Zero WASTE

AWARENESS FOR THE REDUCTION OF FOOD WASTE

ZERO_WASTE:
awareness for the reduction of food waste

Instituto Universitario de Investigación Mixto Agroalimentario de Aragón
cita
Universidad Zaragoza

Erasmus+

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Autores por orden alfabético:

Susana Bayarri Fernández
Rosa Duarte Pac
José Ignacio Iriarte Goñi
Susana Lorán Ayala
Mª Teresa Maza Rubio
Vicente Pinilla Navarro
Ana Serrano González
Pilar Uldemolins Gómez

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Introduction

Food waste represents one of the most urgent and complex challenges in the field of global sustainability. The loss of food along the agri-food chain not only entails a waste of natural, economic, and human resources, but also has a profound environmental and social impact. In this context, the European project **ZERO_WASTE - Awareness for the Reduction of Food Waste** (2020-1-ES01-KA204-083226), funded under the Erasmus+ programme (Key Action 2), was created with the aim of raising awareness, educating, and empowering citizens and educational sectors on the importance of reducing food waste through education, scientific knowledge, and responsible action.

The project brought together international partners from various fields (educational, scientific, technical, and social), and relied on the collaboration of researchers and experts who validated the content through a rigorous and multidisciplinary approach.

As a result of this collaborative effort, a training resource has been developed and structured into **four modules**, which address key aspects of food waste from different but complementary perspectives, from fundamental concepts to the identification of useful resources for its prevention and management.

This document brings together and integrates these modules with the aim of offering an accessible and comprehensive vision of the phenomenon of food waste.It has been developed and scientifically validated by researchers from the **Agri-Food Institute of Aragon - IA2**, a joint research institute of the University of Zaragoza and the AgriFood Research and Technology Centre of Aragon (CITA).

Each module has been designed independently, allowing for stand-alone use, but is presented here as part of a shared learning path that can be adapted to various educational or training contexts. The structure is as follows:

- **Module 1: AWARENESS**

Food waste: environmental, economic and social impacts and implications.
Aims to raise awareness among consumers about the environmental, economic and social consequences of food waste, encouraging a more responsible and informed attitude.

- **Module 2A: KNOWLEDGE**

Food chain, food quality and food spoilage.
Provides in-depth knowledge of the food supply chain and the concept of food quality, focusing on the main causes of food spoilage and contamination, as well as strategies to prevent them.

- **Module 2B: KNOWLEDGE**

Sales and consumption aspects and their relationship to food waste.

Examines consumer habits and behaviours that contribute to food waste, particularly in the phases of sale and consumption, and offers insights to promote more sustainable choices.

- **Module 3: GOOD PRACTICES**

Strategies to reduce food waste.

Promotes individual responsbility and empowerment by introducing practical approaches and effective strategies to prevent and reduce food waste at different levels of the food system.

With this publication, within the framework of the **ZERO_WASTE** project, the aim is to contribute to the development of a more informed, engaged and proactive citizenry in the fight against food waste, in alignment with Sustainable Development Goals of the 2030 Agenda.

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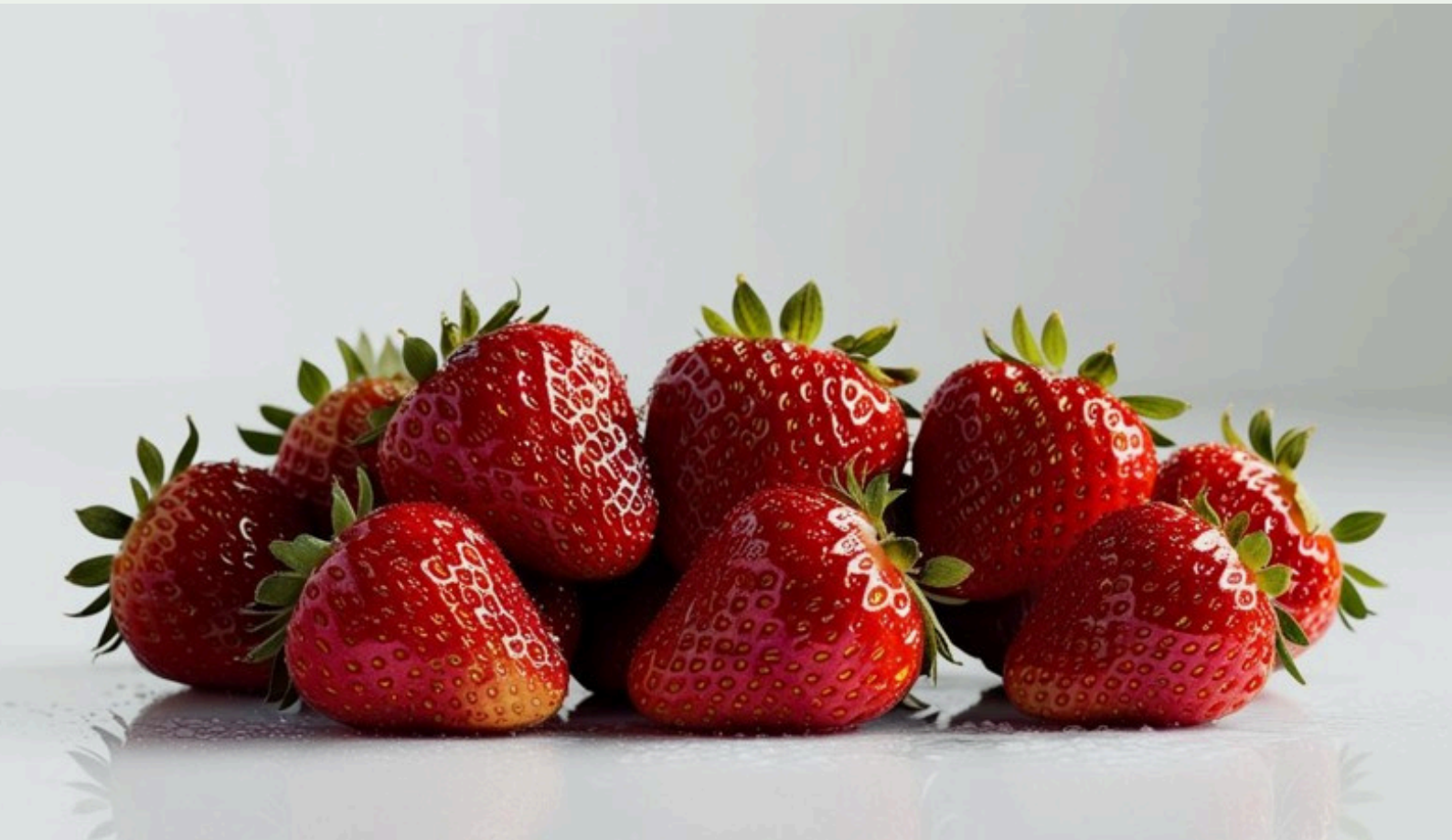
AWARENESS FOR THE REDUCTION OF FOOD WASTE

MODULE 1: AWARENESS

Food waste, environmental, economic and social impacts and implication



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General information. Module 1 AWARENESS

Title:
Food waste, environmental, economic and social impacts and implications

Authors:
Rosa Duarte, Iñaki Iriarte, Vicente Pinilla and Ana Serrano

Duration:
6 hours – The duration of this module is four hours of the lesson and two hours the practice of the exercises.

Objective:
Raise consumer awareness of the environmental, economic and social impact of food waste.

Introduction:
This module describes the different stages in the food chain and their relationship with food loss and waste. Then, the concepts of food loss and waste are defined, alongside the presentation of the main figures worldwide. Additionally, the two main indexes to quantify the progress towards SDG 12 are shown. Likewise, the main causes of food waste are explained as well as the most important socio-economic and environmental impacts. Finally, the module closes with the justification of the fight against food waste.

Learning outcomes
On successful completion of Learning Unit one participants should be able to…

Knowledge

- Know the different stages of the food chain and its implications in food
- Know the concepts of food loss and food waste.
- Identify the main drivers behind food waste.

Technical skills

- Understand the differences between food loss and food waste.
- Interpret the food waste index and the way towards SDG 12.

Soft skills

- Appreciate the economic, social and environmental impacts of food waste.
- Raise awareness on the global dimension of food waste.

Main contents

1.| Motivation / General framework

A famous saying says: "*we are what we eat*"

Food can be defined as any substance – whether processed, semi processed or raw – that is intended for human consumption. Food includes drink and also material that has spoiled and is therefore no longer fit for human consumption.

Food is the essential resource for the life of any living being. If there is no food, there is no life. Food provides us with the necessary materials and energy to develop our basic activities, moving, working, thinking… But unfortunately, in a big part of the world people care very little about where food came from and consider it as an inexhaustible resource that it is not necessary to worry about.

Every year thousands and thousands of tons of food are lost or wasted due to the lack of awareness of its value. "Food loss and waste" refers to the edible parts of plants and animals produced or harvested for human consumption, but not ultimately consumed by people. To put it in big numbers, in 2013, one out of every four food calories intended for people was not ultimately consumed by them (Lipinski et al., 2013), and the problem grew in the last years.

This issue is reaching such importance that it is essential to reflect on it trying to stop it. For this purpose, it is essential to know in depth how to measure it, its scale, its main causes, as well as its direct and indirect social and environmental effects. Knowing the problem well is the way to begin to remedy it.

1.1 | The food supply chain

In urban societies, it is quite usual to forget where the food comes from. Knowing the process of food from the field to the plate is essential to value the importance of food. The whole process is known as "food supply chain" and is divided into four main parts:

1) Production;
2) Storage and distribution;
3) Processing and packaging;
4) Retail and markets.

These stages are interconnected, as the decisions and actions in one stage can influence the others. Besides, altogether they impact the food production process and the kind of food available for consumption (HLPE, 2017). Consumers are the agents at the end of the supply chain. They consume all the kinds of fresh or processed food in households or restaurants.

