say in the production process, increased transparency of the supply

process, higher quality of food by reducing the need for freezing and/or use of preservatives and allowing customers access to a fresh food supply, reduced risk of damage or contamination of food during transportation/ packaging.



Benefits of short food supply chains infographic from Strength2Food and SMARTCHAIN projects (EU-funded projects).
https://www.strength2food.eu/2021/05/26/what-are-the-benefits-of-short-food-supply-chains-infographic/

Food miles – an indicator of sustainability of food supply

The "food miles" is a way to attempt to assess the environmental impact of food supply, by taking into account the distance the food has travelled from where it was produced to the consumer, the mode of transport, and also the food waste taken away from the consumer and to the disposal site.

During the last decades, with the globalisation of the food industry and the continuous increase in food imports and exports, the distance food travels from its production site to the consumer's plate increases. Responding to the consumers' demand, nowadays we are very often offered food that has travelled a long way and/or is often out of season in our country. The transportation of food is made by aeroplane, ships, trains and road transport (trucks), adding to the CO_2 emissions, air pollution, traffic congestions, accidents and noise pollution.

By measuring the food miles for a specific food ingredient and considering the mode of transport used, we are in a position to calculate the impact in terms of kilograms of CO_2 or carbon generated. In principle, the shorter the distance food needs to travel to get to us, the lower the environmental impacts.

A free food miles calculator can be accessed at the following website: www.foodmiles.com

Forms of Short Food Supply Chains

Short Food Supply Chains can take different forms, either focusing on the direct connection between the producers and the consumers or including an intermediary that offers to the consumers clear information about the food production. Different forms of short food supply chains are presented below.

- **Direct sales from the farmer to the end-consumer:** This is perhaps the simplest form of Short Food Supply Chains, and includes on-farm sales, farmers' markets and internet deliveries. The farmers offer their products for sale either on the farm or through a farmers' market or online, and consumers select to buy the products they are interested in without any other obligations towards the farmers.

A farmers' market.

- **Community-Supported Agriculture**: It is an alternative socio-economic model of agriculture and food supply, whereby the producers and consumers connect and share the risk of farming. The consumers (community) support the producers financially through a subscription, in return for the supply of quality fresh (usually organic) products in season throughout the year. The supply is usually done through the delivery of weekly or by-weekly boxes with the quantity of

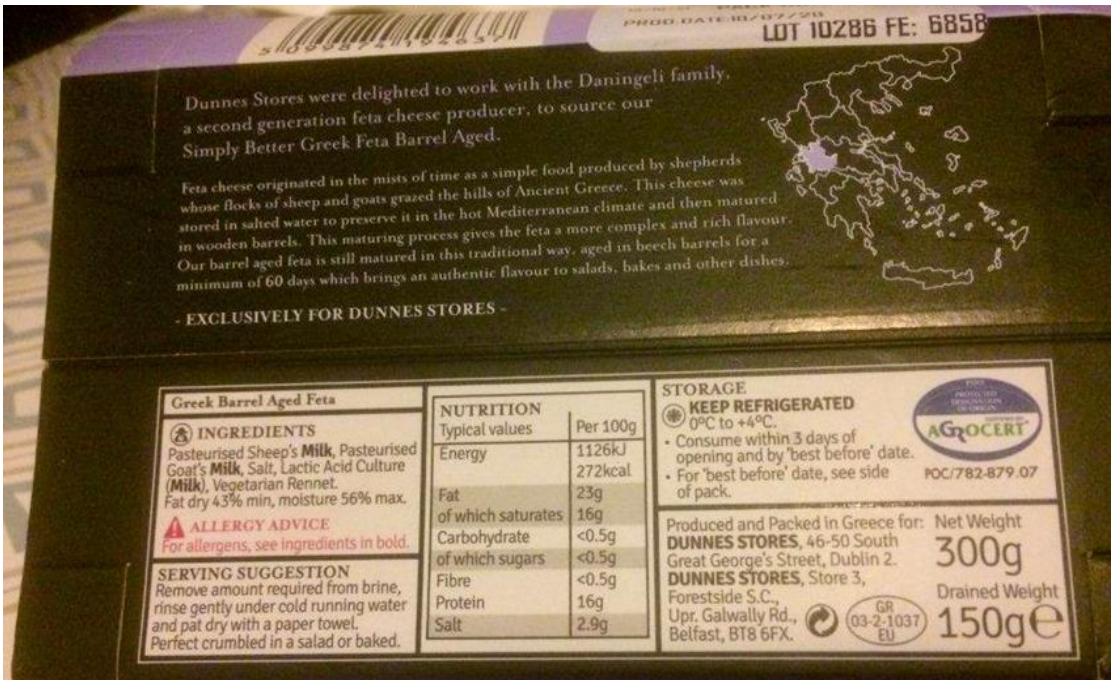
produce corresponding to the subscription, although other methods for the supply of the produce or the subscription may apply – in some cases Community-Supported Agriculture schemes may include an option for contributions in labour in lieu of a portion of the subscription costs. The produce may include in-season fruits, vegetables, and can expand to dried goods, eggs, milk, meat, etc. (see for instance: https://www.montgomerycountymd.gov/agservices/farm-to-table/csa.html).
In Community-Supported Agriculture schemes the focus is on the direct connection between the producers and consumers, and building relationships based on trust is key; in this direction farmers usually maintain contact with their subscribers by regularly sending newsletters of what is happening on the farm, inviting them for harvest, or holding open-farm events. The subscriptions from the consumers/community help provide financial stability and cover the production costs as well as fair wages for the producers (Tay et al., 2024).

There are four main types of Community-Supported Agriculture to-date:

- **Farmer-led:** A farmer sets up the Community-Supported Agriculture programme and is responsible for recruiting subscribers and managing the scheme.
- **Community-led:** Members of a local community set up the Community-Supported Agriculture programme and hire farmers to grow the crops – the management is the responsibility of the shareholders/subscribers.
- **Farmer cooperative:** Multiple farmers cooperate and jointly create a Community-Supported Agriculture scheme.
- **Farmer – community cooperative:** Farmers and members of a local community set up and jointly manage a Community-Supported Agriculture scheme.

- **"Pick your own" schemes:** Pick Your Own or U PICK farms are farms inviting the consumers/customers to the farm to harvest themselves, offering a rewarding experience of coming closer to the land. Although this scheme first appeared in Canada and the USA, in recent years it is also becoming popular in Europe, especially since farmers are increasingly becoming aware of and implementing sustainable and environmentally farming methods like regenerative agriculture, conservation agriculture etc. placing the emphasis on regenerating the farms' soil and biodiversity. Through Pick Your Own, the consumers have an opportunity to learn more about how their food is produced, develop a direct relationship with the land and enjoy a rewarding experience.

- **Through an intermediary that provides information to the consumers about the food production**: supermarkets, grocery stores, butchers, organic food markets, community markets etc. have a direct connection to the producers and are responsible to offer to the consumers clear information about where the food was produced, by whom, and how (e.g., organic farming, biodynamic farming, etc.). Although the focus is usually on local produce, this may also apply to imported products like in the example below where Greek feta cheese available in an Irish supermarket clearly labels information about where the product was produced and who produced it.

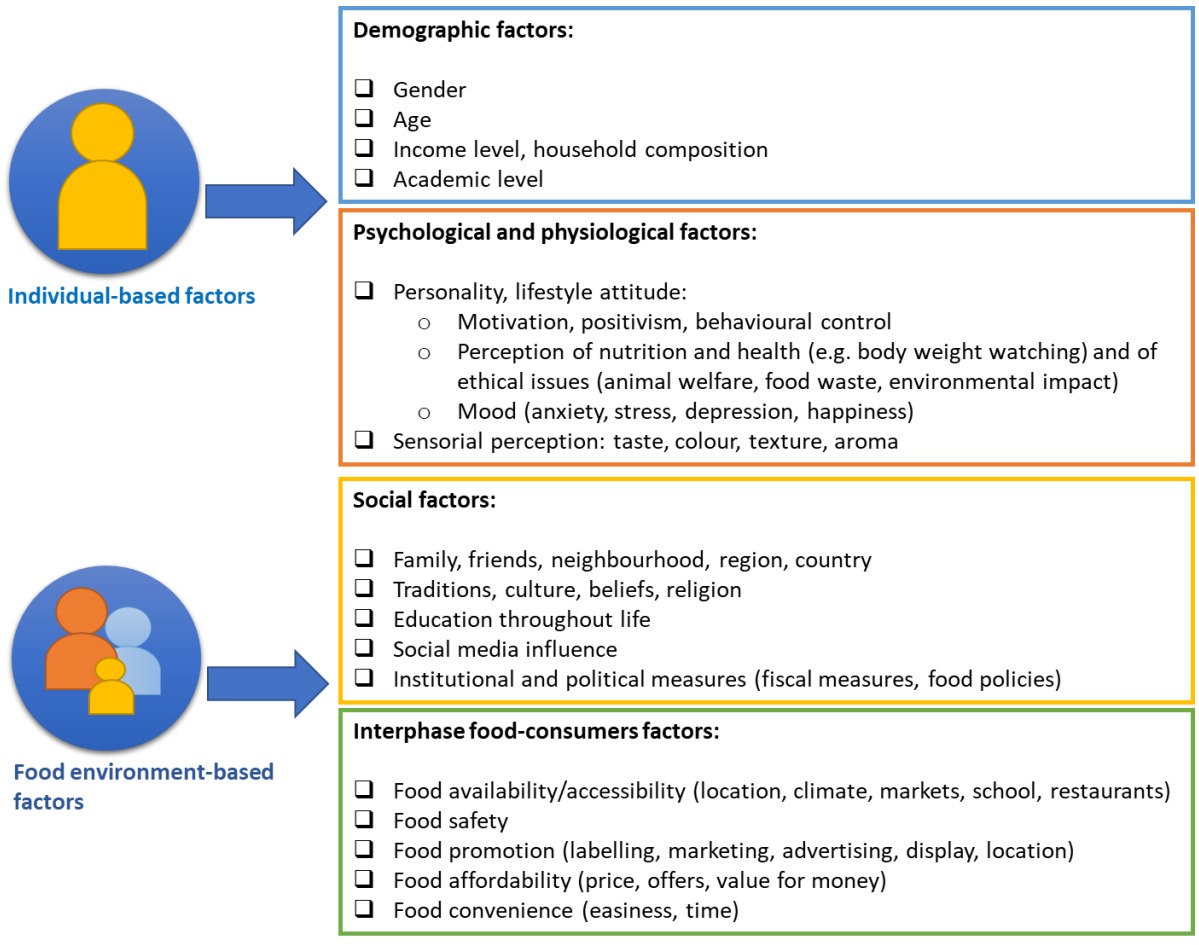


Packaging of feta cheese (a PDO – protected destination of origin – product of Greece) in an Irish supermarket with a clear labelling informing the consumers of where the product comes from and who is the producer (Agrobridges, 2021).

Sustainable Food Selection

Factors Influencing food selection: understanding consumer-decision making

The development of a more sustainable and healthier food system involves a change in the food consumption paradigm and in the food choices of the general population. The transformation of food habits is, however, a complex and slow process (some years or even generations) that requires a better knowledge and understanding of the different reasons and factors that make us choose our daily food. This knowledge will help to improve the policy interventions, and the overall market activities and protocols to move towards a more sustainable world (Fanzo et al., 2022). A lot of research in this area has tried to identify the many different factors and aspects that need to be considered in relationship with the consumer decision-making about their food selection. In the next diagram, we present a summary of some of the main factors identified, grouped in different categories.



Summary of the main identified individual-based and environment-based factors for consumers food decision making. Diagram designed by María-Teresa García Conesa.

Understanding food choices during adolescence is especially important because dietary and lifestyle habits during this period has a major impact and influence on their future habits and health. Food choices may be particularly influenced by specific factors in adolescents including the region (rural, urban) and social environment (home, school, leisure) in which they grow up.

Importantly, during adolescence, the students go through major biological and neurodevelopmental changes that require specific and adequate nutrition. These changes also influence their own motivations and behaviours including dietary habits. In westernised developed mid and high-income countries, body image, identity and sense of belonging, social sensitivity, sharing, taste, and affordability all influence the adolescents' lifestyle and food choices. Of note, adolescents tend to seek unsupervised places (away from home or school) to share food with their friends. Also, there appears to be a trend to reject traditional home-cooked food in favour of unhealthy snack foods (e.g. pizzas, burgers, chips, etc). Even though the adolescents seem to acknowledge the importance of a healthy diet and of the intake of healthy foods (fruits, vegetables, legumes or nuts), they do not necessarily translate this into daily action, especially when they are with friends. The high presence, proximity and promotion of inexpensive nutrient-poor unhealthy foods also influences the adolescents' choices (Neufeld et al., 2022).

During adolescence, the students will slowly move from a time of total dependence to increased autonomy and responsibility in relationship with food consumption which will change who buys and prepares the food, when and who to eat with, and what are their priorities and choices. Thus, adolescents may have a lot to say about why/what they eat what they eat, and they must participate actively in the actions that will support sustainable and healthy eating (Ziegler et al., 2021).

Nutritious and Healthy Food Consumption

By María Teresa García Conesa and Rocío García Villalba

Food and diet definition, composition and roles in our body of the main food components.

Food constitutes the essential source of nutrients which provide the energy our body needs to function as well as the substances needed for the growth, repair, and maintenance of our body cells and tissues. The major groups of nutrients are carbohydrates, fats, proteins, minerals, vitamins, and water which are present in most foods in different quantities. The **diet** is defined as the mixture of foods and drinks usually consumed by a person or a community of people. Diet varies between countries, regions, societies, and individuals. A **healthy diet** helps to maintain, recover or improve our health. There are several different diets that have been investigated and designed with the aim of providing healthier foods, to protect against Malnutrition in all its forms. Among these diets, the **Mediterranean Diet** (MD) constitutes a classical and excellent example of a diet associated with good health and longevity, it is investigated and recommended for its impact on long term health benefits and constitutes a good model for sustainable food choices (Dobroslavska et al., 2024).

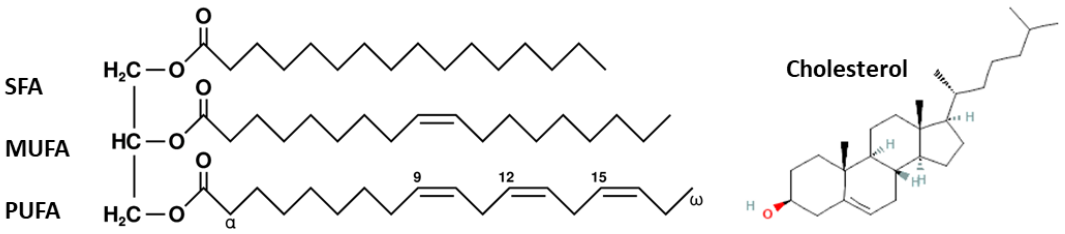
Major food components and types of foods: macro- and micronutrients.

Macronutrients. Needed in larger quantities

- **Carbohydrates (Carbs)**. Main providers of the energy that supports the body functions and physical activity: 1) complex carbs, like starch, digested in the human intestine to form single molecules (sugars) and 2) simple carbs (sugars: e.g. glucose) which constitute the main source of energy for our cells, tissues and organs. Glucose can be used immediately or stored in the liver and muscles for later use. The fibre is a complex carb that is not well digested by the human digestive small intestine but goes to the colon where it is metabolised by the microbiota (bacteria that live in our intestine) with important effects on our health (Ramsteijn and Louis, 2024). The main foods that contain carbs can be divided into 1) low processed carbs: wholegrain cereals and derived products (bread), fruits, vegetables, legumes, and 2) highly processed or refined carbs: white bread, pasta, sweets, cakes, pastries, rice, potatoes, sugar, juices and drinks with high levels of sugar.

Examples of foods rich in carbohydrates (whole bread, legumes, potatoes, fruits).

- **Fats.** Dietary fats (mostly triglycerides, TGs) also provide energy as well as essential vitamins (A, D, E, K) and other important components (fatty acids (FAs), cholesterol) which form part of the cell membranes or are involved in the synthesis of hormones. FAs are made of carbon chains that can contain double bonds, and TGs can be classified into different types with different FA composition, structural, and quality properties: 1) Unsaturated fats include monounsaturated FAs (MUFAs: 1 double bond) and polyunsaturated FAs (PUFAs: 2 to 6 double bonds). These double bonds modify and bend the structure as well as the fat status (solid or liquid). Among the PUFAs, the ϖ3 and ϖ6 PUFAs are essential and have important health benefits; 2) Saturated fats (SFAs): the FAs have all single bonds, the structure remains straight; 3) Trans-fats: are also designed hydrogenated fats contain a double bond but the structure of the fatty acid remains straight. Cholesterol is an essential component of our cell membranes. It is synthesised by all cells and tissues, but it is also consumed as part of the diet from animal foods like eggs, shellfish, meat, liver, full-fat dairy products (cheese, milk).

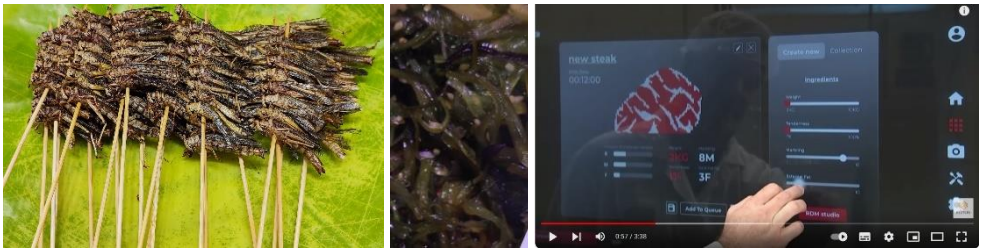


Left. Main structure of a triglyceride with saturated (SFA), monounsaturated (MUFA), and polyunsaturated (PUFA) fatty acids. (Wikipedia, 2005).
Right. Cholesterol molecule (National Center for Biotechnology Information, 2024).

The main food sources of monounsaturated fats are vegetable oils from olives, canola, etc. Polyunsaturated fat is found in sunflower, corn, soy oil, walnuts, fish. Animal foods such as red meat and derived products (i.e. sausages, hamburgers, bacon), butter, cheese, and ice cream, generally contain considerable quantities of saturated fats. Some plant oils (coconut, palm) also contain saturated fats. The trans-fats are mainly present in highly processed foods (e.g. solid margarine attained from partially hydrogenated oil, pizzas, snacks, industrial bakery, etc) although these trans-fats are now being limited and (or) eliminated from many products. Overall, eliminating trans-fats and replacing saturated fats with unsaturated fats, especially ϖ6 PUFAs improves cardiovascular health (Retterstøl and Rosqvist, 2024).

Examples of foods rich in saturated fats (butter, cheese) and monounsaturated fats (olive oil).

- **Proteins.** The proteins are the main building molecules of all the tissues (muscles, bones, skin, etc) in our body and are needed for growth and repair of cells. They also function as enzymes that control most of the reactions that take place in our cells and are involved in the transport of oxygen (haemoglobin). Proteins are made of 20 basic units, the amino acids (Aas). Some Aas can be synthesised in our body but others (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine, must come from food (essential Aas). The main dietary sources of Aas are found in animal foods such as meats, milk, fish, and eggs. Protein can also be obtained from plant foods such as soy, legumes, nuts, and grains (wheat germ, quinoa). New sources of protein are also being investigated and developed such as protein from insects, microalgae, artificial and cultured meat (Quintieri et al., 2023).