The stages of the food supply chain and the actors involved

Source: own elaboration from HLPE (2017)

1) **Production**. It affects the availability, affordability, quality and diversity of food. Production includes the processes of sowing, growing and harvesting cereals, fruits and vegetables, and also all the stages of animal production prior to slaughter as for example, cattle and poultry raising as well as dairy and egg production (HLPE, 2017). Agricultural production can be traditional (small farms managed by peasants) or industrialized (bigger farms highly mechanized). Production can be local when the food is produced near the consumer or global when it travels hundreds or even thousands kilometres before it reaches the final consumer. Many actors as farmers, indigenous peoples, agribusiness, land and plantation owners and fisheries are involved in this step of the food chain (HLPE, 2017).

2) **Storage and distribution**. As a first step, the food that the producers do not consume themselves must be stored. Then, it can be consumed or distributed, that is, transported to the retailers and the different phases of load and unload products. This stage has a great impact on food waste. If the facilities for the conservation of food (for example cold storage and distribution) are not available, food will be wasted. This would be the case of nutrient dense food that cannot be consumed shortly in time or close to the production area. Among the actors involved in this stage, we could highlight transporters, agribusiness and distributors.

3) **Processing and packaging**. It includes milling, cooling, freezing, smoking, heating, canning, fermentation and extrusion cooking. This stage is important to prevent food waste as it extends the life of products, increases the availability of nutrients and improves the properties of food. Some of the agents involved in this step of the food chain are packing plants, the food and beverage industry and small and medium enterprises (HLPE, 2017).

4) Retail and markets. After processing and packaging, food goes to markets (both formal and informal) and the retail sector (HLPE, 2017). Thus, this stage of the supply chain involves the process of shelling fresh or processed food to consumers at different scales. The exchanges can happen in markets, supermarkets and different kinds of restaurants or catering firms. In some cases, retail can involve a second round of packaging or processing, including pre-cooking or cooking food. In sum, we can say that this step comprises retailers, vendors, food outlet owners, traders, restaurateurs and wholesalers, among others.

The European Green Deal has put into the forefront the Farm to Fork Strategy, which seeks to transform the food supply chain into a healthy, fair and environmentally friendly system. Within this general goal, the Farm to Fork Strategy has specific aims closely related to the food chain as the production, processing, distribution and consumption of food in a sustainable way and the prevention of food loss and food waste. Encouraging sustainable food systems not only promotes the health of natural ecosystems, but could also have significant advantages for all the agents that participate in the food chain.

1.2 | Food loss and food waste

Food can be wasted in different ways in each step of the food chain. Usually, a differentiation is made between food loss and food waste.

"Food loss" refers to food that spills, spoils, incurs an abnormal reduction in quality or otherwise gets lost before it reaches the consumer. It typically occurs at the production, storage, processing and distribution stages of the food value chain, and is the unintended result of agricultural processes or technical limitations in storage, infrastructure, packaging, and/or marketing. Losses that occur during storage, transport and processing, also of imported quantities, are therefore all included. Losses consider the commodity as a whole with its non-edible parts.

The differences of food loss and food waste

Source: FAO (2016)

"Food waste" refers to food that is of good quality and fit for human consumption but that is not consumed because it is discarded before or after it spoils. Thus, food goes to one of the following end destinations: landfill, controlled combustion, sewer, litter/discards/refuse, co/anaerobic digestion, compost/aerobic digestion or land application. Food waste typically, but not exclusively, occurs at the retail and consumption stages and is the result of negligence or a conscious decision to throw food away.

Both food loss and waste could be reduced if producers, manufacturers, distributors, retailers and consumers became aware of the problem, and each of us took the necessary measures to avoid it.

As we will see, efforts made to measure food waste are bigger than those to measure food lost.

1.3 | Food waste and the SDG

An important step forward in raising awareness on this issue was the setting of food loss and waste as a defined target within the internationally agreed Sustainable Development Goals (SGD). The problem is directly reflected in objective 12, about sustainable consumption and production (SCP), and more specifically in targets 12.3. (shift towards SCP in the food system) and 12.5. (Environmental impacts such as waste management).

Reducing food loss and waste can also help to achieve progress on SDGs 2 and 4 related to Zero Hunger and Poverty Reduction.

2.| Scale of the problem. Why is it important?

Facts and figures:

- It is estimated that by 2050 the world's population will reach 9.1 billion, 34% higher than today (FAO, 2009). In order to feed this population, global food production should increase by 70%.

- According to UNEP (2021), around 931 million tonnes of food waste was generated in 2019. Households contributed 61% to this figure, food service 26% and retail 13%. These figures suggest that more than 17% of the global food production is wasted.

- If we consider both food losses and food waste, around one third of all food produced worldwide for human consumption in the world is lost or wasted (FAO, 2013).

  "The weight of unused food would be equivalent to that of approximately 23 million fully loaded 40-tonne lorries, which, when lined up, would circle the earth seven times."

- On a global per capita-level, 121 kilograms of consumer level food are wasted each year, 74 kilograms in households.

To put these alarming figures in context, FAO et al. (2020) estimated **that 690 million people in the world suffer from hunger in 2019**, and around 3 billion people cannot afford a healthy diet. According to FAO et al. (2015), **if one quarter of the food currently lost or wasted could be saved, it would be enough to feed 870 million hungry people.**

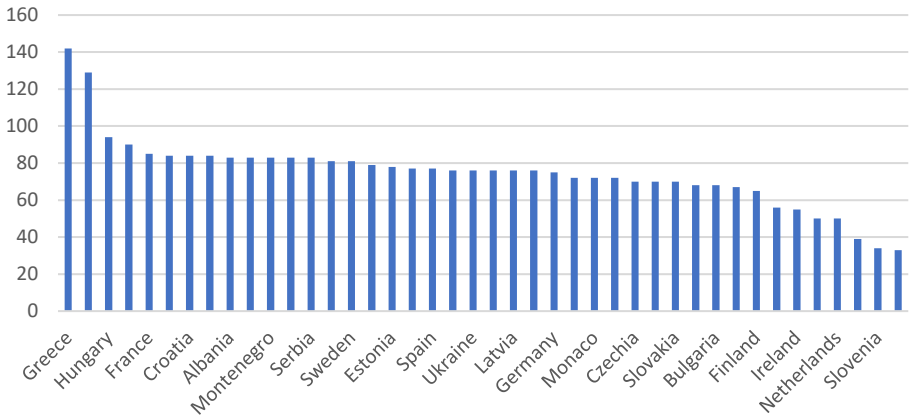
Thus, reducing food waste offers significant gains for the entire population. In addition to improving food security, and contributing to the reduction of social inequalities through food savings and food security, it has important effects on the environment and biodiversity. If food waste were a country, it would be the third largest emitter in the world, behind only China and the USA (FAO, 2013).

- Contrary to the previous belief that food waste was mainly concentrated on developed countries, UNEP (2021) concluded that the **generation of food waste is a global problem**, very similar between countries with different income levels. Thus, in high-income countries, the average food waste in households was 79 kg/capita/year, in upper middle-income countries 76 and in lower-middle income countries it was 91 kg/capita/year.

- Thus, action to combat food waste is equally relevant in countries at different income levels. There is also a consensus that previous

estimates of food waste were clearly underestimated. This also contrasts with the previous narrative of a world where food waste was concentrated in developed countries, while losses were concentrated in developing countries due to inefficiencies in the production, storage and distribution. It is estimated that EU food waste was around 88 million tonnes (Stenmarck et al., 2016). This food waste leads to 170 million tonnes of CO2 emissions and 261 million tonnes of resources. The associated costs are estimated by Stenmarck et al. (2016).

Household food waste estimate (kg/capita/year) in European countries



Source: UNEP (2021)

- In a case study for Spain (MAPA, 2019), 79.1% of households admit to wasting food. Of these, 79% throw away food as they have bought it, and up to 30% admit to throwing it away after cooking, either from the fridge or from the plate. By products, the highest wastage rates are 40-50% for root crops, fruit and vegetables; 35% for fish; 30% for cereals; and 20% for oilseeds, meat and dairy products.

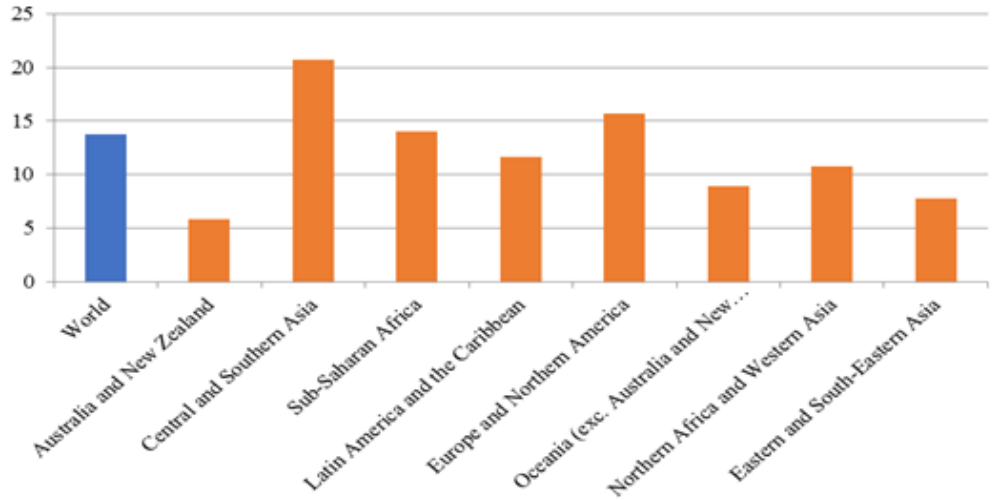
3.| Indexes and measuring tools

3.1 | How to measure Food Waste?