New sources of food rich in protein: algae, insects and cultured meat. 3D printed meat from the video: More 3D-printed steaks are coming to Europe https://youtu.be/zQSCzHaMcTg?si=05QQOu0l-C0lehY0

- **Water.** Water accounts for approximately 60% of our body and thus, optimal hydration is essential for good health. Water has numerous functions in our body: building material (blood), solvent and reaction medium (enzymes reactions), transport of nutrients and waste products (urine, faeces), thermoregulation, restoring lost fluid (breathing, sweating, waste), lubricant of tissues, maintains healthy skin. The amount of water that we need to drink everyday varies from one person to another depending on many factors: age, gender, physical activity, climate, body size. Several foods i.e. fruits (watermelon, oranges, pears, etc) and vegetables (lettuce, cucumber, etc) as well as other drinks (coffee, tea) also contribute to the amount of water we ingest. On average the amount of drinking water to be consumed by an adult is about 1,5-2.0 L (i.e. approximately 6 to 8 glasses) (Popkin et al., 2010).

Micronutrients. Needed in small quantities.

- **Vitamins.** Group of substances that are needed for normal cell function, growth, and development. Vitamins are grouped into two categories: 1) Fat-soluble vitamins A, D, E, and K (stored in liver, adipose tissue, and muscles) and absorbed more easily in the presence of dietary fat; 2) Water-soluble vitamins C and B (B1, B2, B3, B5, B6, B7, B9 and B12) which have to be consumed regularly to prevent deficiencies. High doses of certain vitamins can also be toxic. Each vitamin has an important function. For example, vitamin A helps to keep a healthy vision, teeth, bones, skin; vitamin C, is a strong antioxidant that promotes healthy teeth and gums, and helps in the absorption of iron; or vitamin D, the 'sunshine vitamin', made by our skin after being in the sun (10-15 minutes), that helps the body to absorb calcium to maintain healthy teeth and bones.

  Most of the vitamins are broadly present in many different foods. Just to include some examples: vitamin A is found in dark-coloured fruits and vegetables, egg yolk, fortified dairies (milk, cheese, yoghurt, butter), meat (beef), fish; vitamin D is present in fish (salmon), fortified cereals, and fortified dairies; or vitamin C is abundant in many fruits and vegetables (citrus fruits, berries, tomatoes, green leafy vegetables like spinach, broccoli, etc). A full list with the vitamins, functions and food sources can be found at the following webpage of Medline website https://medlineplus.gov/ency/article/002399.htm.

- **Minerals.** Minerals are solid inorganic substances present in a wide variety of foods. Together with the vitamins, they are classified as micronutrients because they are needed in smaller amounts than macronutrients (carbs, fats, proteins). The human needs to obtain regularly a variety of essential minerals: 1) macrominerals (in larger quantities): calcium, potassium, magnesium, iron, sodium etc, 2) microminerals (trace quantities): selenium, copper, zinc, manganese, etc. Minerals are also very important for your health. Your body uses minerals for many different functions and tissues, including bones, muscles, heart, brain, etc. Minerals are also important for enzymes and hormones synthesis and activity. You can find information about the minerals, their functions and some main food sources at the following webpage of Medline website https://medlineplus.gov/minerals.html.

Counting calories

How much of these different nutrients should we ingest? We need to combine different types of foods to obtain all the nutrients we need. The quantity of each type of nutrient and the total **energy** we ingest is essential to maintain our body weight, function and our health. How much energy can we obtain from the different nutrients? The amount of energy released when your body digests and absorbs the nutrients is called **calories** and 1 calorie (cal or kcal) is equivalent to 4,18 Kj (kilo joules) of energy. Carbs provide 4 cal/g, proteins also yield 4 cal/g, and fats provide 9 cal/g. Water, vitamins, and minerals do not provide any calories. Alcohol, although it is not a nutrient, provides 7 cal/g. On average, a woman needs 2000 cal/day and a man 2500 cal/day. These quantities vary depending on the individual sex, age or activity but we need to maintain a balance between the energy we ingest from the different nutrients in our food and the amount we need for our body functions (10% digestion,

20% physical activity, 70% basal metabolism and functions) (Osilla et al., 2022). Overall, if we consume more than we need, the excess is accumulated as fat in our body (e.g. around the waist) and we may become overweight and (or) obese. There are several dietary reference recommendations that indicate the amounts of the different nutrients that we should ingest to maintain health and avoid or reduce the development of diseases (**Dietary Reference Intakes**, DRIs). On average, it is recommended to ingest 45–65% of carbs, 20–35 % fats and 10–35 of protein (% of total calories) (National Institutes of Health, 2024).

Major diet derived disorders associated with the eating patterns.

Nutrients have a major impact on all physiological and pathological processes. Overall, adequate nutrition is critical for maintaining our health and preventing/reducing the development of diseases Bhattacharya, 2019). The major problems associated with nutrition (**Malnutrition**) can be grouped into:

- **Undernutrition** - general lack of nutrients, which can result in poor/limited growth, weakness, underweight.
- **Nutritional specific diseases** - associated with specific food components (minerals, vitamins) and(or) inherent human alterations (iron deficiency, scurvy, beriberi, osteomalacia, hypervitaminosis, anorexia, bulimia).
- **Overnutrition** - excessive intake of nutrients which is associated with a group of metabolic alterations ('risk factors'), body weight excess (overweight/obesity),

The **Non-Communicable Diseases** (NCDs) are chronic diseases that usually develop with age. The four major NCDs are cardiovascular diseases, cancer, chronic respiratory diseases, and Type 2 diabetes. NCDs are highly prevalent in most Westernised societies and are now increasing in medium- and low-income countries being responsible for 74% of all deaths globally. NCDs are thus threatening the progress towards the **2030 Agenda for Sustainable Development** (https://sdgs.un.org/2030agenda), which aims to reduce the probability of death from any of the four main NCDs by one third by 2030. The main metabolic risk factors that contribute to the development of NCDs are in order of relevance: elevated blood pressure (hypertension), high levels of sugar in blood (hyperglycaemia), body weight excess (overweight/obesity), and high levels of fat in the blood (hyperlipidaemia). There are several factors that influence the development of these alterations, some factors are inherent to the person (e.g. genetic factors) but other factors are **modifiable**, i.e. a poor lifestyle (lack of physical activity, smoking, alcohol consumption), and **unhealthy dietary habits**. The major Western dietary habits currently associated with the development of NCDs (Budreviciute et al., 2020) are:

1. **High intake of salt** (high sodium)
2. **Low consumption** of fresh fruits and vegetables, nuts and seeds, legumes, wholegrains, milk, fish, (low calcium, low unsaturated and polyunsaturated fats, low fibre)

3. **High intake of pre-packaged, highly processed/refined foods** (high sugar and(or) high saturated and trans fats) as in refined grains (white bread and pasta), high-sugar sweetened drinks, candy and sweets, fried foods, red and processed meat, butter, etc. Among these foods, the high intake of sodium, the low intake of whole grains and the low intake of fruits appear to be the major dietary factors associated with deaths for NCDs all over the world.

Main proposed recommendations and solutions to improve our diet and our health.

One essential means of fighting against the NCDs is to try to reduce the risk factors associated with them. In addition to reducing the consumption of alcohol and tobacco as well as promoting the increase in physical activity, there are several key dietary changes that should be promoted and followed and that will help to achieve the objectives of the World Health Organization (WHO, 2020) to reduce mortality from NCDs. Overall, the main recommendations include:

1. reduce the consumption of highly processed foods, the amount of salt, simple sugars and bad-fat (saturated and trans-fat, avoid butter)

2.- increase the intake of fresh vegetables, fruits, whole grains (which contain good quality carbs, fibre as well as a wide range of vitamins and minerals), healthy fats (MUFAs and PUFAs from plant oils, fish, nuts), and healthy proteins (white meat, fish, nuts, legumes). Drink milk moderately (as a source of calcium), tea, coffee and water (6-8 glasses a day) instead of sugary drinks.

These recommendations coincide with those of the typical Mediterranean sustainable pyramid (Serra-Majem et al., 2020) and Healthy Eating Plate (Harvard T.H. Chan School of Public Health and Harvard Medical School, 2012) available at this link https://cdn1.sph.harvard.edu/wp-content/uploads/sites/30/2012/09/HEPJan2015.jpg).

Revising some old and new concepts in food in relationship with health: antioxidants, functional foods, nutraceuticals, superfoods and transgenic foods.

The main function of the diet is to provide sufficient nutrients to satisfy the nutritional needs of an individual. However, there is scientific evidence that supports the hypothesis that some foods and their bioactive components have beneficial health effects beyond the mere contribution of basic nutrients. These bioactive compounds are not classified as essential nutrients but can have specific benefits for health and can be recommended as part of our diet (Kussmann et al., 2023).

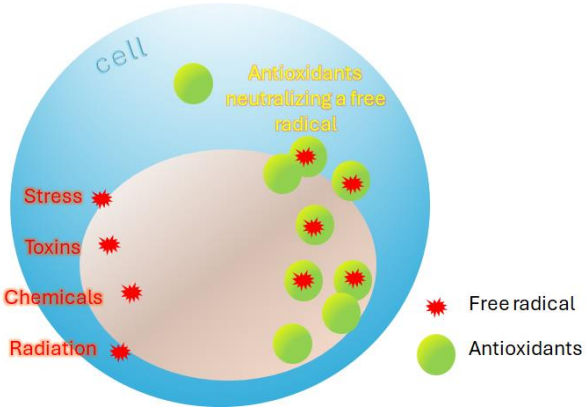
The evidence that the diet is one of the pillars of health is now well consolidated as part of our lifestyle. Thus, an attempt has been made to find in food all those properties that would make them especially

beneficial for health. In relationship with this, new concepts and products have emerged in the food area such as **antioxidants**, **functional foods**, **nutraceuticals, superfoods, and transgenic foods**. These concepts are very much interrelated and the scientific, industrial and economic activity associated with them is huge and constantly growing. Consumers increasingly look for foods with health benefits that have the capability to reduce the occurrence of diseases. The taste for what has been called 'healthy food' or 'natural food' seems to prevail, this appellation being sought after and highly valued by consumers. However, in some cases, there is a lack of verified information, sometimes more based on commercial than scientific criteria.

In Europe, the regulation of healthy beneficial foods was approved in July 2007 with the implementation of the Nutrition and Health Claims Regulation (NHCR), a process promoted by the European Commission (EC) and in charge of the European Food Safety Agency (European Food Safety Authority, EFSA). A ‘Nutrition Claim’ states or suggests that a food has beneficial nutritional properties such as 'low fat', 'no added sugar' or 'high fibre'. A ‘Health Claim’ is any statement on the food labelling, food advertising or food marketing that indicates that the consumption of that food may have a specific beneficial effect on health. The NHCR looks after all health claims requiring a scientific foundation for its approval.

Antioxidants

Our current lifestyle, daily stress, and many different environmental factors are known to promote what is called ‘oxidative stress’. This term indicates a process of oxidation in the human body due to the excessive production of unstable chemicals called free radicals also known as reactive oxygen species (ROS) or reactive nitrogen species (RNS). These radicals may damage our cells and genetic material leading to the development of many chronic diseases including cancer, cardiovascular diseases, cognitive decline, arthritis, respiratory diseases, immune deficiency, Parkinson’s disease, and other inflammatory conditions. Our body has its own antioxidant defences to control free radicals. In addition, food antioxidants may help to reduce these conditions. These are molecules that can occur in certain foods and are capable of scavenging and neutralising free radicals. They are also involved in mechanisms that repair DNA and maintain the health of cells. Antioxidants are found mainly in plant-based foods and include vitamins (A, C, E), β-carotene and other related carotenoids (lycopene, lutein), minerals (selenium, manganese), polyphenols and phytoestrogen among others (Tumilaar et al., 2024). Foods that are particularly high in antioxidants are often referred to as “functional foods” or “superfoods”, terms that will be explained below.



How do antioxidants work? Source: Diagram based on https://immunehealthbasics.com/antioxidants-action/

Many *in vitro* studies (studies conducted in the laboratory with experimental models: cultured cells, animal models) have shown the antioxidant activity of many food compounds. Also, many epidemiological prospective studies have shown the association between higher intakes of natural antioxidant-rich foods (e.g. fruits, vegetables, legumes) and a lower risk of chronic oxidative stress-related diseases. Nevertheless, the evidence of the benefits of antioxidant food compounds in humans remains limited and contradictory and more studies are still needed (García-Conesa, 2017). A lot of research effort is currently focussed on investigating the effects in humans and the highly variable responses of the different individuals to the intake of the food antioxidants (Morand et al., 2020).

Functional Foods

Functional foods are generally defined as those that, in addition to their nutritional properties, may provide some specific health benefits due to the presence of specific components. The concept originated in Japan in the 1980s when government agencies started approving foods with proven benefits in an effort to better the health of the general population (Farr, 1997). These functional foods can be consumed as part of the daily diet. In addition to the normal nutrients, functional foods may contain bioactive compounds which are considered as non-nutrients (e.g. phytochemicals, including polyphenols, prebiotic, etc..) and can have an effect on one or more physiological functions in the body to improve well-being and health or reduce chronic disease risk.

Most natural plant foods (fruits, vegetables, nuts, seeds, legumes, whole grains, fermented foods, herbs and spices, beverages) are sources of bioactive compounds and thus, they all can have beneficial effects on our health (Dixit et al., 2023). For example, tomatoes which contain lycopene can help to reduce the risk of prostate cancer; or fishes like salmon which contain omega-3 fatty acids can help to reduce the risk of cardiovascular diseases; or fruits and vegetables, whose content in flavonoids (i.e. a type of polyphenol) can help to neutralise free radicals (antioxidant effect). With this principle in mind, there are now in the market some functional foods which have been modified by enhancing the content in certain compounds and thus they have become recommended to help against some specific health problems. They come to the market with a message related to a health benefit. For example: milk with added omega-3 fatty acids (help to reduce the risk of cardiovascular disease), margarines enriched with phytosterols (help to lower cholesterol and to reduce the risk of

heart disease), fermented milk products with probiotics (improve the gastrointestinal function). The functional foods come with a health message.

Examples of functional foods currently available at the supermarket (Spain).

Other foods may also have some modifications such as the removal of a known component that causes a detrimental effect, mainly allergens (fat free milk, gluten free food); the substitution of one component for another (sucrose by non- caloric sweeteners); the increase of the concentration of a beneficial component (calcium in milk, vitamin C in fruit juices and folic acid in cereals). These messages are more nutritionally related messages but there is no directly indicated health message. For a particular food to become functional and be released to the market, the beneficial effect must be proven by well-designed and properly executed intervention studies in humans. These studies must be approved by the EFSA committee.

Nutraceuticals

In 1989 Dr. Stephen Defelice created the word “nutraceutical” using the concepts of “nutrition” and “pharmaceutical”. He defined nutraceuticals as “a food or part of a food that provides health benefits, including the prevention and/or treatment of disease." A nutraceutical can better be defined as a dietary supplement containing bioactive natural substances with a favourable effect on health extracted and concentrated from foods (Espín et al., 2007).

Examples of nutraceuticals currently available at the supermarket (Spain).

Therefore, they differ from medicines in that the latter are usually the result of chemical synthesis whereas nutraceuticals are composed of natural compounds. Nutraceuticals also differ from functional foods in the concentration of the active ingredients that is much higher than that found in food as well as in the form of presentation in a non-food matrix (pills, capsules, powder, etc). Ingredients typically used as nutraceuticals contain probiotics, prebiotics, beta-glucans, antioxidants and polyphenols, etc. Nutraceuticals may help to improve health but, in no case, they may replace the daily diet and foods.

Superfoods

Scientifically speaking there is no official definition of a superfood. This is an additional marketing term used to describe foods rich in nutrients and other bioactive compounds, such as antioxidants, fibre, healthy fats, vitamins and phytochemicals that are beneficial to human health (van den Driessche et al., 2018). These foods have high nutritional value and can exert beneficial effects. Foods that are considered superfoods include fermented foods, red berries, chia seed, avocado, nuts, oily fish, ancient grains, seaweed, among others. Besides, many of the foods which are part of the Mediterranean diet should be labelled as superfoods (extra virgin olive oil, legumes, citrus fruit or garlic). Some experts think that superfoods do not truly exist, because no food is miraculous by itself, every food is part of a diet as a whole. They think that "superfood" and "miracle" are only marketing terms for advertising foods and can lead to unrealistic expectations. There is no "miracle" food but the important thing is to eat a balanced and varied diet.

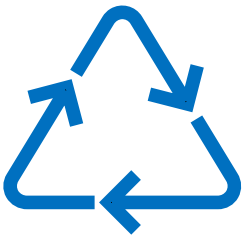
Transgenic foods

This term groups a specific type of foods that have been genetically obtained (GMO: genetically modified organisms) by applying bio-technological procedures that can introduce or modify the genes (DNA information that codifies the synthesis of a protein) within a plant to make that plant to either: i) produce compounds that did not naturally produced or ii) to increase the production of some of those compounds. Normally, these are healthy beneficial bioactive compounds (Chen et al., 2016). Typical examples of GMO foods are the "golden rice" or the "purple tomatoes". The golden rice was modified to introduce the genes that codify the proteins that produce beta-carotene, a precursor of the Vitamin A which is needed for a correct vision. Golden rice can improve the health of many children in Asia who suffer a type of blindness associated with deficiency in this vitamin. The purple tomatoes have been modified to be enriched in the bioactive compounds lycopene and anthocyanins which have both beneficial health effects.

Examples of GMO foods, golden rice and purple tomatoes. Photos by @freepik and Racool studio on freepik, respectively.

Sustainable food waste management

By Serena di Grazia



Food waste

Around one third of all food produced in the world is wasted along the entire supply chain, i.e. from production, collection, transformation/processing, packaging, storage, transportation, and household consumption. Disposal is principally due to defects/damages that affect the quality of the product and that might have occurred due to human errors and (or) technology problems. In medium and high-income countries, and in pro of the food safety and appearance, **food is wasted mainly at later stages in the supply chain** (i.e. retailing, consumers) irrespective of whether it is still suitable for consumption (e.g. Europe, >100 kg food waste per capita per year).

Causes of food waste at different stages of the food supply	
Stage	**Potential Causes**
Production (agriculture, farming)	Mortality of animals (diseases), crops not harvested, p fruits & vegetables, damages during cultivation (inclen weather conditions, pests, etc) and (or) storage.
Collection, Transportation	Mechanical damage, poor conditions (temperature, humidity, etc)
Processing, Storage	Losses during industrial transformation (peeling, slicing, cutting, etc), poor storage conditions (contamination)
Retailing	Poor demand, expiring date (food safety),
Consumers	Excess shopping/cooking, poor storage, hygiene, excess serving,

One of the United Nations (UN) sustainable goals for 2023 is to halve the per capita global food waste at the retail and consumer level as well as to reduce food losses along the production and supply chains by promoting the prevention, donation, and use as animal feed. In Europe, the 'Food Losses and Food waste' platform provides a resources library and repository of practices and materials to raise awareness and contribute to food waste reduction (https://food.ec.europa.eu/safety/food-waste/eu-actions-against-food-waste/eu-platform-food-losses-and-food-waste_en).

Food waste management can become sustainable by imitating natural regeneration systems. In nature, waste does not exist since it is transformed into nutrients for another cycle.

Circular Economy is mostly based on **reducing, reusing, recycling** and **recovering**. This concept applies to all types of waste, including organic waste (e.g. food waste). Different strategies are being developed and implemented across different countries and regions to contribute to more sustainable food waste protocols. For example, **food donation**. Very often, what is left on the shelves is thrown away, but fortunately, more and more projects are active to save this still edible food and donate it to whoever needs it. For example, countries like Denmark, Norway, Sweden or France have mandated that all surplus food from restaurants, hotels and supermarkets have to be redistributed for human consumption. There are also mobile applications that alert the customers of food products near the expiration dates and that can be purchased at a lower price (https://www.toogoodtogo.com/es).

Alternatively, when it is not possible to reuse the food, if this has been properly wasted, it can be transformed and revalorised into other useful materials and resources (**food waste transformation**). For example, organic waste (e.g. food waste) can be processed and treated in biodigesters to subsequently be transformed into quality biogas and compost constituting a perfect example of a circular economy. Some biodigester plants allow the simultaneous production of electricity and heat thanks to two combined cycle cogeneration plants fuelled by natural biogas. Food waste can be also converted into hydrogen, this is an energy-saving and environmentally friendly process (Shin and Youn, 2005). The production of hydrogen by anaerobic fermentation of organic wastes is a promising alternative to fossil fuels due to its clean, renewable and high energy efficiency. According to a study funded by the European Consortium 'Gas for Climate', the European continent has a potential of producing 270 billion m^3 of hydrogen and biomethane which - used in gas infrastructures - would make possible to eliminate CO_2 emissions by 2050 saving 217 billion euros a year compared to a scenario that envisages a minimum contribution from gas (https://www.snam.it/en/hydrogen_challenge/snam_hydrogen/). In fact, "green" gas can be stored and distributed through existing gas infrastructures, efficiently integrated with renewable electricity to reduce the costs of decarbonisation.

Sustainable food waste practices at home

EPA (2024) estimated that in 2019, 96% of food waste at home was not managed properly, ending up together with the unsorted waste or lost into the sewer system. Only 4% was composted. In addition to the strategies, programmes and efforts developed by the Government Organizations, Industry, etc, **consumers can also have a very important impact in the reduction of food waste by learning, and incorporating into their daily lives, more sustainable food consumption practices** (de los Mozos, 2020). A summary of simple tips for this purpose is shown in the figure, and explained below:

Sustainable practices for consumers.

Pre-consumption: Sustainable shopping/storage/cooking.

- **Buying from local producers.** This will contribute to reduce the use of the extra energy needed in transportation/storage.
- **Planning.** Buy only the things you really need. Move away from 'impulsive to rational food shopping and consumption'. Read carefully the expiring date[1] (especially for the cheaper offers like the 3for2) and make sure to use/eat the product before the deadline.
- **Household storing.** Keep the refrigerator clean to avoid the growth of bacteria. Opening it often can cause the temperature to rise and spoil the more delicate foods. Place the earlier expiring products closer to hand and consume it before others expire later. When food is correctly stored in the fridge you can keep it safe and eat it several days after.
- **Rational cooking.** Don't cook more quantities than you feel like/may be able to eat. Keeping the healthy issue in mind will help you to reduce the excessive quantities of different foods.
- **Food expiring date.** Packed foods report what is the best way to preserve it and when to consume it. Ther are two wordings:
  i) Minimum Conservation Term: if the food is stored correctly, the product remains with the same quality until the specified date. After that date, the taste, smell or texture may be different, but still safe.
  ii) Expiration date: indicates the maximum period of time within which a food can be eaten without any risk to health. The choice of the expiring date is set by the manufacturer and is often anticipated in favour of caution to avoid the fear of food poisoning. In addition, this anticipated deadline also favours a fast turn-over, guaranteeing a continuous production. These factors contribute decisively to making deadlines the first cause of food waste in the final consumption stage and to undermine the overall credibility of a system that seems to want to 'protect

companies more than people and the planet they live on' (Tristram, 2009).

Expiration date reported on the lid of a jam jar.

Post-consumption: handling the leftovers.

- **Keep leftovers** for the following day(s). If adequately stored it will still be yummy and edible.
- **Prepare new dishes.** With a little experience in the kitchen, it is possible to create very tasty and personalised dishes. For example, meatballs can be made from leftover fish, meat or vegetables cooked the day before, mixed with egg, boiled potatoes and spices. The vegetables are also recyclable in "velvety" soups with cheese and toasted croutons or in omelettes and constitute perfect and practical meals. It can become a fun and pleasant experience to combine foods in a different way and attain new recipes with delicious flavours encouraging the use of the leftovers.
- **Transform leftovers into compost**. Proper disposal of the food scraps into the organic bins contributes to the work carried out by the companies that deal with the recovery and valorisation of food waste in the form of compost. Compost constitutes a real nutrient reserve for the plants because it is capable of releasing nutrients to the soil (nitrogen, phosphorus, potassium among the most important ones). In addition, those consumers who have an outdoor space can produce their own compost with the adequate "**compost bins**" which can be bought or constructed reusing waste materials. In the composters we will introduce food scraps, mainly, vegetables, coffee grounds, dirty napkins, but also dry leaves and (or) clippings from pruning. The oxygen, moisture and heat inside the composters create an environment suitable for proliferation of microorganisms that, in a few months, will transform those elements into potting soil rich in nutrients, compost, ideal for fertilising the garden.

Packaging

Packaging for food is an essential aspect of the food industry, as it serves to protect and preserve food from contamination, spoilage, and damage during storage, transportation, and distribution. Packaging can also play a role in marketing and branding, as it can help products stand out on store shelves and communicate important information to consumers.

The EU Commission's packaging reform proposal (EU, 2022) presented at the end of November 2022 and which focuses on reuse and returnable containers for plastic bottles and aluminium cans calls

into question the recycling chain. The European goal is to reduce packaging waste by 15% per capita for each country by 2040. According to the proposed regulation, by 2030 20% of take-away beverage sales will have to be served in reusable packaging or using customer containers, to reach 80% in 2040.

Materials for food Packaging

There are several types of food packaging materials available, including plastics, paper, metal, and glass. Each material has its own advantages and disadvantages, and the choice of material depends on factors such as the type of food being packaged, the required shelf life, and the intended use of the packaging.

- **Plastic packaging** is widely used in the food industry because it is lightweight, durable, and cost-effective. Due to the environmental impact of plastic, other more sustainable types of packaging are preferred.
- **Paper packaging** is a renewable and biodegradable option that is becoming more popular for certain types of food, such as bakery products and fast food (van den Oever et al., 2010). However, it is not as effective at keeping out moisture and air as some other materials and is not suitable for all types of food.
- **Metal packaging**, such as cans and foil, is durable and provides excellent protection against air and light. It is often used for canned foods and beverages, but it can be more expensive than some other materials.
- **Glass packaging** is also an effective barrier against air and light, and it is a popular choice for certain types of food, such as jams, sauces, and pickles. However, it is heavy and breakable, which can increase the cost of transportation and handling.

Technology in food packaging

Vacuum Skin Packaging places a product in a vacuum-sealed package with a tight-fitting film that conforms to the shape of the product, creating a skin-like barrier that helps to prevent the growth of bacteria and maintain the quality of the product.

Another technology is **Modified Atmosphere Packaging** (MAP). This technology helps to extend the shelf life of fresh foods by replacing the air inside the package with a modified atmosphere by gas including helium, argon, nitrogen, carbon dioxide, to slow down the growth of bacteria and fungi (Farber, 1991). This can help to reduce food waste and increase the availability of fresh produce year-round.

Biodegradable packaging made from natural materials, such as cornstarch, bamboo, and sugarcane they guarantee high environmental sustainability thanks to their high degradability (Shaikh et al., 2021).

Innovations in food packaging

New technologies are helping to improve the safety, quality, and sustainability of packaged food addressing growing concerns over plastic waste and environmental impact (Fellows, 2000). There have been innovative inventions in food packaging aimed at improving the shelf life, safety, and sustainability of packaged food.

Smart Packaging incorporates sensors and other electronic components into the packaging, allowing manufacturers and retailers to monitor factors such as temperature, humidity, and the

presence of bacteria in real-time. This can help to improve food safety and reduce waste by ensuring that products are stored and transported under optimal conditions.
Another is **nanotechnology-based Packaging**. This technology involves the use of nanoscale materials and structures to create packaging that is more effective at preserving food, reducing contamination, and improving the texture and flavour of the product. For example, nanoscale films can be used to create a barrier against oxygen and moisture, which can help to extend the shelf life of packaged food.

Consumers and companies look for ways to reduce the environmental impact of the food industry. Some of the more sustainable choices in food packaging include compostable packaging, recyclable packaging, reusable packaging, minimal packaging. Minimal packaging is an approach that aims to reduce the amount of packaging used for a product to the bare minimum necessary to protect and preserve the product. This can help to reduce waste and the environmental impact of packaging.

The **key challenges of the food industry regarding sustainability**, food safety and market demands are:

- Increased use of sustainable materials such as bioplastics, paper-based packaging, and plant-based materials.
- Greater use of smart packaging that improves food safety, reduces waste, and provides consumers with more information about the products they are purchasing.
- Development packaging designed to use fewer materials or be more easily recyclable or compostable.
- Increased focus on food safety with packaging that helps to reduce the risk of contamination or spoilage.
- Effective design is an essential aspect of food packaging, as it can help to make products stand out on store shelves, communicate important information to consumers, and enhance the overall experience of using the product.

The future of food packaging is likely to be shaped by a combination of these and other trends, as companies continue to seek innovative solutions that can help to meet the evolving needs and preferences of consumers, while also addressing concerns over sustainability and food safety.

Conservation

The main methods of food preservation we can apply at home are refrigeration and freezing.

- **Refrigeration** is a method of preserving food which consists in storing food at a low temperature which keeps the water present inside the products in a liquid state. Refrigeration blocks the growth of microorganisms that could cause food poisoning. Storing food in the refrigerator must take place with a precise logic and sequence. The heat always goes high, taking this into account, arrange the foods in the fridge following tips:
  - *Keep the temperature between 0°C and 10°C*
  - *Only put cold foods in the cooler*
  - *Fruit and vegetables in the appropriate drawer, designed to preserve food from too cold temperatures*


- *Meat and fish on the bottom shelf of the fridge*
- *Cheeses, dairy products, eggs (with the whole box) and open foods in the central shelves*
- *Packaged products and foods cooked on the top shelf.*

- **Freezing.** Foods can be safely kept in the home freezer for 3 to 12 months without loss of quality. Keeping times vary depending on the food and the product label provides the best indication of keeping time. Freezing delays spoilage and keeps foods safe by preventing microorganisms from growing and by slowing down the enzyme activity that causes food to spoil. As the water in the food freezes into ice crystals, it becomes unavailable to those microorganisms that need it for growth. However, follow these tips to safety freeze food:
  - *Freezers should be kept at or below -18°C. In contrast to refrigerators, deep freezers should be packed tightly as this allows the freezer to function better.*
  - *Use appropriate packaging such as freezer bags and plastic containers to help protect foods and prevent "freezer burn".*
  - *Avoid placing hot foods straight into the freezer as this will raise the freezer temperature and may adversely affect other foods. Cool foods before freezing.*
  - *Make sure that frozen food is completely thawed before cooking.*
  - *Food that has been frozen and thawed should never be refrozen.*

When there were no refrigerators, other methods were used such as salting and pickling. These methods have contraindications: if not done carefully they can allow the development of botox, a dangerous toxin.

GOODFOOD students' and teachers' interests and needs

Students' and teachers' interests and needs

At the beginning of the GOODFOOD project (May 2022) an online questionnaire was distributed amongst the students and teachers of the secondary schools participating in the project in Spain (Institute for Secondary Education 'Monte Miravete', Torreagüera, Murcia), Italy (Elsa Morante – Conti Ginori Environmental Technical High School in Florence and Scientific Lyceum N. Copernico in Prato) and Greece (1st Lyceum of Rafina) with the aim to chart the current knowledge, skills, interests, and attitudes towards the themes of the project and regarding the learning methods and tools that should be applied. Specifically, the survey aimed to chart the secondary education students' knowledge and interest on sustainable food production, sustainable food consumption, and balanced and healthy diet, as well as the students' perception towards the different disciplines (i.e. Science, Technology, Engineering, Art and Maths), and the learning methods and approaches (e.g., hands-on experience, application of Apps and web-based tools, research approach, etc.). The survey designated for the teachers aimed to explore the teachers' general knowledge and skills on the same themes, but also their views on the educational approaches proposed by the project.

Link to the GOODFOOD – Learning Needs Survey for students https://forms.gle/EHrpo55f79XHKAKv9
Link to the GOODFOOD – Learning Needs Survey for teachers https://forms.gle/fbPSY4RiT8Zo4gxZ8

The survey collected responses from 202 students in Spain, 96 in Italy, and 94 in Greece as well as responses from 23 teachers in Spain, 37 in Italy and 12 in Greece. The detailed results of the surveys in each country and the international Synthesis report can be found on the GOODFOOD webpage https://goodfoodeplus.cebas.csic.es/results/.
In the following chapter we summarise the main results that have been considered for the development of the Teaching and Learning Methodology, which aims to make school and STEM more effective and attractive to students, integrating activities related to Arts and Humanities and the Inquiry-Based Learning (IBL) approach, on the themes of sustainable food production, consumption and healthy eating.

Students' survey results

Students' profile:

- The average range of age was 14-17 (12-16 in Spain, 14-19 in Italy and Greece).
- The female participants represented a slightly higher percentage than the male ones. A very small percentage (~3%) preferred not to state their gender.

Students' knowledge

Regarding the Mediterranean Diet (MD)/Healthy diet concepts

- Overall, the students from the three participant schools appeared to have a moderate-to-good knowledge about the degree of association between some general food items and the concept of MD. Like so, fruits, vegetables, olive oil, fish, and pulses were generally ranked highest whereas sweets, butter and salt were placed at the lowest positions.
- In agreement with the above, the students also seemed to identify a healthy diet with plant foods rich in fibre, low processed or organic foods, and low in sugars, fats and additives.

- The connection between MD/healthy diet with other products such as meat, whole grain/white cereals, dairies, red tomato sauce or wine was, in general, less clear as suggested by the variation and small differences in the positioning of these items between the three countries. These differences might be partially attributed to a more limited knowledge on the association between these other food items and the MD which might be, in turn, related to a poorer dissemination of the information about these food items in comparison with, for example, the emphasis given by regulatory policies and media to the need to increase fruits and vegetables and to reduce sugars and salt.
- The results also showed small differences between the students from the three countries in the order they ranked some of the food items. For example, Italian and Spanish participants ranked vegetables and fresh fruits highest in relationship with the MD, while Greek students positioned olive oil and fish/seafood at the top of the list. Also, the Greek students did not relate white meat to the MD as much as the Spanish and Italian students did. The Italian students associated bread, pasta and rice to the MD more than the students from the other two countries. It is possible that these differences might be partially attributed to differences between each country's traditional and local cuisine or the habits at home. Eating at regular intervals in the day was also important for the students. In addition, Greek students considered that eating home-made food was very important to a greater extent than Spanish or Italian students.
- In all 3 countries, most students agreed that following a vegetarian or vegan diet was of little or no importance towards a healthy diet. These results might be indicative of a lack of interest/knowledge about these types of diets.

Regarding sustainable food production

- In all 3 countries most of the students recognized the connection between sustainable food production and several aspects related with the "environmental sustainability": low environmental impact (efficient use of resources), low waste, production by organic farming, and minimum use of pesticides and fertilisers.
- On the other hand, the results suggested that there was, in general, less knowledge of the association between sustainable food production with aspects related with economical sustainability (i.e., low cost of production) or with the development of new sources of food.

Regarding sustainable diet

- In all 3 countries, students attributed a high-to-moderate connection between a sustainable diet and "health benefits", "high nutritional value" and "environmentally friendly".
- Around 50% of the participant students in Spain and Italy indicated a lower connection between a sustainable diet and the hedonic component of the sustainable diet (i.e. the consumption of tasty and pleasurable foods), as well as the affordability of food.

Regarding issues related to food

- In all 3 countries, students indicated to have some knowledge on specific issues connected to food, i.e. sustainable farming, food chain, food waste and recycling, nutritional value of food, food and wellbeing, diet related diseases and eating disorders.
- On the other hand, the participant students appeared to have more limited knowledge on: "Community-supported agriculture" (mainly in the case of Italian and Spanish students),


"Intensive farming", "sustainable farming", "organic farming" (Spanish students), and "sustainable farming" and "food chains" (Greek students).

Regarding specific terminology linked to the project themes,

- In all 3 countries, most of the students declared to know the meaning of the terms "climate change", "greenhouse gas emissions", "biodiversity", and "nutritional value". On the other hand, it appeared that the terms "ecological footprint", "antioxidants", or "genetically modified food" were less known. They also seemed to know little about the terms "carbon footprint" and "virtual water".

Connection between school subjects related to the STEAM methodology and the core themes of the project

- In all 3 countries, most students related Biology, Chemistry and Physical Education to the 3 themes: food production, food consumption and healthy diet, with Chemistry mainly relevant to food production, and Physical Education to a healthy diet.
- In all 3 countries, Physics, Geography, Economics and History were seen relevant mainly to the themes of food production and food consumption.
- Maths, Information Technology, English (foreign language), but especially Art and Literature were, in general, less related to the 3 themes.

Students' skills

Students were asked to rate how often they had performed different activities related to a **set of skills which are relevant to the proposed learning approach and tools**. The main findings are listed here below:

- 'Working in teams' was more often performed by Spanish and Greek students than the Italian ones.
- 'Doing fieldwork to gather information' was practised more regularly by the Spanish students than by the Greek and Italian ones.
- 'Using cameras or video-making software' was more often practised by the Greek and Italian students than by the Spanish students.
- 'Using Art to communicate ideas and notions' was regularly done by Italian students while most of the Spanish and Greek students were not so familiar with this practice.
- 'Using online/mobile applications' to assess the nutritional value of food or its environmental impact was done more regularly by Italian students than by the Greeks and Spanish students.
- 'Assessing information found on the internet through more reliable sources' was often done by most Greek students, followed by Spanish students and the Italian students.

Students' interests

The survey asked students about their interest in the project themes, as well as in the different learning approaches, methodologies and tools.

Regarding the proposed project themes

- In all 3 countries, the participant students showed moderate-to-strong interest in learning about the benefits of being a sustainable consumer, the ways to lead a sustainable and


healthy diet, health and dietary habits, the impacts of dietary habits on the environment, how food is produced, climate change and food production.

- Students appeared to show more interest in themes concerning their own personal wellbeing, like “ways to lead a sustainable and healthy diet” and “association of dietary habits with health”.

Regarding learning approach and tools

- In all 3 countries, students were mostly interested in aspects related to going out of the classroom and doing fieldwork, performing investigations and hands-on activities.
- Using mobile applications to monitor their diet in terms of sustainability, health and nutrition were also of interest to the participant students.
- In all 3 countries, students also showed interest in working together with their fellow students on a school project and discovering connections between school subjects.
- Overall, the students recorded less interest in communicating their experience and influencing others, and especially in involving their families and friends in their school project.

Regarding the perceptions and attitudes

- In all 3 countries, most students (70-80%) indicated to be aware about the environmental issues, and about the importance of a sustainable and healthy diet.
- They were also aware of the need to protect the environment and to have an active role in this effort, but also of the importance of their choices as consumers towards a sustainable and healthy diet. The students also stated their willingness to change their own eating habits to achieve it.

Regarding the approaches in education

- In all 3 countries, the school subjects in which the students felt more comfortable with were Technology, followed by Natural Sciences, Physics, Chemistry, and Biology (especially in Greece and in Italy). The students felt moderately comfortable with Humanities.
- Spanish students felt more comfortable with Arts than their foreign peers whereas the Italian students felt more comfortable in Maths.
- With regards to differences between sexes, it was possible to appreciate that, in general, the male students seemed to feel less comfortable with Arts and, to an extent, with the Humanities (i.e., History, Literature, Geography etc.) whereas the female students appeared to feel less comfortable with Maths and Engineering.
- Engineering was rated very low in the 3 participant countries.
- In all 3 countries, students were also positive towards the integration of new technologies, using Apps, and teamwork in the school education system, while they were also aware of the risk in fully trusting the information they find on the internet.

Regarding the evaluation of some **activities** related the themes of the project that might be **of personal interest or hobbies**:

- In all 3 countries, the students indicated that they often cooked, but that they less often selected personally the food to buy or checked the nutritional value of food or additives/preservatives on the packaging or selected organic food to buy.

- Most students did not usually check the origin of food, searched for the effects of a particular food on health or used an application to calculate the nutritional value of food or its environmental impact.
- A few students indicated to follow a specific diet, which depended mostly on their lifestyle choices and culture (e.g., religion, being vegetarian or pescatarian) or for healthy reasons.