In order to achieve Target 12.3. of the Sustainable Development Goals (reduce by 50% per capita global food waste at retail and consumer levels by 2030, as well as reducing food losses along the production and supply chains) and to **measure the progress towards the SDG target**, two main indices were developed: Food Loss Index (FLI) and the Food Waste Index (FWI).

Food Loss Index: FLI was developed by the Food and Agriculture Organization of the United Nations (FAO) and provides evidence on food losses from production just up to the retail level (not including it). This index measures the changes in percentage losses for a basket of 10 main commodities by country in comparison with a base period.

Food loss index (%) in 2016



Source: UNEP (2021)

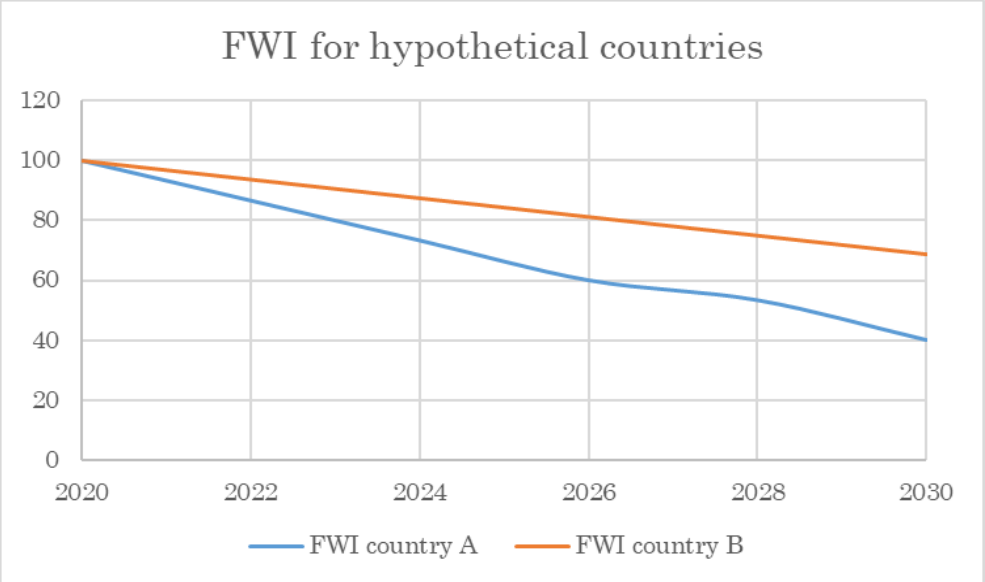
According to FAO, in 2016 **Central and Southern Asian countries exhibited the highest values for the FLI**, accounting for more than 20%, while for Australia and New Zealand the index barely reached 5%.

Food Waste Index

In a complementary way to FLI, the **Food Waste Index**, developed by the United Nations (UN), covers the later stages of the food supply chain – food waste – occurring at the household, food service and retail level.

This FWI index is conceived as an indicator of the **progress in the reduction** of household food waste estimates. For instance, for two hypothetical countries A and B, and considering 2020 as base year, the corresponding FWI index could be as follows:

Household food waste estimate (kg/capita/year)				
Year	Country A	Country B	FWI country A	FWI country B
2020	150	80	100	100
2022	130	75	87	94
2024	110	70	73	88
2026	90	65	60	81
2028	80	60	53	75
2030	60	55	40	69



Although country B reports lower values of per capita food waste over the whole period, its FWI is higher than for country A, as the progress towards the objective of halving household food waste is more intense in country A (reaching the SDG by 2028) than in country B.

In order to obtain data for the construction of the FWI for different countries and sectors, a three-level methodology is implemented:

- Level 1: Modelling and extrapolation is used to generate food waste data for those countries that do not have their own measurement.
- Level 2: (The recommended level to measure the progress towards SDG). It involves the measurement of food waste in countries and sectors, generating primary data on current food waste. In this level, household and retail sector studies are used to provide comparable national data.
- Level 3: Additional information on specific sectors and data disaggregation by destination and other socioeconomic variables is provided, obtaining the most comprehensive picture.

4.| Food waste impacts

Food waste generates burdens that affect the environment, the economy, and also, human well-being. We can analyse these impacts on the basis of different scientific studies.

The environment.

The production, packaging and distribution of food generates important environmental impacts. By wasting food all the environmental resources to produce it are wasted too.

- Food requires energy for its production, transportation and disposal. To give you some numbers:

  "38% of the energy globally used to produce food is lost or wasted" *(FAO, 2014).*

- Food consumes and pollutes (groundwater and surface) water resources. To give you some numbers:

  "Global food waste represents 24% of water resources used in food production" *(Kummu et al., 2012).*

  "In the EU, 12% of the nitrogen emitted to water bodies in food production is due to food waste, with meat being responsible for around 50% of the emissions" *(Grizzetti et al., 2013).*

- Food generates emissions from agricultural machinery and transport vehicles. To give you some numbers:

  "8-10 % of global greenhouse gas emissions are associated with food that is not consumed" *(Mbow et al., 2019).*

- Food production degrades land through desertification and deforestation. To give you some numbers:

  "Food waste accounts for 23% of cropland utilised in food production globally" *(Kummu et al., 2012).*

- Food contributes to biodiversity loss due to agricultural changes and sea food waste. To give you some numbers:

  "Agriculture is responsible for a majority of threats to at-risk plant and animal species tracked by the International Union for Conservation of Nature" *(FAO, 2013).*

Environmental impacts of food loss and waste

Source: UN environment program

The economy.

Food waste generates important financial losses.

- Globally, it involves a decrease in economic value. To give you some numbers:

  "Food wastage of agricultural products in 2007 amounted to around 750 billion dollars, which is equivalent to the total GDP of Switzerland or Turkey in 2011" *(FAO, 2013).*

- At the individual level, it reduces the purchasing power of households. To give you some numbers:

  "In the United States, food waste represents about 10% of the total food expenditure and around 1% of the individual disposable income" *(Buzby and Hyman, 2012).*

- Food waste induces inequality between developed and developing areas. To give you some numbers:

  "Food waste amounts to similar volumes in high and low income areas. However, consumers in industrialized areas waste almost as much food as the entire net food production of sub-Saharan Africa" *(FAO, 2011).*

Human well-being.

Food waste involves high negative impacts on people's lives:

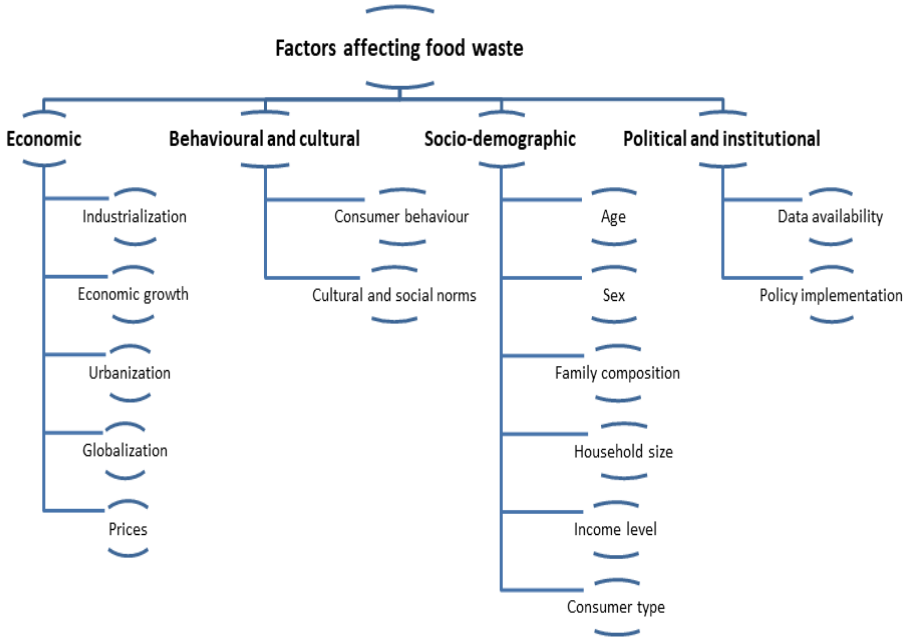
- Despite having enough food available for all the people in the world, many citizens suffer from food insecurity. To give you some numbers:

  "The volume of food wasted globally would be enough to feed 4 times all the hungry in the world" *(FAO, 2011).*

  "Even if 25% of the food wasted globally could be saved, it would be enough to feed 870 million hungry people in the world" *(UN, 2020).*

5.| Drivers of food wastage

According to Thyberg & Tonjes (2016) “food waste is a function of cultural, personal, political, geographic and economic drivers.”. Thus, food waste is affected by a combination of determinants as:



Source: own elaboration

Economic factors

- **The industrialization of food supply chains**: it influences the types and quantity of food waste. Food processing increases packaging (boxes, cans, trays, etc.) and the components of the animals and plants to be disposed (bones, husks, fats, pods, etc.).

- **Economic growth**: it boosts dietary changes towards larger shares of meat, fish and dairy products that involve larger food wastes. Besides, as household’s income increases, food loses weight in the total expenditure and people tend to waste more food. Likewise, the increase in income entails a larger expenditure in leisure and restaurants which increases the likelihood of food waste.

- **Urbanization:** it disconnects citizens from the origin of food, as people are far from the place where it is produced. Thus, the knowledge about the on-site production processes of food is lost. In urban areas food is

diverse and mostly not local, increasing food waste in comparison to rural areas.

- **Globalization**: it widens the distance between the geography of production and the geography of consumption. The globalization of food supply chains induces an increase in the range of available foods and the import of non-local products (mainly farming goods) associated with the new dietary patterns. This growing disconnection between production and consumption triggers food waste.