Teachers' survey results

Teachers' profile

- In the Italian sample, most of the teachers are between 45-64 years old with the majority in the age class 55-64, while in the Spanish and Greek samples, teachers are younger (45-54 years old).
- Responding teachers are mostly female in Italy (86%), while in Spain and Greece male and female genders are in general equally represented.
- Regarding the specialisation fields of the teachers, overall, a wide range of specialisations are represented, including Biology/Geology, Physics, Chemistry, Maths, I.T., Physical Education, Literature, Theology, English (foreign language), Economics, History, Arts and Support for disabled persons.
- Most Spanish teachers are very experienced (more than 20 years of teaching), a great percentage of the Italian teachers have less than 10 years teaching experience (42%) followed by an important proportion of very experienced teachers of more than 30 years of experience. The Greek teachers reflect a balanced level of teaching experience.

Teachers' knowledge

Regarding the foods the participants mostly relate to the Mediterranean Diet (MD)

- In all 3 countries teachers demonstrate a good level of knowledge of the Mediterranean Diet, placing foods like olive oil, vegetables, fresh fruits, pulses and whole grain cereals top on the list, and attributed very low connection to foods like sweet drinks, red meat, deserts, butter/cream and salted nuts.
- Also, for teachers, the views on certain foods differentiate from country to country, apparently influenced by the local traditions. For instance, several Spanish teachers relate white meat to the MD more than Greek or Italians, several Italian teachers connect red sauce and rice, bread and pasta to the MD more than their foreign colleagues, and the vast majority of the Greek teachers attribute a strong connection of red wine and dairy foods (cheese, milk, yoghurt) to the MD, a view not shared by most of the Italian and Spanish teachers.
- From the comparative analysis, like the students' survey results, although the teachers in the 3 countries are generally able to connect the right foods to the MD, the participants' selections of the foods related to MD appear to be influenced by the local context, i.e. the local cuisine and food tradition.

Regarding a healthy diet

- In all 3 countries, teachers seem to have a good level of knowledge of the topic, as the majority stated important the consumption of vegetables and fruits, eating at regular intervals in the


day, consuming organic food and unprocessed food, food rich in fibre or with no preservatives/additives, following a diet with reduced sugars and saturated fats, eating home-made food and food that is typical in own culture or traditional cuisine, and consuming less meat.

- In addition, they agree that following a vegetarian or vegan diet is of little or no importance towards a healthy diet.

Regarding sustainable food production

- In all 3 countries most of the teachers recognize the connection between sustainable food production and proposed aspects like low environmental impact (efficient use of resources), low waste, production by organic farming, and minimum use of pesticides and fertilizers.
- Similarly to the students' results, aspects related to the economical sustainability (e.g. low cost of production) is seen as less connected to sustainable food production, as well the development of new sources of food (e.g., insects, genetically modified food).

Regarding sustainable diet

- In all 3 countries most of the teachers recognize the importance of aspects like being environmentally friendly, having health benefits, being affordable and having high nutritional value.
- Many of the Greek and Italian teachers also recognize the importance of the hedonic aspect of food (i.e. being tasty and pleasurable) for a sustainable diet.

Regarding specific issues proposed by the survey in connection to the project themes

- In all 3 countries there are gaps of knowledge of the teachers on issues related to food production, like "intensive farming" and "sustainable farming" as well as "community supported agriculture".
- Most Greek teachers lack sufficient knowledge on "food chains", and most of the Italian teachers lack sufficient knowledge on "nutritional value of food", "importance of food for wellbeing" and "eating disorders".

Regarding specific terminology linked to the project themes

- In all 3 countries most of the teachers know the meaning of the terms "climate change", "greenhouse gas emissions", "biodiversity", "nutritional value", "antioxidants", and "genetically modified food".
- Most of the teachers do not know the meaning of the term "virtual water" and an important percentage of the teachers (30-40%) do not know the meaning of the term "carbon footprint".

Regarding the relation between a wide range of school subjects within the scope of the proposed STEAM approach to core themes of the project, i.e., food production, food consumption and healthy diet,

- In all 3 countries, Biology, Chemistry and History are seen as mostly relevant to all 3 themes proposed. Physics, Geography, Information Technology, Economics and Maths are seen as relevant mainly to the themes of food production.
- Less relevance was attributed to Art and Literature by the Spanish teachers, while the Greek teachers see Physics, Maths, Art and English (foreign language) as being less relevant.

- The role of subjects like Art, Literature and Physics is not clear to them in relation to the themes of the project.

Regarding the teachers' experience on methodologies and approaches that are recommended as effective teaching methods i.e., Inquiry-Based Learning (IBL), Project-Based Learning and STEAM educational approach proposed by the GOODFOOD project,

- Most of the Italian and Spanish teachers do not have sufficient experience and knowledge on the IBL, while most of the Greek teachers do.
- Most of the Italian and Spanish teachers do not have so much experience in project-based learning, while Greek teachers do, however they would like to participate as teachers in PBL.
- Many of the Italian and Greek teachers often have i**nterdisciplinary collaboration** with teachers of other curriculum subjects, while Spanish teachers do not.
- In all 3 countries, teachers agree that they should be better prepared for cooperating among them and on project-based learning.
- Italian and Greek teachers are more aware than Spanish ones about the meaning of **STEAM approach,** despite this, more Spanish teachers than others have implemented it (60% vs. 40%).
- Teachers have a positive view on the STEAM approach, as it is useful and STEAM skills are increasingly necessary to engage in a knowledge-based economy.
- Most teachers do not feel well prepared to implement the STEAM approach and they do not know if there might be limitations in the school system.

Focusing on the **limitations or obstacles of implementing the STEAM approach in their school**, in fact, on average one third of the teachers did not know what to answer to items related to the possible limitations of implementing the STEAM approach. However, they converge on the

- Knowledge gaps about a STEAM learning approach among the teachers,
- The national education system is not prepared to include a STEAM approach,
- Practical limitations in terms of lack of sufficient equipment and sufficient time in the school program to implement a STEAM approach.
- It is possible to integrate a STEAM approach into the school curriculum as there is sufficient interest on behalf of the teachers and the students.

Teachers' skills

Regarding a **set of skills which are relevant to the proposed learning approach and the tools** foreseen for its implementation, the results showed divergence between the responses from the different countries,

- Using mobile devices (i.e. smartphones or tablets) for education is made on a regular basis by most teachers.
- Using applications to monitor the nutritional value or sustainability of food are not used by most teachers in the 3 countries.
- Using office software (i.e. text processing, spreadsheet and presentation applications) are regularly used by Spanish and Greek teachers, while most of the Italian teachers do not use them so much.

- Working in collaboration with other teachers from different disciplines in one common project course is experienced by about 50% Italian teachers and only 30% Spanish and Greek teachers.
- Guiding students to work in teams, communicate their opinions and ideas verbally, carry out fieldwork to gather information, and keep to deadlines is regularly done by all teachers.

Teachers' interests

Regarding the proposed themes

- In all 3 countries, teachers declare moderate to strong interest in learning about the proposed project themes, i.e. "ways to lead a sustainable and healthy diet", "association of dietary habits with health", "benefits of being a sustainable consumer", "the causes of climate change and its impacts on food production", "impact of their current eating habits on the environment", and "different methods of food production".

Regarding the proposed learning approaches and tools

- In all 3 countries, many of the teachers declared moderate to strong interest in:
  - carrying out the activities proposed, i.e. establishing a closer connection between science subjects and other school subjects like IT, P.E., Literature and Art,
  - supporting students in communicating their findings to a wider audience,
  - taking the students out of the classroom for fieldwork,
  - working in a school project together with the students and experts,
  - instructing students in using online/mobile applications for educational purposes,
  - working in collaboration with teachers from other disciplines,
  - teaching the students how to investigate and verify information available on the internet.

Teachers' perceptions – attitudes

Regarding issues related to the environment, healthy and sustainable diets,

- In all 3 countries, teachers are aware about environmental issues, and they have a positive attitude regarding the importance of a sustainable and healthy diet.

Regarding aspects of the proposed learning approaches

- In all 3 countries, teachers are positive towards the integration of new technologies and teamwork in school education, despite one third of teachers from Italy and Spain stating they do not enjoy using their smartphones or tablets.

Regarding the evaluation of some activities related the themes of the project that might be of personal interest or hobbies:

- In all 3 countries most teachers very often cook and select personally the food to buy, often check the origin and the nutritional value of food or additives/preservatives on the packaging, select organic food to buy, and search on the effects of a particular food on health.
- Most teachers have never used an application to calculate the nutritional value or the environmental impact of food.

Regarding following a special diet, Italian participants showed a higher percentage in comparison to the responses of the Spanish and Greek participants, and they are mostly vegetarian.

Tips for the methodology

The main outcomes from the surveys of the Learning Needs of students and teachers have been taken into account for the development of the GOODFOOD Methodology which is intended as a sequence of actions for the implementation of the project, promoting interdisciplinary teaching, acquiring knowledge, competence and skills on certain themes related to food with relatively long-term involvement of the students in investigations related to different aspects of the connected topics.
We herein present the main indications for the development of the GOODFOOD Methodology derived from the findings listed above.

Regarding the target students and learning methodologies, the GOODFOOD Methodology has considered the following points:

- **Inclusion of teaching methods that are acknowledged to stimulate young students' interest, for engaging them in practical activities** (e.g., hands-on experience) related to the themes of the project in different school subjects and using tools that are in ordinary use by the students according to their age (e.g., mobile phones, video-clips).
- **Development of teaching materials that stimulate critical thinking, group efficacy on environmental and health issues and awareness on personal behaviours**; but also teaching materials whose contents can be adapted by the teacher to other students' age as long as the teaching model (i.e., inquiry-based learning cycle) is maintained.
- **Project-Based learning as a methodology** that allows the students to become expert about a real question/issue/topic as they are involved for a relatively long period in investigations covering as many aspects as possible related to a certain topic/issue/topic, thus connecting different school subjects.

The analysis of the results regarding the students' knowledge evidence that students have a general moderate knowledge of the basic concepts about the proposed food themes, but they also have some limited knowledge on some of the specific topics. Therefore, GOODFOOD should:

- Overall, **reinforce** the students' understanding of the main issues related with a healthier diet as recommended in the MD pyramid, the WHO and the Harvard Eating Plate.
- For the purpose above, **focus the development of learning activities on some of the main issues related with the diet and health** such as: i) the fat component in our diet; ii) the consumption of salt; iii) antioxidants and healthy components of the diet; vitamins, minerals, proteins, etc.
- **Analyse the connection between the general recommendations of the MD and each Mediterranean participant country's cooking traditions**, eating habits and cultural aspects of food. Find out to what extent their area or family eating habits follow the general rules of a MD. Part of the learning activities should help the students understanding how their own traditional cuisine relates with the concepts of the MD and of a healthy diet, as well as to eliminate possible local misconceptions (e.g. regarding the MD as a form of pescatarian diet, as is the case with the Greek respondents).

- **Revise the concept of the vegetarian/vegan diets**: what is the truth about these diets? Are they healthy? Do they provide a nutritionally balanced diet? Are there any problems or misconceptions associated with this type of diet?
- **Reinforce the concept of "sustainability" of food productions** which is not only "environmental" but it also refers to the economic and social aspects.
- **Investigate the sustainability and health aspects of the entry of new foods in the human diet** (e.g. insects, genetically modified foods, artificial meat). As a positive aspect, these foods might enhance the sustainability of food production against potential downsides such as, these foods may influence the local biodiversity and culture. **Impulse the debate** with students **to raise critical thinking and stimulate position taking** on these topics.
- **Clarify the concepts of a "sustainable diet"** and related aspects such as 'organic foods'. For example, the nutritional composition of organic foods in comparison with conventional foods is currently a matter of research and debate. One other important point to learn and discuss about organically produced vs. conventional plant foods refers to the potential higher levels of compounds that protect the organic plants against biotic (pests, microbes) and abiotic stresses (radiation). From a dietary point of view, these compounds are generally termed as 'bioactive' compounds (the so-called 'antioxidants' which includes a diversity of phytochemicals with potential health benefits).
- **Make students aware that organic food might also be healthier than conventional food** since they contain less pesticides or threatening substances (Smith-Spangler et al. 2012). Knowing the regulations is also an important issue: students should be aware that in some countries conventional agriculture might not be allowed in favour of integrated or organic agriculture, and that soil analysis is not required to get the certifications, so that organic agriculture can be done in a contaminated soil. However, in general, it is recognized that organic agriculture is healthier than others because of the ban of pesticides.
- **Stimulate students to train their taste sense**. Denoting differences in flavour between foods of the same type but different origins or variety is not easy. Many studies report that most consumers don't find consistent differences between the flavour of a food produced in an environmentally sustainable way and a food conventionally produced. Only those who do use organic food, can feel the difference (Theuer, 2006). However, as mentioned above, in organic agriculture, plants develop more substances to coexist and resist pests and other abiotic stresses that might influence the organoleptic properties of the organic foods.
- Provide students with learning materials to fill their knowledge gaps on "Intensive farming", "Sustainable farming", "Organic farming", "Community-supported agriculture" and "Food chains".
- GOODFOOD learning materials should not take for granted the students' knowledge of some common terms (e.g., ecological, carbon and water footprints or virtual water, antioxidants, genetically modified food). Instead, some specific materials and activities should focus on such terms to increase the students' awareness and knowledge.
- GOODFOOD fosters an integrated approach among different STEAM subjects, while students relate the themes mainly to science subjects (Biology, Chemistry) and physical education. They are aware that other subjects (Physics, Geography, Economics and History) are

connected to specific issues but among these, they do not take too much into consideration Arts and Literature.

Approaches, methodologies, and tools

Based on the findings related to the **set of students' skills which are relevant to the proposed learning approach and the tools foreseen** for its implementation, and the students' interests on learning approaches and tools, which suggest a connection between the students' level of skills and their educational systems, GOODFOOD should:

- propose activities that are based on **team working** as, in the 3 countries and despite some slight differences, students already perform it and appreciate it very much. Team working enhances collaboration, rules definition and respect of a shared pace of work, allows sharing of ideas and experience, enhancing learning.
- propose activities that include **fieldwork** to gather information as well as **hands-on and laboratory experiences** which raise students' interest. Some kinds of activities might be constrained by school regulations, or family constraints such as field trips, outdoors activities or other experiences. The project should not create the condition in which economic problems or diversities may generate disparity or exclusion; therefore, the activities and the choice of the activities should be based on **inclusion**.
- encourage skilled students (especially in Greece and in Italy) in using **cameras or video-making software** to produce final outcomes and ask these students to teach their less skilled peers using these tools.
- promote **visual arts** to communicate a message and findings, therefore, Italian students who are apparently the most familiar with this skill, might show examples of artistic outcomes (even from other projects) to their foreign peers.
- have a list of **Apps** for mobile devices and computers that can be used by teachers and students to assess the nutritional value of food or its environmental impact. These Apps are apparently very interesting to students; therefore, students may share their knowledge and suggest further Apps to the list.
- nurture students to always search for the **source of information**, especially when it comes from websites for commercial or entertaining purposes. However, also "apparently serious news sources" may fail, therefore, learning and acquiring information must come from reliable and verified sources.

As students in all 3 countries do not seem keen to involve relatives and friends in school activities, GOODFOOD should

- stimulate the dialogue between generations without forcing the inclusion of intergenerational learning activities and different generations (i.e., parents, relatives, friends) participation in the project.

Because in all 3 countries, students seem to be rather familiar and comfortable with scientific subjects (e.g. Science, Biology, Maths) but not so much with other subjects, GOODFOOD should

- promote the integration of different subjects in investigating a certain theme and include activities that are related to **Engineering** (e.g., design, building, use of machines etc) thus introducing the STEAM approach in the schools.

- foster the inclusion of **Arts and Literature** among the educational activities to make students aware that learning is not a box and widening the knowledge is important also to identify one's own skills and interests.

As students state that they often cook, GOODFOOD should

- include activities that allow students to have such a creative experience in their learning process.

Regarding the project themes and the educational approaches, considering the **teachers' skills and knowledge**, GOODFOOD should provide teachers with

- Sufficient knowledge and a structured Methodology for the implementation of the STEAM approach and the teaching methodologies such as Inquiry-Based Learning and Project-Based Learning. Therefore, the Methodology needs to provide:
  - **Disciplinary contents** about the project themes, covering the aspects that are less familiar for the teachers.
  - **Learning materials (modules and activities)** covering different school subjects so that the **STEAM** approach is smoothly implemented.
  - Learning materials (modules and activities) that are clear, feasible, including **hands-on/practical activities, use of technologies and Apps,** stimulating creativity.
  - A **training course** addressing teachers on the themes of the project and the Methodology and its educational approaches.
- A list of **Apps and software** that are user friendly for teachers and appealing for the students.

Therefore, the GOODFOOD methodology implies an integrated STEAM approach in which teachers of different subjects will coordinate as a team and will involve students in activities connected to a food theme, applying Project-Based Learning.
Learning methods will include Inquiry Based Learning with investigations based on hands-on activities, experiments, and research but also creative activities that will inspire and stimulate students.

Learning approaches and methods

Learning approaches and methods

In the present society, there is an increasing need to confront a range of critical issues (i.e., environmental, economic, social, political, etc.) that require the development of specific knowledge and competences, but also the capacity to deal with them in an interdisciplinary manner. The Internet and the Information and Communication Technologies (ICT) have greatly contributed to enhancing the people's skills to access and use information but, at the same time, with the overflowing of information that can be retrieved, and the increased use of social networks and social media, there is also an increased need to verify the truthfulness of the sources and to enhance our critical thinking. Thus, individuals are continuously required to get new knowledge and skills to critically analyse and understand the world around and be able to propose and promote solutions and appropriate behaviours.

Formal and informal learning environments should adapt to the changing world's needs and offer educational courses that motivate students to understand a topic or a problem from different perspectives and make suitable links. In other words, stimulating students' interdisciplinary thinking and ability towards a topic or a problem, instead of proposing a disjointed array of school subjects. In addition, it is very much important to use an inquiry approach in order to maximise their own learning and understanding of a phenomenon or a certain topic.

In this context, GOODFOOD has selected several relevant and most effective methodological as pillar basis of the Learning Methodology, that are described in the next chapters:

1) Integrated STEAM approach
2) Project Based Learning
3) Inquiry Based Learning
4) Intergenerational Learning

Integrated STEAM approach

Formal education is traditionally based on the division of knowledge into different areas or subjects, generally, without much connection between them and with the real world. This condition hinders the ability to apply the acquired knowledge to real situations and(or) to solve practical problems. Surely, there is an increasing need for more interdisciplinary learning procedures and a wider range of transversal skills and thus, the school system has the urgent necessity to adapt to the changing requirements and to provide the most suitable skills for tomorrow's people.

STEM education has been widely promoted in the last ten years as a way to apply interdisciplinary teaching and give students the ability to solve complex and realistic problems (Honey et al., 2014). STEM promotes interdisciplinary teaching of Science, Technology, Engineering, and Maths within complex projects that require the application of skills and knowledge from all these subjects. However, in practice, STEM often results in "patchwork" curricula of several different subjects without a real disciplinary integration (Thuneberg et al., 2017). Among the causes of this are the inadequacy of the school system and schedule to integrate such an approach, and the insufficiency

of teachers' skills (Blackley and Howell, 2015). Recently the STEM approach has evolved into STEAM as scholars have increasingly realised that Arts and Humanity subjects (A) can help students to understand the connection between different disciplines and to achieve a more comprehensive perspective (Watson and Watson, 2013, Kant et al., 2018). Joint technology and creativity are increasingly considered to impulse student's motivation and enthusiasm into the learning process, where Art can be incorporated in different ways, i.e. applying Science and Maths to understand what is underneath Art (colours of painting, materials, physics of sounds and materials of music instruments, the connections between Maths, Physics and Philosophy, etc.), or presenting the results of a scientific study in a creative artistic way with the use of technology. In summary, the application of STEAM promotes learning motivation, self-efficacy, and acquisition of interdisciplinary knowledge (Jia et al., 2021).