- **Prices:** Excessively low prices perceived by farmers could hurt food producers and farm workers, generating an increase in food waste.

Behavioural and cultural drivers

- **Consumer behaviour**: the way that consumers behave depends on issues that affect them individually. First, one of the most important determinants modelling consumer's behaviour and food waste is awareness. Knowing how much food we waste is key to carrying out the right changes. Second, attitudes towards food waste also induce the reduction of wasteful behaviour. These attitudes are influenced by the information that consumers have (think for example about the difference on the expiry and the durability date). Third, habits also influence food waste. Past behaviours as food waste are likely to be repeated (Russell et al., 2017). Finally, emotions also influence wasteful behaviour. For example, consumers tend to feel guilty when they waste food (Watson and Meah, 2012). Emotions as anticipated guilt can help to avoid food waste.

- **Cultural and social norms**: Cultural values influence the individual behaviour and attitudes. Perceptions of edibility are different among cultures. Besides, some societies have strong historical traditions regarding food, which makes them less vulnerable to the modernization of food systems and to food waste. In developing economies, there is a tendency towards buying small portions of food each time, which reduces the probability of wasting food. Furthermore, in some regions, cultural values such as hospitality induce to cook more than the necessary for guests, involving large food waste (Zhang et al., 2018). In other places, food is used as a way to celebrate. This is the case of "La Tomatina" in Spain (where people throw tomatoes away) or similar festivities around the world.

Socio-demographic determinants

Although there is no consensus about the socio-demographic issues boosting food waste, the existing evidence points at:

- **Age:** Young people seem to waste more than old people. In developed areas, the oldest cohorts lived periods of austerity in the past.

- **Sex:** women tend to waste less.
- **Family composition:** households tend to waste more if there are children in the family.
- **Household size:** Large households waste more than small ones in per capita terms. People that live alone tend to generate more waste.
- **Income level:** food waste seems to increase with the household income.
- **Consumer type**: price-oriented consumers tend to waste less food.

Political and institutional issues

- **Limited data availability**: it makes it difficult to quantify the level and trajectory of food waste. There are problems in distinguishing the magnitude of food wastage in developed versus developing areas. It is not possible to differentiate the waste of edible versus inedible parts, mainly in low income countries.
- **Policy implementation**: some policies that were implemented to achieve food safety or enhanced nutrition can also induce food wastage. This could be the case of certain laws as the data label laws that restrict donations.

6.| Justification of the fight against food waste.

As we have seen in this module, food waste is a big problem that needs to be shown in order to shed light on the ways to contribute to its reduction and to increase people's awareness. We have seen that many efforts are made to measure the true scale of the problem. The methods to quantify food waste are varied, however all of them point to it as an important problem. We have also found that the impacts of food waste are wide and imply economic, social and environmental aspects. Therefore, fighting against food waste can result in positive outcomes in different directions.

If we start with the economic side of the problem, reducing food waste can help all the agents involved in the different steps of the food chain to save money, from the producers to the consumer. The food wasted needs a previous investment to be produced, processed, transported and retailed. Therefore, if we throw it in the landfill, we are also wasting money. And this happens both at the macroeconomic and at the household level.

The food wasted each year is remarkably similar in low-middle income and high-income countries, suggesting that most countries have room to reduce food waste. Nevertheless, savings could be more important for low-income countries. This is true also at the household level. Families with lower purchasing power spend a higher proportion of their income on food. Therefore, they could benefit if they became aware of the problem and wasted less food.

Reducing food waste has also an important social side. Food saved from being wasted increases the amount of available food, and it can benefit the weakest part of the society. If a similar quantity of food were destined to feed the poorest, the fight against hunger could largely improve, using the same resources. Reducing food waste can also help to achieve food security, contributing to avoiding famine.

Finally, the environmental perspective of food waste is quite astonishing. If food loss and waste were a country, it would be the third biggest source of greenhouse gas emissions. Food waste also burdens waste management systems, making it a major contributor to the three planetary crises of climate change, nature and biodiversity loss, and pollution and waste. Similarly, the food wasted has been produced using land, water, fertilizers and pesticides. Amounts of oil, electricity and materials have been used to process, package and transport it. Indirectly, we can also imagine that a part of the food wasted can have contributed to deforestation or land erosion. Therefore, reducing food waste can avoid all those resources being wasted.

To sum up, food waste reduction offers multi-faceted wins for people and the planet as saving money, improving food security, addressing climate change,

as well as reducing the pressures on land, water, biodiversity and waste management systems. Yet, this potential has until now been woefully under-exploited.

Evaluation section

1. | Multiple choice questions

1. **The economic factors that drive food waste are:**

a) Globalization, urbanization, culture and sex.
b) Globalization, culture, age and sex.
c) Economic development, industrialization of supply chains, globalization and urbanization.
d) Economic development, industrialization of supply chains, culture and the household size.

2. **The globalization of food supply chains**:

a) It is related to hospitality and the effect of social norms on food waste.
b) It disconnects the production and consumption of food, boosting food wastage.
c) It is related to consumer's sex.
d) None of the above.

3. **The limited data availability about food waste:**

a) Makes it difficult to quantify food waste and evaluate its trend
b) Makes it difficult to compare food waste in high income and low income countries.
c) In developing areas, it is not possible to differentiate the waste of edible and inedible parts.
d) All of the above.

4. **Food wastage generates negative impacts on:**

a) The environment.
b) The economy.
c) Human well-being.
d) All of the above.

5. **Regarding the financial effects of food wastage, we could say:**

a) It contributes to the increase in household's purchasing power.
b) It generates notable losses on the global economic value.
c) It does not affect to the disposable income of citizens
d) None of the above.

6. **Considering the environmental connections of food wastage, it is possible to say that:**

a) It increases the use of water resources.
b) It makes greenhouse emissions grow.
c) It degrades land quality.
d) All of the above.

7. **Food wastage affects human well-being because:**
a) It contributes to improving the health of citizens.
b) It reduces inequalities among people.
c) It generates food insecurity.
d) None of the above.

8. **According to UNEP (2021),**
a) Households are the main contributor to food waste in the supply chain.
b) Food service is the main contributor to food waste in the supply chain.
c) Retail sector is the main contributor to food waste in the supply chain.
d) None of the above.

9. **Recent studies show that:**
a) The generation of food waste is a global problem, very similar between countries with different income levels.
b) Developed countries produce significantly higher levels of per capita food waste than developing countries.
c) Developing produce significantly higher levels of per capita food waste than developed countries.
d) All of the above.

10. **In order to measure the progress towards the SDG Target 12.3., the main indexes are:**
a) Food Loss Index (FLI) and Food Waste Index (FWI).
b) Food improvement index along the global value chains.
c) It is not possible to measure this progress.
d) None of the above.

11. **“Most households in Spain admit to wasting food both, as they have bought it, and after cooking”. This sentence is:**
a) True.
b) False.

12. **Complete the missing links of the food chain:**
a) Production
b) Storage and distribution
c) Processing and packaging
d) ……. (Retails and markets)

13. **“Food loss” refers to food that spills, spoils, incurs an abnormal reduction in quality or otherwise gets lost before it reaches the consumer.**
a) True.
b) False.

14. **“Food waste” typically does not occur at the retail and consumption stages.**
a) True.

b) False.

15. Families with lower income levels spend a higher proportion of their income in food. Therefore, they can benefit if they become aware of the problem and waste less food.

a) True.
b) False.

16. If food loss and waste were a country, it would be a not significant source of greenhouse gas emissions.

a) True.
b) False.

17. Reducing food waste, we can

a) Save money.
b) Improve food security.
c) Reduce pressures on land, water and resources.
d) All of the above.

2. | Activities/optional exercises

- Think about the food you have consumed in the last weeks. Note the quantity of the food you have wasted and the reasons for doing it.

- Following the infographic about the determinants of food waste, explain which ones (and why) affect you mostly.

- Trace a strategy to be able to achieve the SDG 12.3 individually, i.e., ¿how could you as a consumer halve food waste by 2030?

3. | Multiple choice answers

1	a	**6**	d	**11**	a	**16**	b
2	b	**7**	c	**12**	d	**17**	d
3	d	**8**	a	**13**	a		
4	d	**9**	a	**14**	b		
5	b	**10**	a	**15**	a		

Key concepts and vocabulary

Key concepts and vocabulary

Agricultural production: farming process of sow, grow and harvest cereals, fruits and vegetables, and also cattle and poultry raising and dairy or egg production. Agricultural production can be traditional (small farms managed by peasants) or industrialized (bigger farms highly mechanized using big amounts of fertilizers, pesticides and phytosanitary products). Production can be local when food is produced near the consumer, or global when it travels hundreds or even thousands kilometres before it reaches the final consumer.

Consumption: final stage of the food chain and involves all the different kinds of fresh or processed food in households or restaurants.

Distribution: process of transport to the retailers and the different phases of load and unload products.

Food: any substance – whether processed, semi processed or raw – that is intended for human consumption. It includes drink and also material that has spoiled and is no longer fit for human consumption.

Food loss: Food that spills, spoils, incurs an abnormal reduction in quality or otherwise gets lost before it reaches the consumer. It typically occurs at the production, storage, processing and distribution stages of the food value chain, and is the unintended result of agricultural processes or technical limitations in storage, infrastructure, packaging, and/or marketing.

Food Loss Index: Indicator developed by the Food and Agriculture Organization of the United Nations (FAO) that provides evidence on food losses from production just up to the retail level (not including it). This index measures the changes in percentage losses for a basket of 10 main commodities by country in comparison with a base period.

Food supply chain: series of processes by which food is grown or produced, sold, and eventually consumed. It is divided in six main parts: 1) Agricultural production; 2) post-harvest handling and storage; 3) manufacturing; 4) distribution; 5) retailing; and 6) consumption.