Project-Based Learning

The main philosophy of project-based learning is based on the constructivism approach in which learners create their own knowledge, making learning meaningful and effective. In project-based learning, students are themselves involved in the project by doing and experimenting with different disciplines instead of the more traditional teacher-oriented practices. The project-based learning method provides long-term learning and consists of the following stages: topic selection, resource scanning, time calendar, cost calculation, determining the methods of collecting information on the subject, compiling the findings and reporting. When the students have to solve problems, work in small groups and make their own self-assessment, they increase their interest and willingness in learning which becomes more meaningful to them. In addition, this methodology improves interpersonal communication. In project-based teaching, the way and the reason why learners will learn is at the forefront as much as what will be learnt. This allows students to explore the knowledge acquisition process by structuring it, so that learners take an important responsibility in the learning process. This approach makes the school learner-oriented where the teacher's role is organising, directing, and guiding the process, encouraging the learner's willingness to work. These environments allow learners to adapt better to school and lessons, to have positive attitudes towards learning as well as to achieve higher success in their courses, put more effort, self-confidence, to be persistent in difficult research, to remember the information, and to recognize the necessity of information to better understand a particular issue. Studies on project-based teaching have evidenced the acquisition of transversal skills such as social skills, self-efficacy, and lifelong learning tendencies.

Inquiry Based Learning

Inquiry Based Learning (IBL) is an approach to learning focussed on the student, who should design and build the body of information, solve problems that arise, and reflect on possible solutions and their significance. This approach allows students to actively acquire new knowledge rather than receiving it passively through routine teaching or standard frontal instruction, whilst the teacher facilitates the learning process. In IBL, the aim is to investigate a topic with the following pathway: finding a problem, creating a hypothesis, and carrying out tests to find answers to the problem. This means that the teacher should support students' engagement in inquiry and engage them in constructing meaningful understandings. The teacher encourages the students to put forward their ideas, explore, and debate their point of view while using dialogic, critical and thought-provoking questions and giving students time to think and answer (Chin, 2007; Maaß, 2011).

IBL has a long history. Already in 1933, Dewey outlined several important aspects of IBL, such as defining a problem, formulating a hypothesis, and conducting tests. Later on, the interaction between phases, the sequencing of phases, modifications in terminology, and more definitions were progressively introduced. Contemporary inquiry cycles implicitly reflect aspects of earlier frameworks. White and Frederiksen (1998) proposed an inquiry cycle of five phases: Question, Predict, Experiment, Model, and Apply; more recently, Bybee (2006) published the 5E learning cycle model in which he proposes five inquiry phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation. Pedaste et al. (2015) found that different descriptions of inquiry cycles in the research literature use various terminologies to label phases that are very similar. These authors summarise the IBL phases from different frameworks into 5 phases: **Orientation, Conceptualization, Investigation, Conclusion** and **Discussion.**

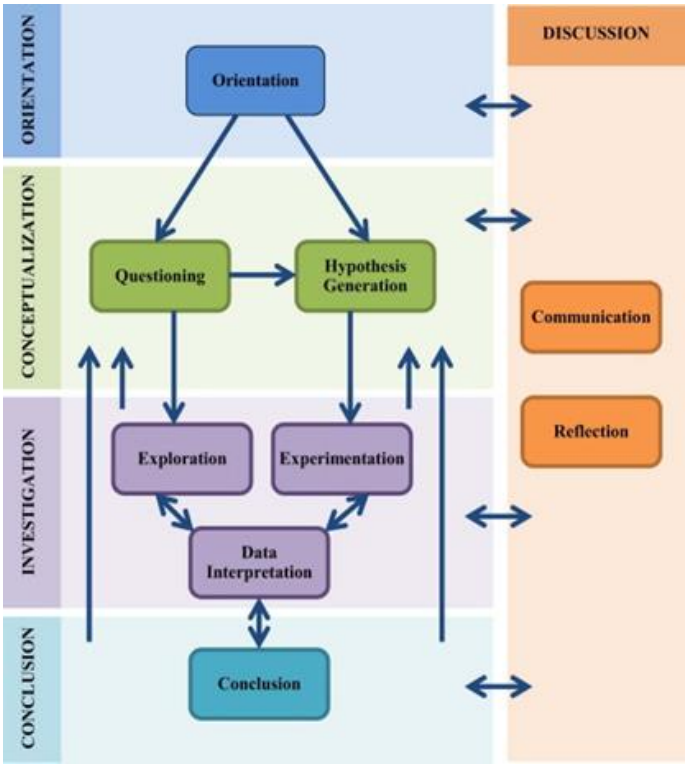


Diagram representing the 5 phases of IBL from Pedaste et al. 2015.

In the **Orientation** phase, the aim is creating curiosity and motivation about a topic. It can be done addressing a learning challenge through a problem statement, a multimedia or a talk.

In the second phase, **Conceptualization**, the students elaborate the questions or hypotheses that they have to answer or test to understand the topic/problem or phenomenon.

Next, in the **Investigation** phase, a methodology is determined and applied to search for the specific results. It includes the process of planning and exploration, or experimentation. The exploration includes a systematic and planned data generation based on a research question, including bibliographical research. The experimentation will deal with the design of an empirical protocol that will be applied to test the initial hypothesis. Both processes aim at collecting and analysing the results which should be interpreted in order to make meaningful the information found and synthesising new knowledge.

Then, in the **Conclusion** phase, which is strictly connected to the previous phase, the students draw their conclusions about the results they obtained with respect to the formulated hypothesis, or the research question posed at the beginning.

Finally, in the **Discussion** phase, students present their results. The results are summarised and discussed to make inferences and deductions and further questions may arise. Communicating their own experiences to the public increases the communication skills and other transversal skills (learning how to use ICT, making videos and presentations, group work, language skills etc.) of the students. This phase is an important test to verify the students' learning.

Intergenerational Learning

Intergenerational Learning describes the way that people from different age groups can learn together from each other. The main idea of this method is to provide an exchange of information between different generations, such that a group of, for example, teenagers can learn from their peers and elders and vice versa. By using this method, the learning environment becomes wider and it makes the learning more effective and permanent. Intergenerational learning is an important part of Lifelong Learning in which not only knowledge and skills are acquired between generations, but also other human, social and cultural values. Indeed, beyond the transfer of knowledge, Intergenerational learning encourages relationships between different generations, and it is a way to improve intergenerational solidarity. Bringing together people from different generations in activities with a common purpose and from which they may mutually benefit, increases the respect between generations, and provides each generation with the positive resources they can offer to each other.

Intergenerational Learning can be achieved through **meetings**, generally connected to institutions and planned according to a programme with scopes and schedules. Further, they are also opened up to unexpected situations and events and to the spontaneity of the people involved. The actors can be *doing things together* (they have a common activity or project to implement) or *doing things for each other* (when one generation can do something like a service for the other one), so that the two generations recognize the value and the personal utility for the other. In all kinds of interactions, there is a *transmission* of culture, knowledge, know-how and experience. Intergenerational interaction has many benefits. For elders, it helps to be productive and active, feel useful and pass on their own experience and history. For young people, it helps to improve one's esteem and to build up one's own identity, but also develop an open mind and stimulate learning from life and human relationships, increasing the experiences of life and maturity. In general, Intergenerational Learning helps to be more inclusive and tolerant, to have new relationships and improve communication and technological skills, as well as sensitivity towards others, historical heritage, culture and traditions.

Youth and elders can share knowledge and teach each other.

Digital tools

Digital tools

The GOODFOOD Learning Methodology is supplemented by digital tools that can support the learning process. The role of the digital tools in the framework of the GOODFOOD Methodology is complementary; digital applications aim to facilitate different stages of the proposed methodology, by enhancing collaboration among teachers and students, and facilitating learning activities within the IBL framework through:

- Providing inspirational material and/or stimulating the interest of students on the GOODFOOD themes
- Enhancing the investigation activities of students by offering easy and user-friendly access to information regarding the environmental impact, nutritional value or health benefits of food ingredients, and by facilitating other investigation activities like surveys, interviews, data collection and analysis etc.
- Enabling the reporting and presentation of conclusions/findings and the outputs of the GOODFOOD school project (i.e. GOODFOOD recipes)

The advent of mobile devices (i.e. smartphones and tablets) and the fast evolution of mobile and online applications has created new opportunities for learning. On the other hand, the recorded interest, positive attitude and skills of students of secondary education in using them facilitates their integration into the learning process. There is a great number of mobile applications available in both major platforms (Android and iOS) on the GOODFOOD themes, however not all available mobile applications are suitable for use within the GOODFOOD learning methodology, both in terms of scope – for example there are many applications in the field of nutrition and healthy diets but they are solely oriented towards weight loss and this is outside the project scope – and usability as learning tools. The proposed digital applications were selected by the GOODFOOD project team to better respond to the following criteria:

- **Open source and free of charge**: the applications selected are open source and free of charge, at least in their proposed version for application, to make sure they can be easily adopted within a variety of learning frameworks.
- **User-friendliness**: the selected applications are user-friendly and do not demand any additional expertise from the user. Although the level of complexity and available features vary from application to application, they all include friendly user interfaces, and do not assume any special expertise. All selected applications can be used by both students and teachers.
- **Potential for learning and awareness raising**: all selected tools have been reviewed by the GOODFOOD project team regarding their learning and awareness raising potential, as well as their suitability within the proposed learning methodology. They can facilitate learning both during their application and afterwards.

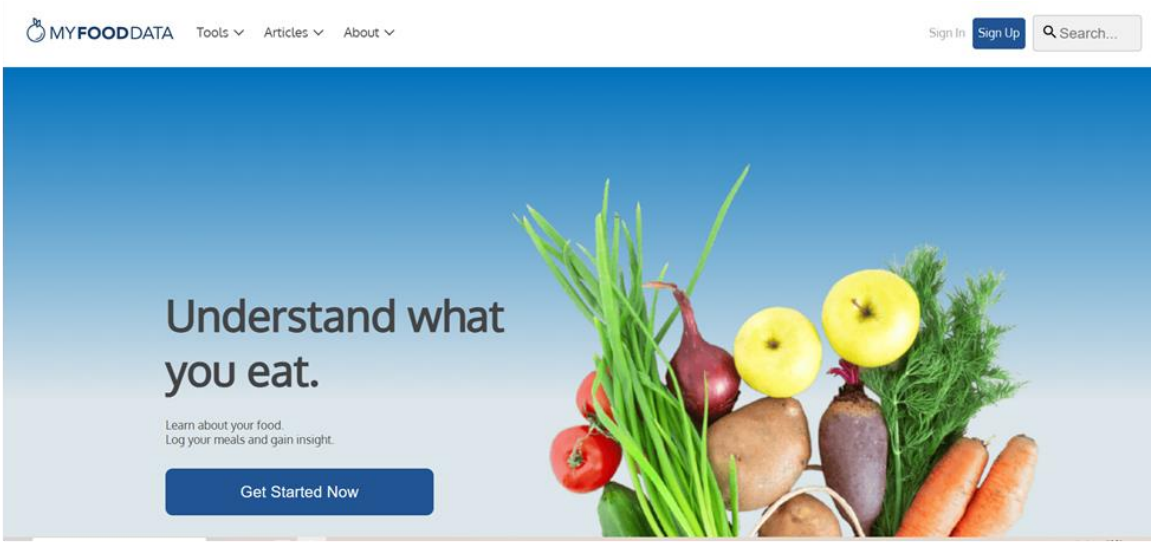
- **Facilitating engagement and participation of users**: all suggested applications include a component of encouraging the users' active engagement, and in some cases offer opportunities for collaboration.
- **Stability and support**: the suggested applications have been reviewed in terms of stability in their use and available support, taking also into account the operating systems (platforms) they are available in.

The proposed selected tools in the GOODFOOD learning framework are listed at the GOODFOOD Library of Learning Resources at this link https://goodfoodeplus.cebas.csic.es/educational-material-2/ on the project website. Each proposed tool/application listed includes relevant information including:

- Title
- Relevant GOODFOOD theme(s) (i.e. Sustainable Food Production, Sustainable Food Supply and Selection, Nutritious and Healthy Food Consumption, Sustainable Food Waste Management)
- GOODFOOD Learning Unit(s) under which it can be employed
- Language(s) it is available in
- Short description of its objectives and available features
- Access link

Below you can find indicative examples of the suggested digital tools/applications, targeted at inspiring and stimulating the interest of students or facilitating the investigation activities, related to the different themes of GOODFOOD.

MyFoodData
Objective: Stimulating interest in nutrition, nutritional comparison between different foods
Related GOODFOOD theme: Nutritious and Healthy Food Consumption
Website: https://www.myfooddata.com/



Screenshot of the MyFoodata Nutrition Tool https://www.myfooddata.com/

My Food Data is a place where you can track, learn and understand the composition of the foods you eat to create better and healthier meals. It has different tools such as the 'Nutrition Facts Search' which contains nutrition facts for over 600,000 foods. Enter ingredients to your own recipes and meals to view totals. Over 132 nutrients and micronutrients are available (free!).

Taste Atlas

Objective: Inspiration, stimulating interest

Related GOODFOOD theme: All

Website: www.tasteatlas.com

Taste Atlas is a website application for exploring traditional food recipes around the world, offering a good insight to traditional and representative dishes and foods from different regions. The application uses a map feature (see below), allowing the users to Zoom in and explore a rich collection of foods, dishes and recipes around the world (more than 10.000 dishes and 5.000 local ingredients). By clicking on a specific dish, the user has access to more information like the name of the dish in the national language and other languages if relevant, a short description of the food/dish, a taste rating 1 to 5 by users, and information on where to try it and similar dishes. The website app is suitable for exploring and getting inspiration on the recipe or recipes to focus on in the GOODFOOD project in each country.

Screenshot of the Taste Atlas Map www.tasteatlas.com

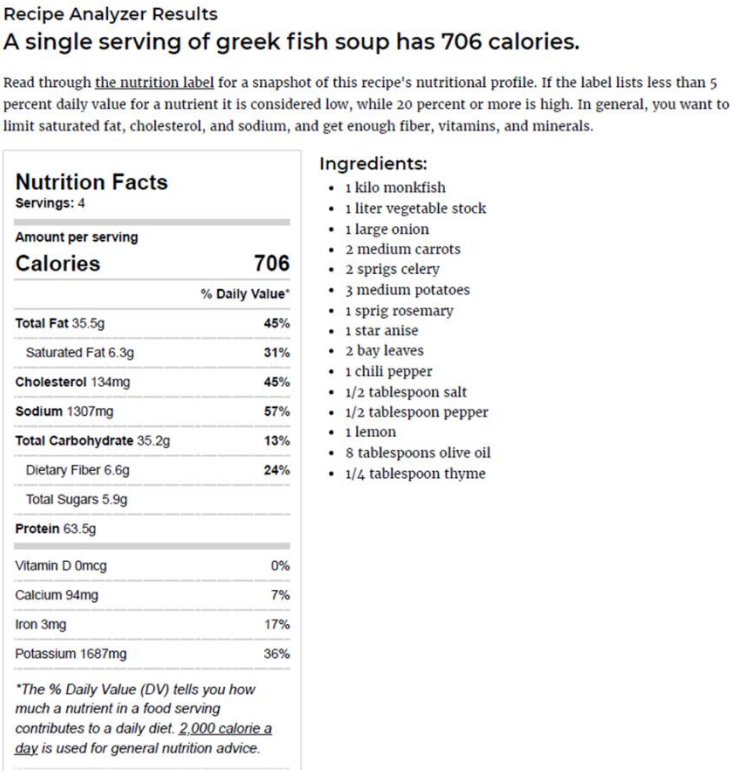
Recipe nutrition analyser

Objective: Investigation

Related GOODFOOD theme: Nutritious and Healthy Food Consumption

Website: https://www.verywellfit.com/recipe-nutrition-analyzer-4157076

This Recipe Nutrition Analyser is a website application allows the user to insert a recipe (i.e. ingredients and amounts) and number of servings, and the application calculates the calories, fat, cholesterol, sodium, carbohydrates, protein, as well as Vitamin D, Calcium, Iron and Potassium per serving, also indicating the percentage of the indicated daily intake. In the example below for Greek Fish Soup (ψαρόσουπα), you can see the layout of the application results after inserting the recipe ingredients, amounts and servings. The application is suitable for use within learning units under the GOODFOOD theme of "Nutritious and Healthy Food Consumption", facilitating the analysis and comparison of nutritional aspects of recipes.



Recipe Analyzer Results

A single serving of greek fish soup has 706 calories.

Read through the nutrition label for a snapshot of this recipe's nutritional profile. If the label lists less than 5 percent daily value for a nutrient it is considered low, while 20 percent or more is high. In general, you want to limit saturated fat, cholesterol, and sodium, and get enough fiber, vitamins, and minerals.

Nutrition Facts

Servings: 4

Amount per serving	
Calories	**706**
	% Daily Value*
Total Fat 35.5g	**45%**
Saturated Fat 6.3g	**31%**
Cholesterol 134mg	**45%**
Sodium 1307mg	**57%**
Total Carbohydrate 35.2g	**13%**
Dietary Fiber 6.6g	**24%**
Total Sugars 5.9g	
Protein 63.5g	
Vitamin D 0mcg	0%
Calcium 94mg	7%
Iron 3mg	17%
Potassium 1687mg	36%

**The % Daily Value (DV) tells you how much a nutrient in a food serving contributes to a daily diet. 2,000 calorie a day is used for general nutrition advice.*

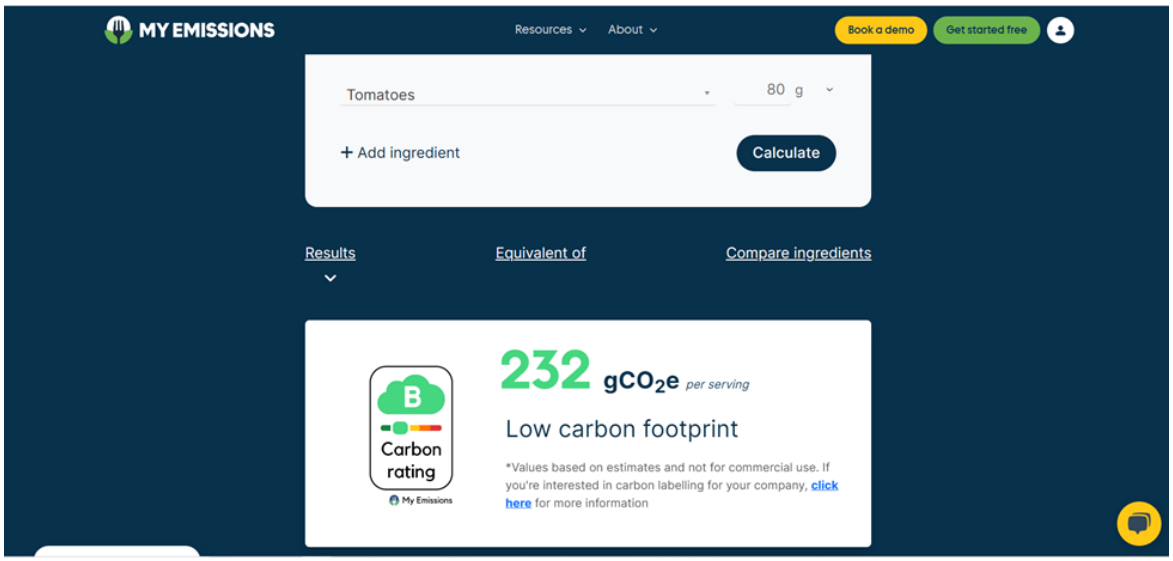
Ingredients:

- 1 kilo monkfish
- 1 liter vegetable stock
- 1 large onion
- 2 medium carrots
- 2 sprigs celery
- 3 medium potatoes
- 1 sprig rosemary
- 1 star anise
- 2 bay leaves
- 1 chili pepper
- 1/2 tablespoon salt
- 1/2 tablespoon pepper
- 1 lemon
- 8 tablespoons olive oil
- 1/4 tablespoon thyme

Screenshot of the Recipe nutrition analyser https://www.verywellfit.com/recipe-nutrition-analyzer-4157076

MY EMISSIONS

Objective: Stimulating interest and investigation about the carbon footprint of many foods.
Related GOODFOOD themes: Sustainable Food Production, Sustainable Food Supply and Selection
Website: https://myemissions.co/resources/food-carbon-footprint-calculator/

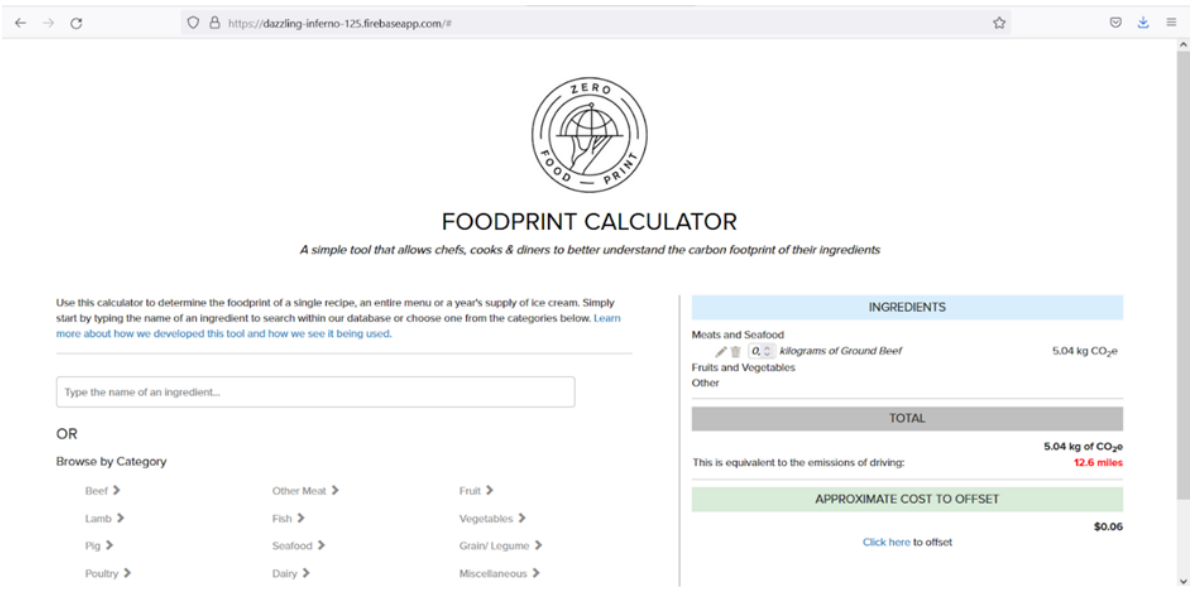


Screenshot of the My Emission Tool https://myemissions.co/resources/food-carbon-footprint-calculator/

Around ⅓ of the world greenhouse gas emissions come from food. So why do we only see nutritional labels on products or calorie counts on menus? My Emissions is changing this with a carbon label and dedicated food emissions reporting. This is a freely available food carbon footprint calculator so you can find out the carbon footprint of your recipes. You can also sign up to a free account to save results, use our AI recipe generator and get more insights from My Emissions.

Zero Foodprint Calculator
Objective: Investigation
Related GOODFOOD themes: Sustainable Food Production, Sustainable Food Supply and Selection
Website: https://dazzling-inferno-125.firebaseapp.com/#/

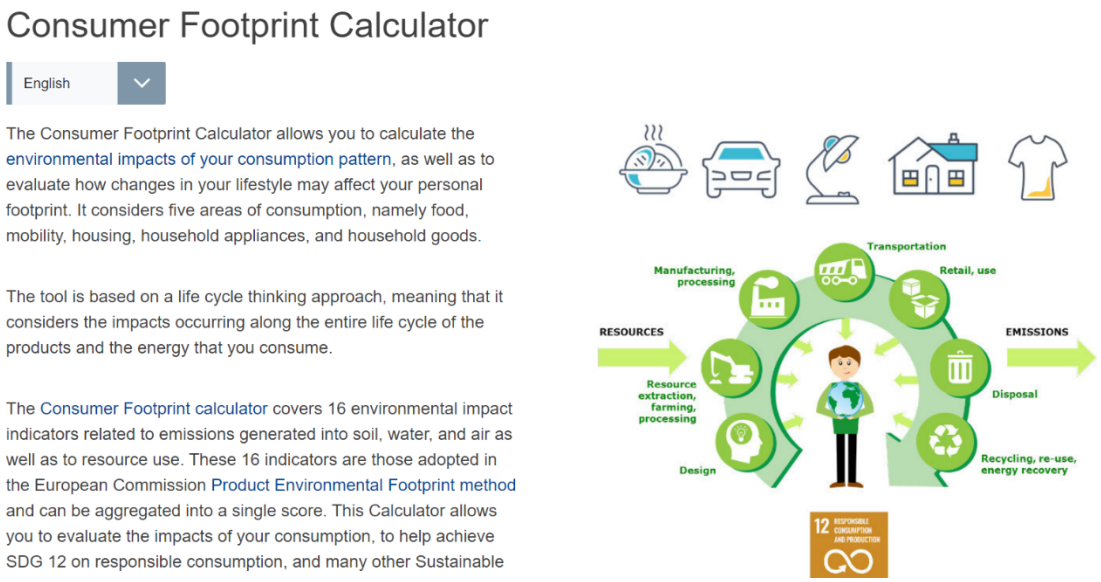
The Zero Foodprint Calculator is a website application that helps calculate the carbon footprint of food (foodprint) for a whole recipe, by inserting each ingredient and the amount, taking also into account the means and distance of transport. Although the list of ingredients available is not too detailed (i.e. the user can select "cheese" but not specific types like mozzarella or feta), it contains general food categories that help get an estimate of the “foodprint” of a given recipe and find ways to reduce the foodprint of a given recipe. This application is suitable for use within learning units under the GOODFOOD themes of “Sustainable Food Production” and “Sustainable Food Supply and Selection”.



Screenshot of the Zero Foodprint Calculator https://dazzling-inferno-125.firebaseapp.com/#/

European Commission Consumer Footprint Calculator
Objective: Inspiration, stimulating interest
Related GOODFOOD themes: Sustainable Food Production, Sustainable Food Supply and Selection
Website: https://knowsdgs.jrc.ec.europa.eu/cfc

The EC Consumer Footprint Calculator is available in English, Italian and Spanish, and allows the users to calculate the environmental impacts of their consumption pattern, as well as to evaluate how changes in lifestyle may affect their personal footprint. It considers five areas of consumption, namely food, mobility, housing, household appliances, and household goods. The application is based on a simple and user-friendly quiz that takes into account different areas of consumption, including food. The application can be used to inspire and stimulate the interest of students on the concept of the environmental footprint.



Screenshot of the European Commission Consumer Footprint Calculator https://knowsdgs.jrc.ec.europa.eu/cfc

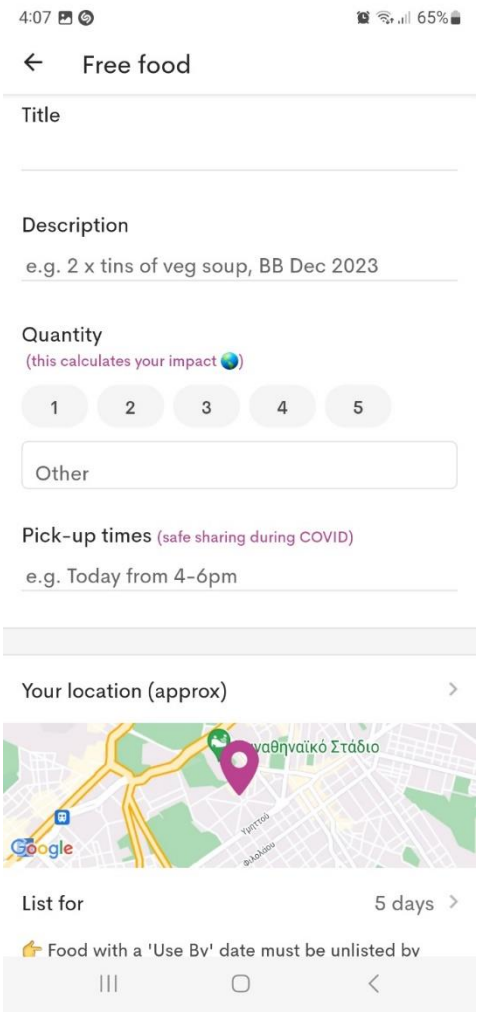
Olio

Objective: Investigation

Related GOODFOOD themes: Sustainable Food Waste Management

Website: https://olioex.com/

Olio is a community of people who want to share any types of products and food in order to promote re-use and waste reduction. Olio is an app that facilitates food sharing in order to reduce food waste. The user needs to simply download and install the application on a smartphone/tablet and register with a valid email account. Donating money to support the app is optional. It can be a useful tool to share food and minimise waste as long as there is a vibrant Olio community in your location. The application is suitable for use with learning units under the GOODFOOD theme of “Sustainable Waste Management”, as the students can register and start sharing food between them, recording the reduction of food waste. The students should agree to use the app in a responsible way and make sure they follow the community's ethics.



Screenshot of Olio https://olioex.com/

GOODFOOD Educational Methodology

GOODFOOD Educational Methodology

The GOODFOOD Methodology is intended as a sequence of steps to carry out a GOODFOOD Project with the class. It is based on the learning methods and approaches that have been described in the previous chapters and it proposes a step-by-step implementation process based on Inquiry Based Learning. First of all, we think important to indicate the main terms that will simplify understanding the whole Methodology.

Term	Description
GOODFOOD Project	The realisation of the project at school, with an organised group of teachers of different subjects that are willing to involve their class into a project-based learning experience on food related themes through the application of the GOODFOOD Methodology.

GOODFOOD Themes	• Sustainable Food Production
	• Sustainable Food Availability and Food Selection
	  ○ Sustainable Food Supply
	  ○ Sustainable Food Choices
	• Nutritious and Healthy Food Consumption
	• Sustainable food waste management

GOODFOOD Thematic Module	A thematic module is seen as a "container" of a collection of Learning Units for specific investigations on specific topics related to each of the GOODFOOD Themes.
GOODFOOD activity	Any activity that is needed to carry out within the GOODFOOD Project in the Learning Units by teachers and students.
GOODFOOD Learning Unit	An IBL-structured unit on specific topics of the theme, that can be carried out applying specific school subjects (one or more than one). The Learning Units investigate specific aspects of the Thematic Module.
GOODFOOD Topics	Any specific topic object of study in the investigations.

How to start a GOODFOOD Project

The implementation is based on the collaboration between teachers of different subjects (STEAM), including humanistic studies as we believe that learning in boxes is not effective and project-based and real life-based learning allows to engage more students and to understand how things work in a holistic way, making learning more effective.

Therefore, the school director or representatives of teachers should spread a call for teachers from all STEAM (including humanistic subjects) for gathering those willing to initiate a GOODFOOD project.

Presentation of GOODFOOD to STEAM teachers

- As an initiative of the school director or upon request of a teacher/group of teachers, **the GOODFOOD project is presented** (themes, objectives and expected commitments) to interested teachers. This can be done in different ways (e.g., during a teachers' school meeting, in a specific event organised for such a purpose).

Creation of the Focus Group

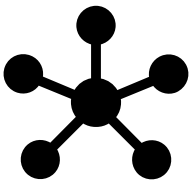
- Teachers interested in the project methodology application appoint and create the **Focus Group**, committed in collaboration for an interdisciplinary integrated approach, under one's coordination, and in applying the methodology and its approaches and technologies.

Focus Group Meetings and Implementation of the project.

- The 1st Focus Group foresees the presence of representatives of the students. As many Focus Group meetings as needed are organised during the project realization, one after each main step with the class (detailed descriptions are shown below).

Teachers' Focus Group

Teachers of different school subjects (STEAM) agreeing in implementing a GOODFOOD Project, are committed in the organisational aspects for the project implementation. This means that they form a **Focus Group** in which roles and objectives in different subjects are defined and the types and the schedule of learning activities. The Focus Group will meet or exchange information regularly during the school year using different communication tools (face-to-face meetings, WhatsApp, emails) to set the pace of the project and follow the learning progress of the students.



The meetings will be useful to discuss about:

- experiences of the project implementation,
- strengths and weaknesses of the activities,
- reactions of the students,
- solutions to encountered problems,
- following activities with their schedule and logistics.

It is very important to develop an interdisciplinary team of teachers that will guide the students in the implementation of the modules and learning units centring learning on the theme rather than on the school subject.

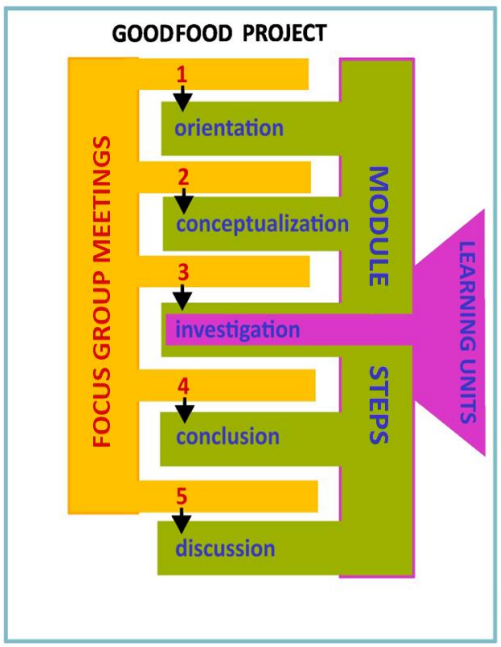
The following chapter describes the tasks and steps of development of a GOODFOOD project in more detail.

GOODFOOD project structure

The development of a GOODFOOD Project with the class follows the structure of Inquiry-Based learning models considering 5 phases:

- Orientation – the phase of engagement, raising curiosity
- Conceptualization – the phase of formulation of questions and hypothesis
- Investigation – the phase in which research and experiments answer and verify the hypothesis
- Conclusion – the phase in which results are brought together
- Discussion – the phase in which the results and the whole learning process is discussed to find major findings. Students reflect on how a dish recipe can be more sustainable and healthier, and on the message to take home and to others through the video slogan.

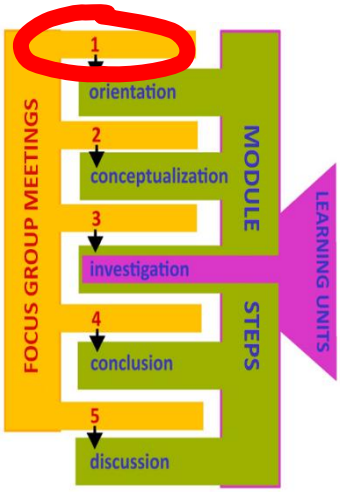
The synthesis structure of the GOODFOOD project implementation is summarized in the figure below, in which the different steps of the methodology follow one another, and the involved teachers remain updated and collaborate on the project ongoing through the "Focus Group" meetings.
The Learning Units are educational materials covering a variety of aspects and suitable to different school subjects (Learning Units can be downloaded from the project website: https://goodfoodeplus.cebas.csic.es/learning-units/).



GOODFOOD Project implementation structure.

The description of each step of the methodology with indications for the implementation with the class of students and for the focus group teachers is provided in the following pages.

1st Focus Group meeting



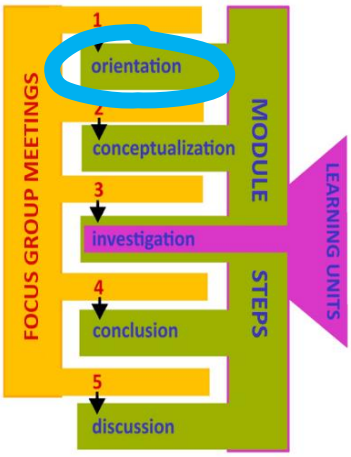
This meeting aims to

1) **Set the list of the involved STEAM teachers,** the school subjects that will be implicated in the project.
2) **Select the class/es of students to be involved in the project.**
3) **Select the Learning Units** of different thematic modules that might be interesting and feasible for the students. The Learning Units available from the website are examples that can be selected, adapted to the context; however, teachers may also propose new ones. The Focus Group decides how different subjects (teachers) contribute to the implementation of the learning unit with the class.
4) **Set the learning objectives in each subject in order to match the school curriculum and the schedule of activities** along the school year, including the evaluation phase (submission of questionnaires for assessing the efficacy of the methodology) of students and teachers.
5) **Identify the rules and the referent teachers**: the coordination of the Focus group (the coordinator will ensure that the project develops according to the schedule, check the progress with other teachers); communication and promotion of the project inside and outside the school (e.g., posts in social media, finding events to show results etc.); organisation and logistics for field trips, laboratory visits, experiences (etc.) (e.g., getting in contact with external experts or stakeholders, organisation of travels etc). The project coordinator is committed to prepare the minutes of the meetings with the taken decisions and plans for the next steps.
6) **Decide the means of communication** between Focus Group members (e.g., WhatsApp, e-mail, etc.).
7) **Decide how to start the project with the class:** who will be the teacher/s (in which subject) in GOODFOOD project is introduced to the class and the Orientation will start (see the details below).
8) **Set a date for the following meeting** and a preliminary schedule of regular meetings during the project ongoing.

GOODFOOD START WITH THE CLASS

Orientation

Students' engagement



Where: In the classroom and at home
Aim: To introduce the GOODFOOD project to the students and stimulate their interest in the thematic modules.
Estimated time: 2 lessons and homework
Organisation: Expected subjects involved: any, run by one or more teachers in the same lesson.

In the classroom, the teacher will:

1. Briefly **introduce GOODFOOD to the class, brainstorming students** on issues e.g. why food is important to us, health, students' food habits and traditions, known issues connected to food productions, sustainability and asking opinions
2. **Ask students for a dish or a meal they like/eat frequently/would offer to a friend** (something representative of their everyday lives or tradition). The dish/meal may consist of one or more dishes e.g., first course, main course, and dessert). The dish will be analysed during the project to assess to what extent it is sustainable and healthy.
3. Invite the students to split into teams to **cook the dish/meal (as homework)**.

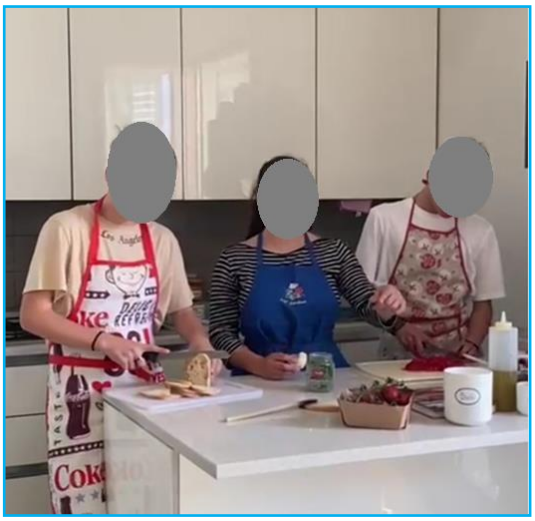
As homework, students will

4. Buy the ingredients and **cook the dish/meal** (with the support of parents for cooking),
5. Make a video about the preparation (i.e., how/where accessed the ingredients, used quantities, recipes, taste and look) with the support of the art/technology teacher for video-making.