Food waste: Food that is of good quality and fit for human consumption but that is not consumed because it is discarded before or after it spoils. Food waste typically, but not exclusively, occurs at the retail and consumption stages and is the result of negligence or a conscious decision to throw food away.

Food Waste Index: Indicator developed by the United Nations (UN) that covers the later stages of the food supply chain – food waste – occurring at

the household, food service and retail level. It is conceived as an indicator of the progress in the reduction of household food waste estimates

Manufacturing: stages of processing food (peeling, cutting, boiling, cauterizing, …) and the bulk packaging of products

Post-harvest handling and storage: processes of drying, cleaning or milling products after harvest, slaughtering cattle or poultry and the storage of the net product.

Retailing: process of shelling fresh or processed food to consumers at different scales. It includes markets, supermarkets and different kinds of restaurants or catering firms. In some cases, retail can involve a second round of packaging or processing, including pre-cooking or cooking food.

Useful resources

Useful resources

https://en.reset.org/knowledge/global-food-waste-and-its-environmental-impact-09122018#:~:text=Global%20food%20waste%20is%20a,financial%2C%20ethical%20and%20environmental%20costs.&text=An%20estimated%201.3%20billion%20tonnes,FAO)%20of%20the%20United%20Nations.

http://www.fao.org/resources/infographics/infographics-details/en/c/414196/

https://menosdesperdicio.es/publicaciones-enlaces/documentos

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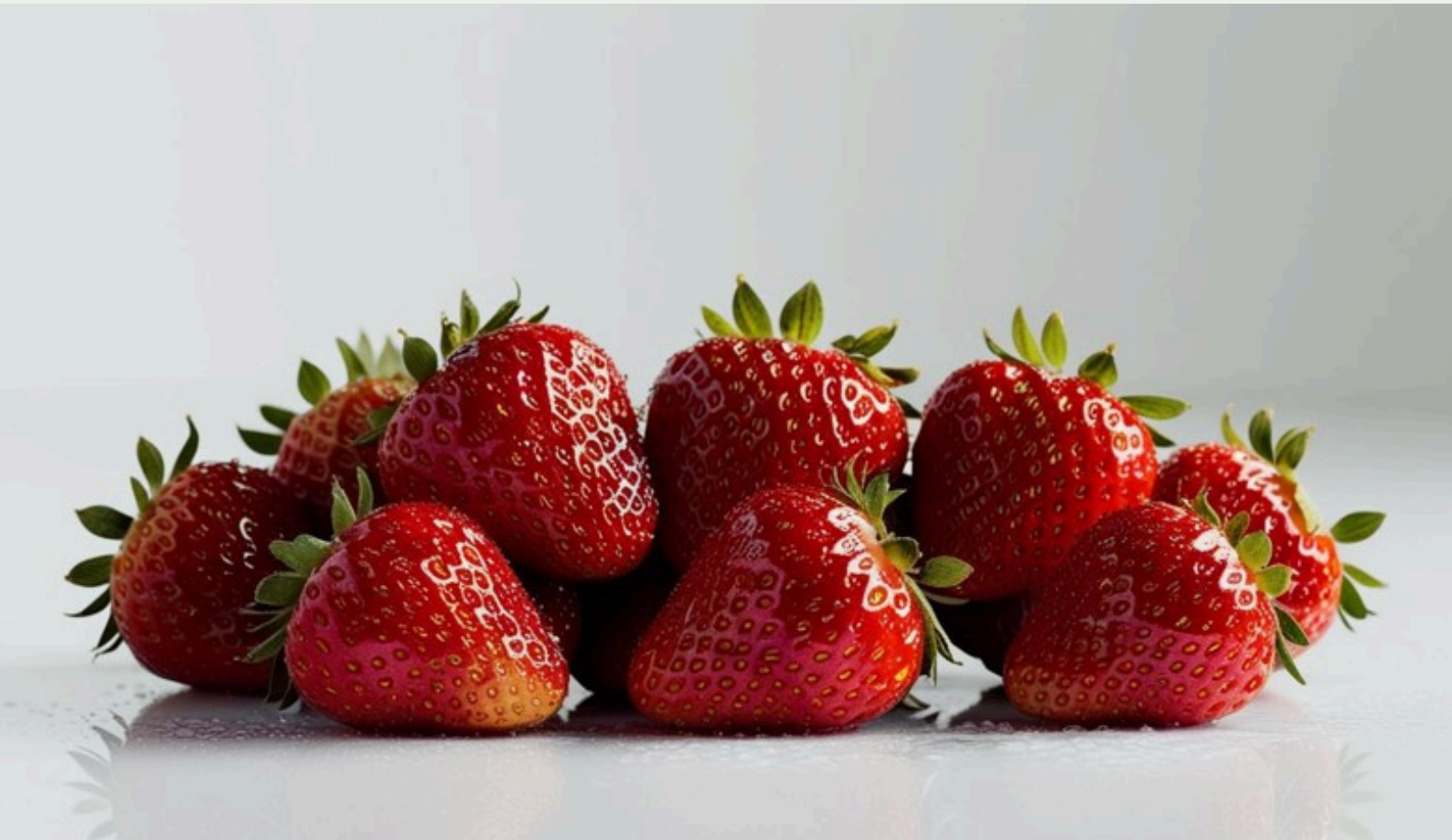
Zero WASTE

AWARENESS FOR THE REDUCTION OF FOOD WASTE

MODULE 2A: KNOWLEDGE

Food chain, food quality and food spoilage



Instituto Universitario de Investigación Mixto Agroalimentario de Aragón
cita
Universidad Zaragoza

Erasmus+

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General information. Module 2A KNOWLEDGE

Title:
Food chain, food quality and food spoilage

Authors:
Susana Bayarri, Susana Lorán

Duration:
6 hours – The duration of this module is four hours of the lesson and two hours the practice of the exercises.

Objective:
To deepen the basics of food chain and food quality, and the food spoilage and contamination causes as well as the strategies for their prevention..

Introduction:
This module introduces the concept of food chain and food quality, and defines what is shelf-life of foods. Then, it focuses on food labelling and the information for consumers that helps to ensure that food will be stored and used properly, preventing food waste. It deeply explains the meaning of date of minimum durability ('Best before') and the 'Use by' date. Nutritional components of food are detailed, as well as the information that makes it easier for consumers to choose healthy diets. Waste of valuable nutrients through food loss and waste is also explained. The module goes deeply on food spoilage and contamination, and on food storage and different preservation strategies to minimize their impact. Finally, food safety in the redistribution of food is described.

Learning outcomes
On successful completion of Module 2A participants should be able to…

Knowledge
- Understand the concept of food chain.
- Know what is food quality, and shelf-life of foods.
- Understand the information shown in food labels.
- Know the factors and mechanisms of food spoilage and the concept of food contamination.
- Know proper food storage and preservation strategies to delay food spoilage.
- Know the importance of food safety in the redistribution of foods.

Technical skills
- Knowing how to interpretate food labelling, particularly being able to distinguish between 'Best fefore' and 'Use by' dates.
- Improving food preservation at home.

Soft skills

- Appreciate the benefits of preventing food spoilage and contamination as a way to minimize food waste

Main contents

1.| Food chain and Food quality. Shelf-life of foods

1.1 | Food chain and food quality

As it has been explained before, food undergoes a series of operations until it reaches the consumer that altogether are called Food Chain. These set of phases or stages necessary for obtaining food from primary production to consumption influence the types of food available and accessible, as well as the way they are produced and consumed (HLPE, 2017). Strategies that consider the entire food system as a whole, from producers to consumers, are known with the term “From farm to fork” and must be applied in order to make the food chain sustainable and safe (Figure 1).

In general it can be said that food chains have become increasingly length and complex. That is especially noticeable in developing and developed countries. In that way it is well known that food supply chain of today is more and more globalized with certain food items that are produced, transformed and consumed in very different parts of the world. However, there are different types of food chain from traditional food systems in which consumers rely on minimally processed seasonal foods, collected or produced for self-consumption or sold mainly through informal markets, to the modern ones. The latest are characterized by more diverse food options all year long, and by processing and packaging to extend food’s shelf life (HPLE, 2017).

Whatever the case may be, it is necessary to ensure that food chains will provide sufficient food to all people at all times to meet their dietary needs for a productive and healthy life as well as to satisfy the consumer requirements.

To achieve food security for all, a multidimensional and integrated global strategy is necessary (Godfray el al., 2010). The responsibility for the supply of food that is safe, healthy and nutritious is shared along the entire food chain, by all involved with the production, processing, trade and consumption of food. This is what FAO defines as the **food chain approach** and it encompasses the whole food chain from primary production to final consumption (FAO, 2003). The food chain approach differs from the traditional model where it requires all actors in the food chain recognizing that primary responsibility lies with all those who produce, process, and trade in food. This approach is meant to ensure the production and supply of safe food products. Likewise, the relevant information regarding the safety of food should be provided to the next party in the food chain.

But it is also true as we have seen above, that at present, around one-third of the food that is produced for human consumption, is at the same time lost or wasted along the food chain from production to consumption. Accordingly,

food is lost or wasted throughout the entire supply chain, from initial agricultural production down to final household consumption. In medium- and high-income countries food is to a significant extent wasted at the consumption stage. Significant losses also occur early in the food supply chains in the industrialized regions. In low-income countries food is lost mostly during the early and middle stages of the food supply chain; much less food is wasted at the consumer level (FAO, 2011).

Food loose and waste (FLW) impact food security and nutrition by different ways. First, it means a reduction of availability of food. Second, it may have a negative impact on food access. This is the case not only for those involved in production and processing operations that face food loose and waste in relation to economic and income losses but also for consumers due to the increase of food prices that may occur as a result of FLW. Finally, a longer-term effect on food security resulting from the unsustainable use of natural resources on which the future production of food depends (HPLE, 2014).