Again in the classroom, the students will

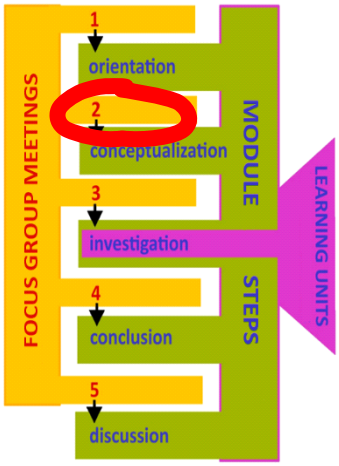
6. Present the videos and vote for the dish/meal with the best preparation and details.
7. Decide which dish(s)/meal(s) they want to focus on during the Project implementation.

Then, the Conceptualization phase follows.



*Activities performed during the **Orientation** phase in the classroom and at home by the Spanish, Greek and Italian school.*

2nd Focus Group meeting



This meeting aims to update all teachers about the activities carried out during the Orientation phase and select the Learning Units that are suitable for the class.

In this meeting:

1) **The teachers involved in the Orientation will report and analyse the students' experiences**: strengths and weaknesses of the activities as well as encountered problems will be indicated (e.g., what worked smoothly, what students liked, how students' brainstorming worked out etc.)

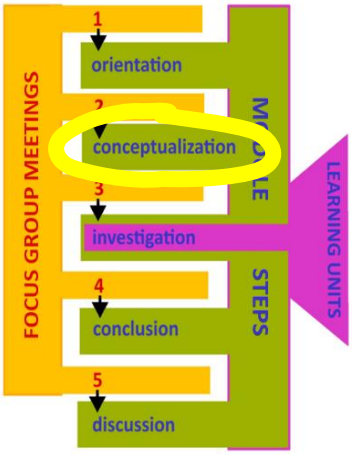
2) **All teachers will carefully check and select the Learning Units** (or propose new ones) related to the modules, they will check how different teaching subjects will be involved, any match with the school curriculum.

3) **The teachers will decide a draft calendar** of the implementation of the Learning Units in the class.

4) **Set a date for the following meeting** and a preliminary schedule of regular meetings during the project ongoing.

Conceptualization

Students' questioning and hypothesis



Where: In the classroom
Aim: To set questions and hypotheses on whether and why the selected meal is sustainable and healthy.
Estimated time: 1 lesson
Organisation: Expected subjects involved: any, run by one or more teachers in the same lesson.

In the classroom, after students have selected the dish/meal, the teacher will:

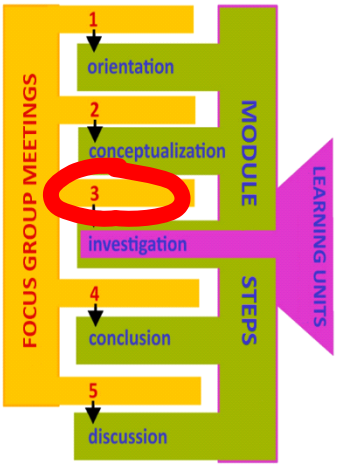
1. **Ask students whether they think the dish/meal is sustainable and healthy**. Students formulate the hypothesis and explain why. Students' prior knowledge is recalled, and the teacher may guide the discussion on the hypothesis by brainstorming on the following elements regarding the food (or ingredients) needed to cook the dish/meal:
   - *Where do the food ingredients come from?*
   - *How have the ingredients been produced?*
   - *How have the ingredients been transformed into food?*
   - *What are the processed behind its delivery?*
   - *Is it made with leftover?*
   - *Why is it considered healthy or unhealthy?*
   - *What are the nutritional aspects?*

These questions can be answered by applying the different Learning Units (see Investigation).

In addition, brainstorming may introduce the scope of GOODFOOD: identifying ways to improve the dishes/meals (e.g., to make them more sustainable/healthier/tastier/generating less waste etc.), for instance by changing some ingredients. This is important because the students eventually will create their own recipes with alternative ingredients that improve the quality of the original dishes/meals regarding the investigated themes.

Then, the Investigation phase follows.

3rd Focus Group meeting



In this meeting,

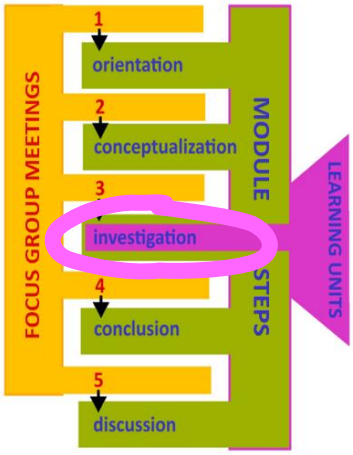
the teacher/s who carried out the Conceptualization report about the experience of the implementation in the classroom to the Focus Group (e.g., the questions raised in the Conceptualization phase the interaction of the students), and analyse the strengths and weaknesses, encountered problems etc.

All the Focus Group teachers decide:

- Schedule of the suggested activities within the chosen Learning Units and the subjects involved.
- Any practical aspects of the project implementation are defined (e.g., logistics, external expert's visit, field visits or others during the Investigation phase (Learning Units implementation).

Investigation

Implementation of the learning units



Where: In the classroom or laboratory Outdoors for fieldtrips
Aim: To explore specific aspects and topics to verify the hypothesis or answer the questions posed in the previous phase, through the implementation of the **Learning Units**.
Estimated time: Lessons and homework depend on the number of the selected Learning Units.
Organisation: Run by the STEAM teachers according to the Learning Units of the relative Module.

In the classroom, the teacher guides the students to implement the Learning Units, which are investigation activities to answer the original questions or hypothesis.
The development of a Learning Unit also follows the structure of Inquiry-Based Learning in 5 phases (Orientation, Conceptualization, Investigation, Conclusion, Discussion) and include activities that can be performed by teachers of STEAM subjects (e.g., surveys, analysing data, field trips, laboratory experiments, hands-on experiments, and activities etc.).

On the GOODFOOD website, there are available the following **Learning Units** in English, Spanish, Greek and Italian:

Sustainable food production

- Food Carbon Footprint
- Sustainable Food Labels

Sustainable Food Supply and Food Selection

- Short Food Supply Chains
- Dietary choices and habits of adolescents

Nutritious and Healthy Food Consumption

- The fat component of the diet - the importance of the quality and quantity of fat in our food.
- How much salt do we eat? How does salt affect our health and how can we reduce its level in our daily diet?
- Improving our knowledge about the concept of bioactive compounds.

Sustainable Food Waste Management

- Food packaging
- The reuse of leftover food

Then, the Conclusion phase follows.

*Activities performed during the **Investigation** phase in the classroom, laboratory and field trips by the Spanish, Greek and Italian school.*

More Focus Group meetings

During the Investigation phase, teachers can meet more than once.

In the meetings, the teachers

- report about the experiences with the students,
- analyse the strengths and weaknesses,
- identify the problems and all together propose solutions.

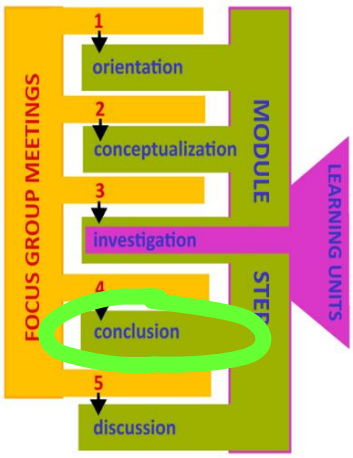
The teachers finalise

- the organisation of the module(s) and Learning Units implementation and in terms of timetable,
- contribution of STEAM teachers,
- necessary equipment, schedule for the activities and
- report about the state of the organisation.

They start planning the final steps of the Module and identifying the teacher who will mostly support the students in the last part of the project i.e. preparation of the final outcomes such as the book of recipes and the video-slogan.

Conclusion

Summary of the findings
Alternative recipe



Where: In the classroom and at home
Aim: To gather the findings from all the Investigations (Learning Units) and "to design" an alternative Recipe for the selected dishes/meals.
Estimated time: 2 lessons.
Organisation: Run by one or more STEAM teachers

As homework, the students, organised in teams,

- prepare a presentation of the main findings obtained from the Investigations (the summary of the findings from the Learning Units implementation).
- In the presentation, students answer the original questions and validate the hypothesis formulated in the Conceptualization, regarding the sustainability and health of the dish/meal.

In the classroom, as brainstorming, students

- suggest alternative ingredients/methods that can improve the sustainability and health of the investigated dishes/meals.

Based on the alternative ingredients, the students design the new GOODFOOD Recipes of the selected dishes/meals for the final book.

Then, the Discussion phase follows.

Table Results Fat Recommendations - Activity 3 .XLSX

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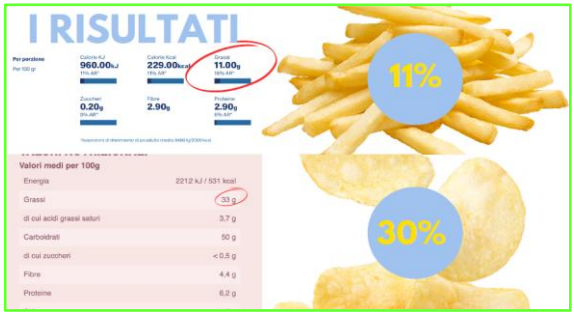
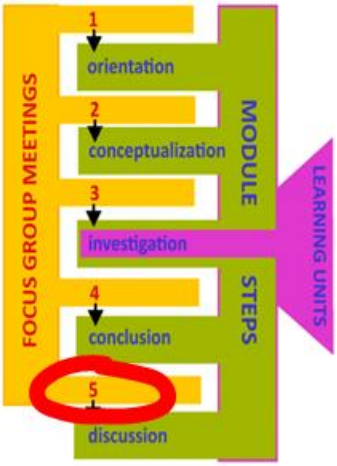
		(From Activity 1)	(From Individual RI calcuclations)		
Food item/Person	Estimated serving size (g)	Total FAT (g/100 g)	Mean recommended FAT intake (g/day)	Total FAT per serving size (g)	% Recommended intake
Sausage/Volunteer 1	35	29,5	65	10,3	15,6
Sausage/Volunteer 2	35	29,5	122,9	10,3	8,4
...					
Almonds/Volunteer 1	20	53	65	10,6	16,1
Almonds/Volunteer 2	20	53	122,9	10,6	8,6
...					
...					
TOTAL/Volunteer 1				20,9	31,7
TOTAL/Volunteer 2				20,9	17,0

Ingrediente	Gramos del ingrediente en la receta.	Equivalente de CO2 por gramo	Equivalente de CO2 en la receta Multiplicar columna 2 por columna 3	CO2 correspondiente emitido por kilómetros recorridos
patata	400gr	1,273gCO_2/g	509,2gCo_2e	558,7 km en coche 683,2 km en avion 2955,5 km en tren
cebolla	180gr	1,051gCO_2/g	189,216gCo_2e	116,5 km en coche 142,4 km en avion 616,1 km en tren
pimiento	500gr	2,019gCO_2/g	1009,6gCo_2e	279,6 km en coche 341,6 km en avion 1479,3km en tren
ajo	10gr	0,452gCO_2/g	4,523gCo_2e	1,3 km en coche 1,5 km en avion 6,6 km en tren
aceite	125ml	2.391gCO_2/g	298,929gCo_2e	82,8 km en coche 101, 2 km en avion 438 km en tren
sal	5,5gr	1,133gCO_2/g	5,663gCo_2e	1,9 km en coche 2,3 km en avion 10 km en tren



*Examples of results of activities performed during the **Investigation** phase in the classroom and at home by the Spanish, Greek and Italian school.*

Last Focus Group meeting



In this meeting, the teachers

- report about the experiences with the students,
- analyse the learning outcomes,
- identify the problems and strengths of the overall project.

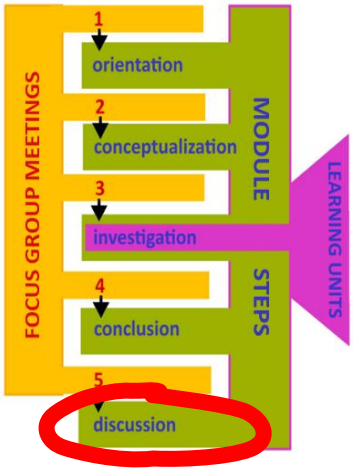
Teachers also

- plan the organisation of the final phase (Discussion)
- plan the promotion of the final outcomes produced by the students, for instance through the organisation of a final event at school, promotion on radio or social media etc.

Class representatives can be invited to the meeting if necessary.

Discussion

Reflection on findings
Message home and others



Where: In the classroom, at home, in public events
Aim: - To test the alternative Recipe and describe it in the Recipe Book, - To share the Project's outcomes with a wider audience through video slogan and other forms of communication.
Estimated time: 2 lessons and homework.
Organisation: Run by one or more STEAM teachers

As homework, the students, organised in teams,

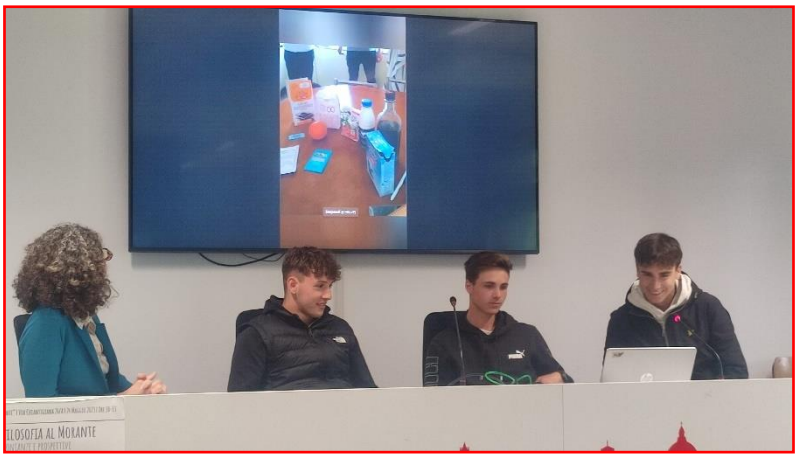
- cook the dishes of the new GOODFOOD Recipes and report on the experience,
- prepare a presentation of their project experiences and findings, as well as their alternative Recipes for wider communication.
- prepare a Video Slogan for GOODFOOD

In the classroom, students

- prepare the description of the new Recipe for the **GOODFOOD Recipe book** and complement it with drawings, images, photos, videos etc.

In a **public event,** students

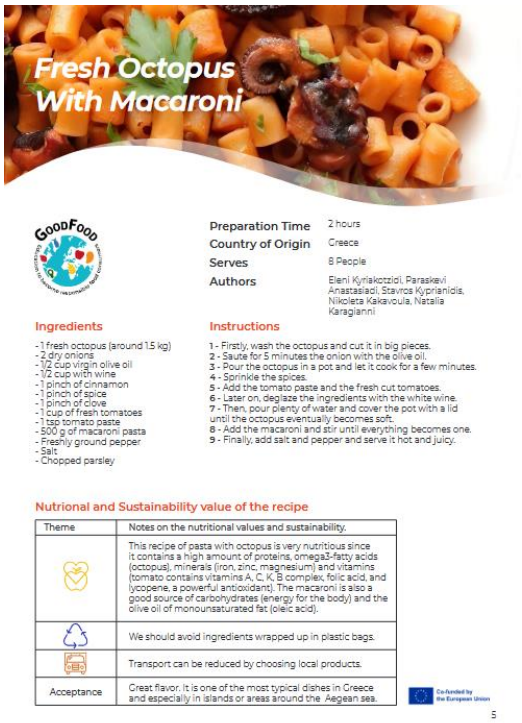
- present to a wider audience at school and/or local community or at conferences, and/or other events.



*Activities performed during the **Discussion** phase in the classroom and in the conference venue to present the project results by the Spanish, Greek and Italian school.*

GOODFOOD Recipe book

The GOODFOOD project stimulated the secondary school students not only to work on food-related topics but to carry out activities such as cooking traditional recipes from their own countries as well as investigating their sustainability, nutritional and health properties. The recipes selected by the students were collected in the CookBook. In this CookBook the students described a total of 27 recipes from Spain, Greece and Italy. The main aim of this book was to inspire others to try new healthy and sustainable foods with new tastes and flavours from different countries.



Each recipe was described by a team of students and contains information about the preparation time, the country of origin, the number of serves and the list of the ingredients with quantities, besides the instructions for its preparation.

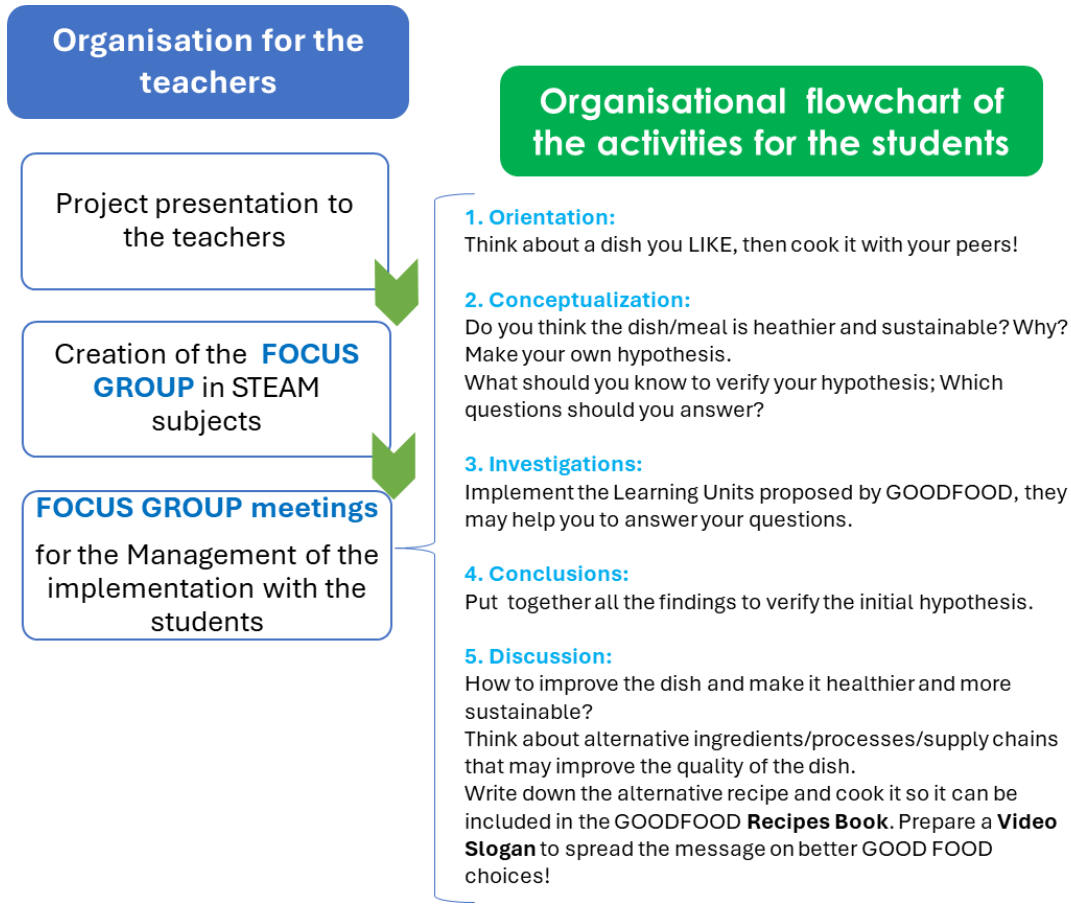
The novelty of the recipes is the inclusion of a table that provides information about the main areas of GOODFOOD: sustainable production, nutrition and health, sustainable supply and sustainable food waste. For example, the students included recommendations to make the recipe more sustainable (e.g. choice of ingredients based on production methods, distance of production, transportation and packaging), or what were the main and healthy nutrients in the recipe (e.g. content of omega-3 fatty acids, vitamins, minerals, etc.). They concluded the table with some information about the flavour of the dish (hedonic value).