Figure 1. The Farm to Fork strategy for a fair, healthy and environmentally-friendly food system (https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy_en

Changes in the way that food is produced, stored, processed, distributed, accessed and consumed are required to face the challenge of feeding the food demand from a larger population to it supply but doing so in ways that are environmentally and socially sustainable and ensuring that the world's poorest people are no longer hungry (Godfray el al., 2010).

Identifying the causes of food loose and waste is primordial to apply solutions to reduce them, and priorities for action. In addition, it also requires an integrated perspective along the food chain and to consider any action at one

specific stage as part of a whole (HPLE, 2014). Since the different stages of the food chain are all connected, the decisions made by the many actors at any stage have implications for others. In fact, food loose and waste happening at one stage of the food chain can have their cause at another stage.

It is possible to be hundreds of different causes of food loose and waste, the importance of which may vary greatly according to the produce and the context, and the stage of the food chain considered. What is being analyzed here, are those related with food wasted at the consumption stage and so mainly related to the loss of food's attributes.

Food products are marketed as a composite of attributes or characteristics that have significance in determining the degree of acceptability of that product to the consumer. That is food quality. The entire list of the attributes that defines food product's quality and affect consumer's choice for a product may be really extensive. The importance of such characteristics varies according to the circumstances and also among customers. Therefore, there is not a single list of all attributes of food quality, though they are usually subdivided into five categories: food safety, nutritional, value, packaging and process attributes.

- Food safety is the assurance that the food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use. Food safety assurance involves the prevention and control of hazards which may occur in the food.

- Nutritional attributes refers to maintaining nutrient levels in food, using ingredients and formulating foods with nutritional profiles that contribute to consumer interest in healthful diets.

- Value attributes desired by consumers extend beyond sensory characteristics, such as taste, aroma, palatability and appearance to include purity, consumer utility and economic advantage, involving attributes such as convenience, packaging and shelf-life.

- Packaging includes package materials, labeling and other information that is provided as for example handling and cooking instruction

- Process attributes refers to the circumstances of food processing such as animal welfare, the use of biotechnology, the environmental impact of the worker safety.

Food quality is a central issue in today's food economics and the last few decades testify that there is an increasing consumers' concerns for food safety and quality and healthier lifestyles as well as environment care. But also, food waste is a major global challenge not only from an ethical and social point of view, but also from environmental and economic ones.

Furthermore, it represents an inefficient use of the scarce resources used to produce it, such as land and water (FAO, 2013; Caldeira et al., 2019).

Working to minimize food loose and waste also contributes to make the food chain more sustainable. A sustainable food value chain is defined as “the full range of farms and firms and their successive coordinated value-adding activities that produce particular raw agricultural materials and transform them into particular food products that are sold to final consumers and disposed of after use, in a manner that is profitable throughout, has broad-based benefits for society, and does not permanently deplete natural resources” (FAO, 2014).

Despite of all the efforts that are made, we cannot forget that foods are perishable and that there are many factors that can deteriorate the quality and safety of food products shortening their "shelf life”.

1.2 | Shelf-life of foods

Along the food chain, from the point of primary production to consumption food attributes may change. These changes can either lead to a more desirable product, as for example the achieve of the appropriate level of ripeness in fruits but they can also deteriorate or contaminate food products so that they are rejected or even be responsible of food poisoning.

> Shelf life is a term frequently used in different ways. Generally speaking it can be said that shelf life of food products refers to the period for which they can be used while maintaining the food quality, provided any stated storage conditions have been followed.

The shelf life of a product begins from the time the food is prepared or manufactured and during this time it must preserve its sensorial, chemical, physical and microbiological.

Depending on their shelf life food may be classified as:

- **Stable or non-perishable food**. These are food products that have been treated and/or which contain less than 12% of free water so that they that can be stored for a long period even of several years or longer. Sugar, flour, canned food or dry beans are some examples of non-perishable foods.

- **Semi-perishable**. These are foods having lower than 60% of free water or containing some ingredients as acids or sugar, able to control microbial growth. These food items may therefore be preserved for long time (about six months) if they are properly handled and preserved. Cheeses, potatoes and apples are examples of semi-perishable food items.

- **Perishables**. These are food products that are easily spoiled. Therefore its shelf life usually ranges from several days to about three weeks if

specific conservation processes are not used. Milk and dairy products, eggs, meats, poultry, and seafood are examples of this kind of foods.

The way and the rate in which food deteriorates vary depending on the product and it can be due to several circumstances. Extrinsic factors, such as relative humidity or storage temperature may influence the shelf stability and perishability of food but it is also influenced by intrinsic factors as the formulation of ingredients, the methods of processing or the type of packaging. Therefore, the use of appropriate processing, packaging and storage techniques among other good practices, can enhance food product's quality.

However, food safety and quality standards imposed by supermarkets and regulators may lead to the discarding of food that is still safe for human consumption, representing an enormous waste of natural resources (FAO, 2017).

It is therefore necessary to understand the causes that shorten the shelf-life of food and the measures to deal with them. Along with the understanding of the information that is depicted in the food labelling it will help to develop strategies to reduce food waste.

In summary…

Food quality is the group of attributes or characteristics that have significance in determining the degree of acceptability of consumer. The loss of food's attributes is a cause for food waste.

To guarantee food quality preventing from food waste is a shared responsibility along the entire food chain: primary production stage, processing and manufacturing in the food industry, distribution and retail and finally, consumers.

2.| Food labelling: food information to consumers

Food labels are an important information tool for consumers as they communicate facts about the product or the production process. The food business operator is responsible for the food information in accordance with law requirements. Showing the right information in the labels, and convey this clearly, helps to ensure that consumers will not misinterpret it, and that food will be stored and used properly being safe and fit to eat. This will significantly contribute to the reduction of food thrown away from our homes due to it not being used in time and also help surplus food redistribution (Weinrich and Spiller, 2016; WRAP et al., 2019).

2.1 | Mandatory particulars

Regulation (EU) No 1169/2011, commonly known as the Food Information to Consumers Regulation, establishes the general principles, requirements and responsibilities governing food information, and in particular food labelling. It lays down the means to guarantee the right of consumers to information and procedures for the provision of such information. The provision of food information will provide a high level of protection of consumer's health and interests by providing a basis for them to make informed choices and to make proper use of food.

The following information must be present on all European Union food labels:

- **The name of the food**

The name of the food must be clearly stated on the packaging and not be misleading.

If there is a name prescribed in law this must be used. In the absence of a legal name, a customary name can be utilized. This might be a name that has become commonly understood by people and established over time. If there is no customary name or it is not used, a descriptive name of the food must be provided. This must be sufficiently detailed to inform the purchaser of the true nature of the food.

The name of the food needs to include an indication of the physical condition of the food e.g. powdered, refrozen, concentrated, smoked in all cases where omission of such information could mislead the consumer.

- **The list of ingredients**

If a food product has two or more ingredients (including water and additives), they must be listed under the heading 'Ingredients'. They will appear in descending order of weight, with the main ingredient first, as recorded at the time of their use in the manufacture of the food.

Some foods are exempt from the need to display an ingredient list, such as fresh fruit and vegetables which have not been peeled, cut or treated; carbonated water; fermentation vinegars; cheese, butter, fermented milk and cream, to which no ingredient has been added other than lactic products, food enzymes and microorganism cultures essential to manufacture; or foods consisting of a single ingredient where the name of the food is identical to the ingredient name, or the name of the food enables the nature of the ingredient to be clearly identified.

- **Allergen information**

Where a food product contains any of the substances causing allergies or intolerances required to be declared by law (Table 1), these ingredients must be emphasized within the ingredients list using a different font, style, background color or by bolding the text. In the absence of a list of ingredients, the indication of these substances shall comprise the word “contains” followed by the name of the substance. This enables consumers to understand more about the ingredients in packaged foods and is helpful for people with food allergies and intolerances who need to avoid certain foods.

Table 1. Substances causing allergies or intolerances (Regulation (EU) No 1169/2011)

Cereals containing gluten	Milk and products thereof (including lactose)
Crustaceans and products thereof	Molluscs, and products thereof
Peanuts and products thereof	Mustard and products thereof
Eggs and products thereof	Sesame seeds and products thereof
Fish and products thereof	Lupine and products thereof
Nuts, including Brazil nuts, pistachios, almonds, hazelnuts, walnuts, pecans, cashews and macadamia nuts	Sulphur dioxide and sulphites at concentrations of more than 10 mg/kg or 10 mg/litre
Soybeans and products thereof	Celery and products thereof

- **Minimum durability date, “use by” date and date of freezing**

Food labels must be marked with either a “best before” or “use by” date so that it is clear how long foods can be kept and how to store them. The date of freezing or the date of first freezing shall also be indicated in the case of frozen meat, frozen meat preparations and frozen unprocessed fishery products.

- **Any special storage conditions and/or conditions of use**

In cases where foods require special storage conditions and/or conditions of use, those conditions shall be indicated.

To enable appropriate storage or use of the food after opening the package, the storage conditions and/or time limit for consumption shall be indicated as well, where appropriate.

Open life is the period of time during which a food will remain safe and/or of a suitable quality for consumption after the primary product packaging has been opened and it is stored as instructed (WRAP et al., 2019).

- **Instructions for use**

Instructions on how to prepare and cook the food appropriately must be given on the label if they are needed.

- **Nutritional declaration**

The mandatory nutrition declaration provides values for food energy and fat, saturates, carbohydrate, sugars, protein and salt. It can be supplemented with an indication of the amounts of one or more of the following: monounsaturated, polyunsaturated, polyols, starch, fiber, and vitamins or minerals.

- **The name and address of the food business operator**

The food business operator responsible for the food information shall be the operator under whose name or business name the food is marketed.

These mandatory particulars described above are closely related to the prevention of food waste. The rest of mandatory information that must be depicted in prepacked foods to the final consumer is the net quantity of the food, the quantity of certain ingredients, the alcoholic strength in beverages containing more than 1.2 % by volume of alcohol, as well as the country of origin or place of provenance. We must take into account that pack size conditions compulsory labelling requirements. If largest surface area is <10cm2 then only the name of the food, allergen labelling, date mark and quantity declaration are required.

Directive 2011/91/EU regulates another mandatory information related to indications or marks identifying the lot or batch to which a foodstuff belongs.

Lot means a batch of sales units of a foodstuff produced, manufactured or packaged under practically the same conditions.

Indication of the lot to which a foodstuff belongs meets the need for better information on the identity of products. It is therefore a useful source of information when foodstuffs are the subject of dispute, or constitute

a health hazard for consumers or need to be redistributed, and it is required in order to facilitate traceability. It is usually positioned next to the durability indication, and shall be preceded by the letter “L” except in cases where it is clearly distinguishable from the other indications on the label. When the date of minimum durability or “use by” date appears on the label, the indication lot need not appear on the foodstuff, provided that the date consists at least of the uncoded indication of the day and the month in that order.

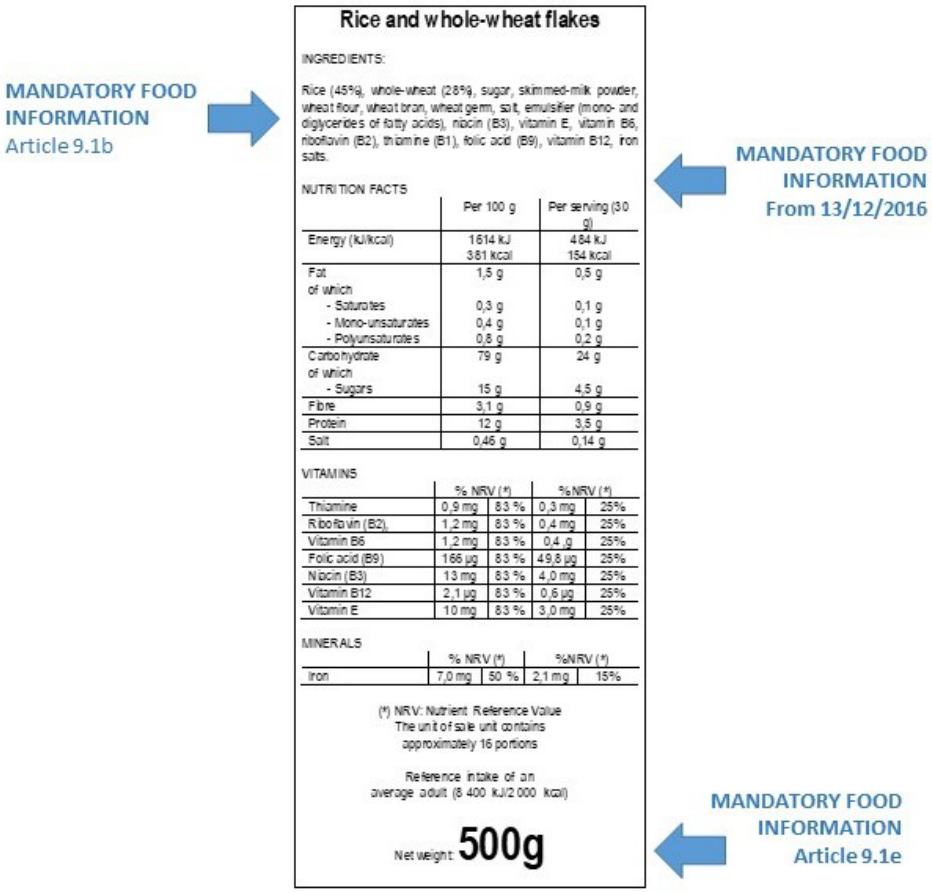


Figure 2. Food labelling
(http://eletiquetadocuentamucho.aecosan.msssi.gob.es/etiquetado.html)
Translation: ZERO_WASTE project

How to display mandatory information on packaging and labels

Mandatory food information must be easy to see; be clearly legible and be difficult to remove, where appropriate; not be in any way hidden, obscured, detracted from or interrupted by any other written or pictorial matter; and should not require consumers to open the product to access the information.

All mandatory requirements shall be printed on the package or on the label in characters using a font size where the x-height is equal to or greater than 1.2 mm to ensure clear legibility (Figure 3). Exemption for smaller packs where largest surface area is less than 80 cm2 “x height” of 0.9 mm.

Figure 3. Minimum font size of mandatory food labelling information (Regulation (EU) No 1169/2011; FDII, 2013).

2.2 | The date of minimum durability (“Best before”) and the “Use by” date

Misinterpretation by consumers of the meaning of the "best before" and "use by" dates can contribute to household food waste. The European Commission estimates that up to 10% of the 88 million tons of food waste generated annually in the European Union is linked to date marking on food products. Clear and correct information on packaging and a better understanding and use of date marking on food by all actors concerned, can prevent and reduce food waste while food safety is ensured (EFSA, 2020).

Regulation (EU) No 1169/2011 defines **date of minimum durability of a food** as the date until which the food retains its specific properties when properly stored. The date of minimum durability shall be preceded by the words **“Best before …”** when the date includes an indication of the day, or **“Best before end …”** in other cases. The words referred shall be accompanied by either the date itself, or a reference to where the date is given on the labelling. If need be, these particulars shall be followed by a description of the storage conditions which must be observed if the product is to keep for the specified period.

The date shall consist of the day, the month and possibly, the year, in that order. However, in the case of foods not being kept for more than 3 months, an indication of the day and the month shall be sufficient; for foods which will keep for more than 3 months but not more than 18 months, an indication of the month and year shall be enough; and those foods which will keep for more than 18 months, an indication of the year shall be adequate.

“Best before” date refers to quality rather than safety. Until this date, a foodstuff is expected to maintain its taste, aroma, appearance, vitamin content etc., when it has been stored appropriately and the package unopened, and after which it will not be in optimal conditions. It is important to note that the food will be safe to eat after this date but may not be at its

best. Common sense can be used, and if the food or drink is organoleptically acceptable to the consumer after the best before date, then it can be eaten.

On the basis of Regulation (EU) No 1169/2011, the indication of the date of minimum durability shall not be required for some foods such as fresh fruit and vegetables which have not been peeled, cut or similarly treated; wines and beverages containing 10% or more by volume of alcohol; bakers' or pastry cooks' wares which are normally consumed within 24 hours of their manufacture; vinegar; cooking salt; solid sugar; confectionery products consisting almost solely of flavoured and/or coloured sugars; or chewing gums and similar chewing products.

In the case of foods which, from a microbiological point of view, are highly **perishable** and are therefore likely after a short period **to constitute an immediate danger to human health**, the date of minimum durability shall be replaced by the **"use by" date**. Food can be eaten up to the end of this date but not after, even if it looks and smells fine and it has been stored correctly, because it shall be deemed to be unsafe (harmful microorganisms are odorless and flavourless).

Regulation (EU) No 1169/2011 establishes that the data will be expressed by the words "use by …" indicating the date itself, or, a reference to where the date is given on the labelling, The date shall consist of the day, the month and, possibly, the year, in that order and in uncoded, and shall be followed by a description of the storage conditions which must always be observed.

In summary…

The term **"Best before"** indicates the period for which a food can reasonably be expected to retain its optimal condition and so relates to the quality of the food. Best before dates appear on a wide range of foods including frozen, dried and tinning foods.

The term **"Use by"** should only be applied on foods which, from a microbiological point of view, are highly perishable and are therefore likely, after a short period, to constitute an immediate danger to human health. It will appear on food that goes off quickly such as ready-to-eat salads, fresh meat or fish, among others.

Figure 4: https://ec.europa.eu/food/system/files/2020-06/fw_eu-actions_date-marking_infographic_en.pdf

How date marking is utilised by food business operators and regulatory authorities in managing the supply chain can also have an impact on food waste. For example, the approaches followed by food business operators in defining whether to utilise a "use by" or "best before" date, market practices such as the amount of shelf life required by retailers on product delivery, or further redistribution of foods past the "best before" date, can influence the generation of food waste. In this context, EFSA has developed a tool to help food business operators decide when to apply the “use by” or “best before” date to their products, that is based in a decision tree with a series of questions to be answered. Questions range from whether date marking requirements for a food category are already regulated by legislation, whether a product undergoes any treatment to eliminate hazards, whether it is handled again before packaging, and its characteristics and storage conditions (Figure 5). Assisting them in their choice of the type of date and on setting the appropriate shelf-life, storage conditions and open life instructions contribute to the better management of foods (EFSA, 2020).