The CookBook is available from the project website at this link:
https://goodfoodeplus.cebas.csic.es/pr3/

Learning methodology in brief

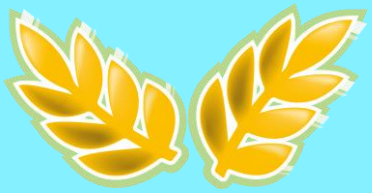
The Learning Methodology integrates STEAM subjects in a GOODFOOD project structured according to the Inquiry Based Learning model. All materials such as Learning Units are also structured according to IBL and make use of different educational tools and methods (e.g. digital devices, practical experiences in the kitchen, in the school laboratory or outdoors) on the four main themes:

- Sustainable Food Production
- Sustainable Food Availability and Selection
- Nutritious and Healthy Food Consumption
- Sustainable Food Waste Management.



Organisation of the teachers and of the activities with the students.

GOODFOOD efficacy



GOODFOOD efficacy

To assess the success and impact of the GOODFOOD project, we developed and applied an evaluation system by means of two surveys, one for the students and one for the teachers, aimed to assess the efficacy in increasing the students' interest in STEAM and food-related subjects but also their attitudes towards school and changes in food habits and behaviours.
The survey addressed to the teachers aimed to assess the acquired confidence in innovative teaching methodologies, changes in food habits and behaviours and self-efficacy in front of new challenges.

Pre- and post- piloting surveys

The questionnaires contain a number of multiple-choice questions (e.g. *Yes vs. No vs. I don't know or somewhat*; *Likert scale for expressing the level of agreement*) that were revised and corrected by all the partners regarding the suitability and the clarity of the questions. Then, the surveys were translated into the three partnership's languages (Greek, Italian, Spanish) before being distributed among the three schools that have participated in the GOODFOOD Project, i.e. IES Monte Miravete (Spain), Lyceum of Rafina, (Greece) and ISIS Ginori Conti (Italy). All the questionnaires were voluntary and anonymous.

The questionnaires were responded before and after the implementation of the school projects (pre- and post-piloting surveys, respectively).

The students' questionnaire was developed to assess the efficacy of the project at enhancing the students' interest in food-related subjects and food habits (nutrition, health and sustainability) but also in their attitudes towards school, learning methodologies and technologies (i.e STEAM, hands-on activities, working in groups, etc). The questionnaire consists of the following parts:

- personal details (gender and age)
- interest in food-related topics
- attitudes towards school, innovative learning methods and tools, STEAM and approaches
- communication
- food-related habits and behaviours
- future career

In the post-piloting survey, we distributed to the students the same survey but with some additional questions about the "impact" of GOODFOOD, relative to their opinion on school learning and food-related behavioural change.

Here below you can find the links to the questionnaires for the students in the project languages

Pre-piloting for students	**Post-piloting for students**
English https://forms.gle/rDJ5r7unFcFQSDNo7	English https://forms.gle/qD7AN4cF8ruRYnyK8
Spanish https://forms.gle/Skk8TRSTbvrSkZow5	Spanish https://forms.gle/2fbv3udyejYvHQr18
Greek https://forms.gle/9Jf1XZuph2qpV18H6	Greek https://forms.gle/Knmt8EYFT5p5Hr3Y6
Italian https://forms.gle/GX9zTJo5hSiYcWXYA	Italian https://forms.gle/jwtz8j3bHdqxSa3KA

Regarding the teachers' evaluation, the survey aimed to assess the acquired confidence in innovative teaching methodologies, collaboration between colleagues and experts from different disciplines, food habits and behaviours and self-efficacy in terms of self-esteem when facing new challenges. The teachers' questionnaire was made of the following parts:

- personal details (gender and age)
- attitudes towards innovative learning methods and tools
- students' interest in the subject when dealing with food-related topic
- teachers' habit and behaviour regarding food
- curricula changes or new extra activities

In the post-piloting survey, we added one question about the "impact" of GOODFOOD, relatively to opinion on the GOODFOOD impact on teaching.

Here below you can find the links to the questionnaires for the teachers in the project languages

Pre-piloting for teachers	**Post-piloting for teachers**
English https://forms.gle/aBLZyhWDhrfPkRAC8	English https://forms.gle/CY2YKMC3VQtzysLz6
Spanish https://forms.gle/6TFRZFHtDhv5upE68	Spanish https://forms.gle/93C3PVHycnntwhjY6
Greek https://forms.gle/mcLB1VTGyR2qGHwS8	Greek https://forms.gle/Wdcp7yT6pZCwoCQd6
Italian https://forms.gle/66m3B2sKdonBztSy8	Italian https://forms.gle/Kb33Zium7yLG8fAF9

Below we report the most relevant results in the three countries, focusing on the positive attitude of the students and teachers' results. Detailed surveys' results can be read in the Report of the GOODFOOD evaluation of efficacy. https://goodfoodeplus.cebas.csic.es/results/

Students' survey results

The questionnaire to students was administered before GOODFOOD piloting (on the 4th and 19th of October in Spain and in Greece, and on the 6th of November in Italy), and after GOODFOOD piloting (on the 13th of May in Greece, 5th and 7th of June in Italy and in Spain). A total of 171 students filled in the pre-piloting questionnaire and 135 students participated in the post-piloting survey. Students' age ranged between 14/15 and 17/18. In all countries, females were more numerous than males (60% vs. 40%).

- **Interest in school subjects**

Both Spanish and Italian students liked scientific topics like ICT, Biotechnology, foreign language etc. and they also felt they are important for their future. Humanities and agronomy were generally less liked or perceived as more difficult in both countries.

- **Interest in food-related topics**

After project implementation, students' interest slightly increased in Italy and in Greece, especially regarding **"how food is produced"**, **"how to reduce food waste"** (Italy) and **"food flavours and tastes"** (Greece)**. I**nstead, students' interest slightly decreased in Spain, likely due to extra workload stress or because they already knew a lot about these topics.

- **Attitudes towards school**

All the students generally had a positive attitude towards school and after piloting the number of positive students increased. They especially liked formulating questions and expressing opinions. There also was an increased number of Spanish and Greek students appreciating teamwork but less Italians. In addition, after piloting Greek and Italian students "feeling scared facing new challenges" decreased.
In general, Spanish students showed a decreased interest and attitude towards school probably for the stress of the extra work due to the project activities.

- **Attitudes towards learning tools and methods**

All the students felt more skilled in "technologies (e.g. instruments, software)". Almost no change or a slight decrease in Italy was scored regarding "fieldwork/outdoor activities", "manual/practical activities" and "laboratory activities" that were already highly appreciated in the pre test. More Spanish and Greek students liked working on surveys.

- **Attitudes towards STEAM and approaches**

After the project, less Italian students felt that STEAM topics were difficult, while Technology and Maths were difficult for more Spanish students and Technology and Science for the Greek ones. All the students liked very much "the freedom to select the topic of their own project" and "connecting school studies to real life" even before the project implementation. In Italy, more students appreciated "approaching a theme from different school subjects".

- **Attitudes towards communication**

Overall, GOODFOOD did not change very much the students' appreciation of the different communication means of their projects and activities. Only "using digital devices to make videos" and "creating artistic outcomes" were slightly more appreciated by all the students after the project.

- **Changes in food habits and behaviours**

  In general, there were only small changes in food habits and behaviours (slightly positive in Italy and Greece and negative in Spain). However, there was an increased sensitivity towards food waste since there was a slight increase of students “saving leftover food” and “using leftover food for other recipes” in all the three countries.

- **Future job or career you would like**

Before piloting, students’ interest was mainly towards popular careers like medicine, marketing, economy and scientific research. After piloting there was no substantial change in career preferences, despite a small increase in careers connected to the health and nutrition sectors, cook chef, graphic design and tourism in the three countries.

- **GOODFOOD project impacts**

The qualitative questions on the project impacts resulted in different results in each country. The project activities carried out during the GOODFOOD experience seemed to have a slight positive impact in Italy and Greece while they were not as successful as expected in Spain, probably for the perceived work overload, stress and difficulty of some of the activities proposed within the project.

Some additional questions were posed to the students at the end of the project, in the final questionnaire. The most recurrent and interesting answers are reported in the following tables.

What did you like about the GOODFOOD experience?		
Spanish students	**Greek students**	**Italian students**
• *Promoting the project at the university.* • *New knowledge about types of food and their impact to our life* • *The excursions.* • *Working as a team.*	• *The combination of learning and fun.* • *Learning about nutrition, eating habits and disorders, and sustainable fishing that we had never thought about in our lives.* • *The educational trips.* • *Working together, taking a break from the lessons.* • *Learning more about how to keep my body healthy.* • *Interviews, group cooking, presentations by experts.* • *Doing something more relaxed and enjoyable instead of a lesson.*	• *Sharing opinions and working in a group.* • *Cooking a healthy recipe; cooking together, learning to use food that we usually throw away.* • *GOODFOOD made me reflect on some topics that I didn't pay too much attention to.* • *The education related to everyday life.* • *Being able to work on something different from the usual schoolwork.* • *Making creative videos together with classmates, learning new culinary concepts.*

What ideas/activities would you like to suggest to us to help us improve the GOODFOOD project?		
Spanish students	**Greek students**	**Italian students**
• *Do more visual work and present it to other courses* • *More excursions* • *not making jobs so long and making them more practical* • *Outdoor kitchen* • *Not overload students with work.* • *Broader collaboration with other schools* • *More practical activities* • *Little more organization* • *More outdoor activities like cooking*	• *More hours dedicated to the project* • *More educational trips to a food factory* • *More extracurricular activities* • *Allow the school to take all the expected actions, without being influenced by other teachers' complaints* • *To get in touch with students from other schools, and other countries so that we can exchange opinions and share our experiences* • *Don't suggest that students count calories*	• *More interactive and practical activities on how to reuse leftovers* • *Don't include activities which include listing our food habits* • *Reasoning together* • *Visit a company/industry to see how specific foods are treated* • *Produce dishes with the whole class, work with others, tasting others' dishes* • *More meetings with experts at school.* • *International exchanges*

What did not meet own expectations?		
Spanish students	**Greek students**	**Italian students**
• *I have learned many things* • *So many computer jobs were boring* • *it has become very heavy* • *It burden us with too much work* • *I expected more excursions and less work* • *Too much work coinciding with other school commitments and exams while low acknowledgement of the work that has been done*	• *Do more activities outside of school* • *Not too much organization in terms of time* • *I didn't like the professional behavior of some nutritionists* • *There was a little interaction with other students*	• *Too much pressure by the teachers* • *Some activities were too specifics and personal (e.g. making the list of everything we eat in the school break)* • *It would be nice to have started the project the year before* • *I would expect more meetings and more educational visits and activities*

Have you already changed or are planning to change some food habits that you now know may not be good for your health and/or for the planet?		
Spanish students	**Greek students**	**Italian students**
• *Eating healthier.* • *Take care of the environment* • *Eating better since I have learned the amount of nutritional substances in food* • *I will look at the origin of each product* • *Eat healthier, don't waste food, etc.* • *Buying food in supermarkets near my house*	• *Eating healthier.* • *More sustainable and healthy food.* • *Not yet but I'm thinking about it* • *I take care and listen to my body, and most importantly I try to have the products I buy come from Greek farms, and crops* • *More fruits and vegetables* • *More fish* • *As much as I can avoid outside and processed food* • *Reduction of snacks.* • *More attention to food packaging.*	• *Exercising more, paying attention to the needed calories* • *Reduction of the meat consumption, especially red meat* • *Eating well, sustainable food, healthy foods produced in Italy* • *Eliminate sweets as much as possible* • *Being more aware about food habits* • *Increasing recycling and separating waste well*

Teachers' survey results

At pre-piloting, 41 teachers participated in the pre-piloting survey (18 in Spain – 61% females; 13 in Italy – 84% females, 11 in Greece – 64% females) and 34 teachers participated in the post-piloting survey, meaning in the GOODFOOD project implementation (13 in Spain – 39% females; 9 in Greece – 44% females and 12 in Italy - 90% females). In all countries, teachers represented a variety of teaching subjects (e.g., Physics, Chemistry, Geography, History, Economics, Technology, Biology, English, sports).

- **Use of innovative teaching methods and tools**

GOODFOOD had positive impact in the use of innovative teaching methods and tools in the three countries as it increased the number of teachers using IBL, applying interdisciplinary STEAM, using Apps and mobiles for educational activities and asking students for creative outcomes. There was also greater agreement in implementing students' group work or outdoor practical activities or visit to other places, particularly in Spain and in Italy. After GOODFOOD, the number of teachers feeling "confident in innovative teaching methodologies" substantially increased.

- **Attitudes towards innovative teaching methods and tools**

GOODFOOD increased teachers' interest in "being updated on innovative teaching methodologies" and appreciation in applying innovative teaching methods and approaches such as "collaboration between STEAM colleagues", "mentoring and facilitation" but also "project-based learning" to increase students' soft skills, besides "topic-centered teaching instead of subject-centered".

- **Constraints on the use of innovative teaching methods and tools**

GOODFOOD made teachers more conscious about the limitations in the application of innovative methodologies as more teachers in all countries agreed with constraints such as "school commitments do not allow carrying out collaborative teaching between STEAM teachers", "innovative teaching methods require greater workload to design lessons", or regarding the "logistic constraints and costs to organise outdoors activities".
Teachers were more positive regarding the length of the school hours (at pre-piloting most teachers thought being too short) but they got aware that the number of students in class should not be too high.
Italian and Greek teachers had a positive attitude towards co-teaching thanks to the school system.
Overall, the GOODFOOD experience has reinforced the opinion of a need for essential changes in the school system in order to be able to implement in the future similar projects and activities.

"What is your level of agreement regarding yourself efficacy in front of new challenges?"

In general, teachers do not "avoid facing new challenges" but the number of "self-confident teachers on the capacity to achieve key goals" decreased in Greece and in Spain. Most of them were "able to ask their colleagues for help if needed" and the percentage increased after piloting.
After GOODFOOD, confidence regarding the class management capacity increased regarding the "application of Inquiry Based Learning", "ensuring the participation of students with learning difficulties" and in the "capacity to take necessary measures to ensure that activities continue effectively" or establish "establish a good communication with the students". However, less Greek and Italian teachers felt capable after piloting "to prevent troubled students from disturbing the entire class".

- **Students' interest in school subject by teaching about food-related topics**

There was a general agreement on using the GOODFOOD themes and activities about food, health and sustainability to increase the students' interest in the different subjects, such as "how food habits affect health", "food disorders", "how food choices affect the environment" and "how to reduce food waste at home".
Some of the GOODFOOD activities may not be so easily related with some subjects and thus some doubts were raised about their potentiality to increase interest in those subjects.

- **"What is your habit and behaviour regarding food?"**

GOODFOOD improved teachers' behaviour and habits related to food as more teachers after piloting declared "cooking food", "monitoring the height-weight development" and "reusing and recycling". More Italian teachers declared "posing attention on food portion size" or "getting information on how to maintain body health" while more Greek teachers after piloting declared "reducing the consumption of meat-based products" or "buying organic or sustainable food", while in Spain, teachers don't seem to have improved much any of these habits.

- **Curricula changes or new extra activities**

After the GOODFOOD experience, most teachers thought necessary applying the integrated STEAM approach and implementing extra activities on health and sustainable food on top of those included in the curriculum, making these topics compulsory in the school curriculum. However, many teachers considered it necessary or important "changing the current school system to implement more Inquiry- and Project- Based Learning".

- **GOODFOOD impacts on teaching**

GOODFOOD was interesting for the majority of the teachers and stimulated to think about their own food habits. Despite some stress associated with the extra load of work (especially by Spanish teachers), most teachers thought that GOODFOOD increased competence and skills in teaching and the interest in certain topics, contributing to feeling more enthusiastic about one's own job. They also were enthusiastic about the creative outcomes and considered that the project should be continued.

Some additional questions were posed to the students at the end of the project, in the final questionnaire. The most recurrent and interesting answers are reported in the following tables.

What did you like about the GOODFOOD experience?		
Spanish teachers	**Greek teachers**	**Italian teachers**
• *Everything, working with teacher- colleagues and how well we worked in class.* • *The laboratory practices e.g. in Physics and Chemistry and excursions that have been carried out.* • *The topic it deals with, being able to learn and teach about it.* • *Its innovative approach for promoting healthy eating habits among young people.* • *Students learned basic skills, such as the use of new technologies and apps for academic uses, implementing research techniques, teamwork, and they have improved their oral expression skills.* • *Skills to apply in daily life.* • *Interdisciplinary activities; student participation*	• *The new knowledge also thanks to experts' visits. The innovative teaching methods used. The interesting findings of the investigations carried out.* • *The collaboration with some colleagues, the actions, the excursions.* • *Teaching visits and the application of STEAM in teaching.* • *The interest shown by the students in the subject and the approach of the courses with experiential and discovery learning.* • *The creativity developed by the students.* • *The fact that we worked exploratory / student-centered.* • *The cooperation of my students as well as the cooperation with other colleagues... also the range of activities in which I participated offered me beautiful experiences and knowledge!!!*	• *The coordination between teachers and the students' creation of videos* • *The reflection and discussion with the students about our food habits* • *Integrating curricular laboratory experiences with the project* • *The international character of the project*

What did not meet own expectations?		
Spanish teachers	**Greek teachers**	**Italian teachers**
• *Extra workload for the students* • *Not so much motivation* • *Limited collaboration between teachers*	• *The strict time due to a stressful and strict school curriculum schedule* • *The limited collaboration between teachers*	• *The lack of meeting, even virtual, between students of the three nations*

What would you recommend to enhance GOODFOOD?		
Spanish teachers	**Greek teachers**	**Italian teachers**
• *"Activities such as bringing food to class to study its origin, ingredients, nutritional value, type of packaging, etc. and searching the market for better alternatives to those same products. Visits to farms, agricultural operations, food packaging companies, etc."* • *More dissemination of the students' work.* • *Possibility of modifying the activities with total flexibility and can include new ones.* • *Promote interdepartmental participation. Collaboration with other schools* • *A weekly meeting hour is necessary to be able to move the project forward.* • *Cooking in class* • *Establish collaborations with nutrition experts and chefs to provide up-to-date, high-quality content and advice.* • *More time dedicated to the project* • *More laboratory and field activities*	• *Strengthening experiential learning and visits to places where food is produced, as well as the interconnection with the social processes of each region.* • *More students and teachers participated. To have a fixed time weekly for its implementation.* • *To be made up of only students who wish to participate in the program.* • *Flexible zone in the time schedule e.g., it should take place on a weekly basis.* • *Better organization.* • *More visits to places related to food production and consumption.* • *The possibility for students from all participating states to meet in order to exchange experiences and knowledge.*	• *A guided tasting of some food (oil, cheese, balsamic vinegar) to stimulate attention to perceive the organoleptic properties of foods* • *To make concrete proposals, to talk about it widely and a discussion with other users.* • *Greater interaction between students of the different nationalities* • *A moment of synthesis and connection with the other entities involved and greater clarity on the product that the students will have to create* • *Greater sponsorship* • *Provide students with models, examples and video tutorials that provide practical guidance on managing our nutrition.*

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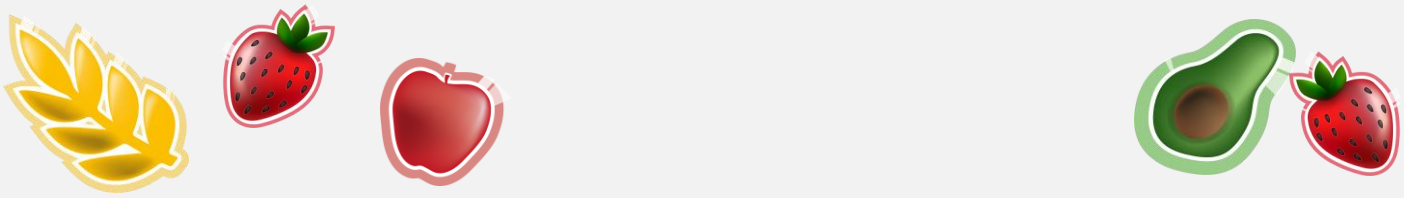

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