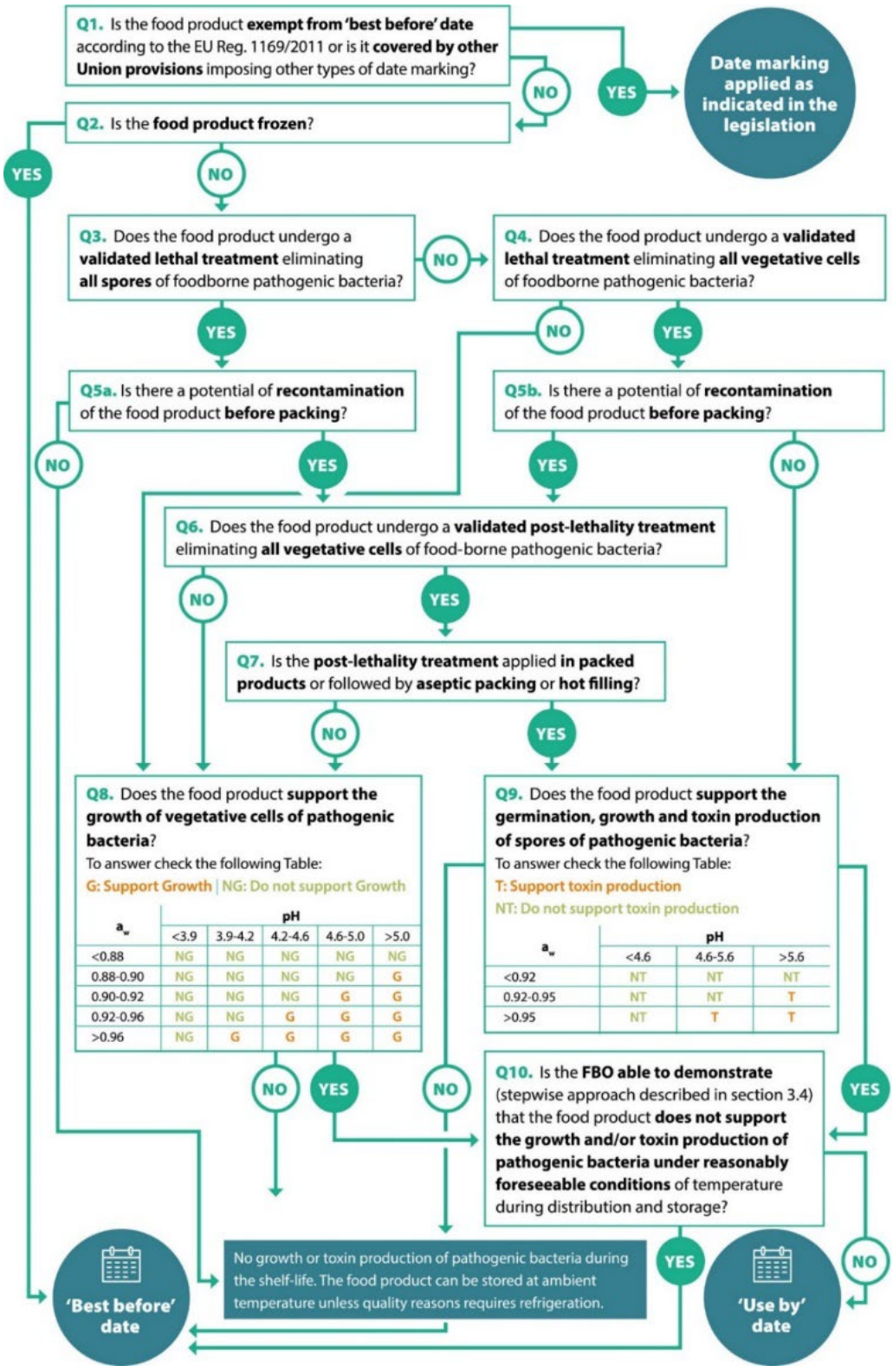


Figure 5. Decision tree on the appropriate date marking for temperature controlled prepacked foods (EFSA, 2020).

2.3 | Shelf-life studies

Food business operators are legally responsible for the determination of the date of minimum durability of the foodstuffs they place on the market. Shelf-life studies allow establish this date with certainty, and to document that the food will remain safe and/or will retain its quality until the end of said shelf-life. Shelf-life analysis include chemical, sensory, and microbiological testing of food products to examine how they change with time and other environmental factors. Different aspects like the product ingredients, packaging, processing, and storing conditions are considered (Giménez et al., 2012).

As well, and regarding food microorganisms, the European law establishes that the food business operators shall conduct studies in order to investigate compliance with the microbiological criteria throughout the shelf-life of the food product they manufacture (Regulation (EC) No 2073/2005). In particular, this applies to ready-to-eat foods that are able to support the growth of Listeria monocytogenes and that may pose a risk for public health. These studies include:

- Specifications for physico-chemical characteristics of the product, such as pH, aw, salt content, concentration of preservatives and the type of packaging system, taking into account the storage and processing conditions, the possibilities for contamination and the foreseen shelf-life.
- Consultation of available scientific literature and research data regarding the growth and survival characteristics of the microorganisms of concern.
- Predictive mathematical modelling established for the food in question, using critical growth or survival factors for the microorganisms of concern in the product.
- Tests to investigate the ability of the appropriately inoculated microorganism of concern to grow or survive in the product under different reasonably foreseeable storage conditions.
- Studies to evaluate the growth or survival of the micro-organisms of concern that may be present in the product during the shelf-life under reasonably foreseeable conditions of distribution, storage and use.

There is not a generic method to estimate and establish the shelf-life of foods. The most commonly methods used are the following:

- **Direct method or standard shelf-life study**

This method is a real-time study that consist of storing the product under similar conditions to those that it will be during commercialization, monitoring its evolution in different intervals of time. It creates a very accurate estimation of the time it takes for a product to deteriorate.

- **Accelerate shelf life study**

In this type of studies, the food product is conditioned and stored at elevated temperature and/or humidity, and the product quality changes are analyzed at a specific sampling rate. The accelerated shelf life study can be two to four times faster than the standard shelf life study, it is very versatile and allow for the comparison of different scenarios.

- **Microbiological challenge test**

A challenge test is a practical study to determine the behavior of relevant microorganisms if they should be present in a food product. It implies the experimental inoculation of a known concentration of the microorganism into the food product and aims at evaluating its evolution under the foreseen storage conditions.

- **Predictive microbiology**

This methodology studies the response of microorganisms in foods under different environmental conditions, based on mathematical and statistical models, in order to predict the behaviour of the microorganisms in the product.

- **Survival method**

This method is based on the opinion of the consumers, and the probability of them accepting a product beyond a certain storage time. Although it is not a method to accurately estimate the shelf life, it can be complementary to other tests.

3.| Nutrition. Food composition

3.1 | Nutrition

World Health Organization (WHO) states that access to sufficient amounts of safe and nutritious food is key to sustaining life and promoting good health. With the ingestion of food, our organism absorbs the minerals, vitamins, fats, proteins, carbohydrates and water providing the energy and the necessary elements to support a healthy life.

The contents of a healthy diet varies depending on the nutritional status and dietary needs of a person. The WHO recommendation for a healthy diet for an adult is the following (Lindgren et al., 2018; FAO and WHO, 2019): the basic diet should consist of fruits, vegetables, legumes, nuts and whole grains, with a daily intake of 400 g of fruits and vegetables; free sugars and fats should be less than 10% and 30% of total energy intake, respectively; unsaturated fats are preferable to saturated fats. Industrial trans fats, found in processed food should be avoided; and the intake of salt should be less than 5 g per day.

It is important to achieve food requirements of the population and to do it within a sustainable development framework. **Sustainable healthy diets** are dietary patterns that promote individuals' health and wellbeing, have low environmental pressure and impact, are culturally acceptable, accessible, affordable, safe, equitable, and reduce food loss and waste (FAO and WHO, 2019). However, our world is rapidly changing, and the increment of food consumption by a growing population, together with the changes in dietary habits, constitute an important challenge for the global food system (Lindgren et al., 2018; Al-Thani et al., 2020).

European food is already a global standard for food that is safe, nutritious, abundant, and of high quality. This is the result of the European Union policy to protect human health, to improve nutrition and healthy diets, to strength food systems and to reduce food waste. Food processors influence consumers' dietary choices through the types and nutritional composition of the food they produce, their production methods, and marketing practices. On the other hand, consumers continuously become more aware that proper food is directly connected to their wellbeing and can prevent nutrition-related diseases (European Commission, 2020; Galanakis, 2021).

The provision of clear information that makes it easier for consumers to choose healthy diets will benefit their quality of life, and reduce health-related costs. Related to this, the European Commission has proposed harmonized mandatory nutrition labelling to food products (Regulation (EU) No 1169/2011).

3.2 | Food composition

Food provides the energy and nutrients we need to be healthy. Therefore, food composition is critical for nutrition, health promotion, disease prevention, and food production (Pehrsson and Haytowitz, 2016).

Energy is required continuously for normal organ function, metabolic homeostasis, thermoregulation and physical activity. Food energy is the energy released from carbohydrates, fats, proteins, and other organic compounds contained in food. The unit of energy is the Joule (J). One calorie (cal) is equal to 4.2 Joules (Costa-Pinto and Gantner, 2020).

Nutrients can be classified into macronutrients (proteins, lipids and carbohydrates), that are essential compounds ingested in large amounts (g), and micronutrients (vitamins and minerals) because small amounts of these components are needed for the body (mg or g).

To know more… (1)

On the basis of Regulation (EU) No 1169/2011 regarding food information to consumers, mandatory information shall include information on food nutritional characteristics so as to enable consumers, including those with special dietary requirements, to make informed choices. The mandatory nutrition declaration shall include the following: energy value, and the amounts of fat, saturates, carbohydrate, sugars, protein and salt.

The content of the mandatory nutrition declaration may be supplemented with an indication of the amounts of one or more of the following: mono-unsaturates, polyunsaturates, polyols, starch, fibre, and vitamins or minerals present in significant amounts (Table 2). As a rule, for vitamins and minerals a significant amount means 15% of the nutrient reference values (NRVs) per 100g or ml for products other than beverages; 7.5% of the NRVs per 100ml for beverages.

Table 2. Vitamins and minerals which may be declared and their nutrient reference values (NRVs) (Regulation (EU) No 1169/2011)

Vitamins	NRVs	Minerals	NRVs
Vitamin A (µg)	800	Potassium (mg)	2 000
Vitamin D (µg)	5	Chloride (mg)	800
Vitamin E (mg)	12	Calcium (mg)	800
Vitamin K (µg)	75	Phosphorus (mg)	700
Vitamin C (mg)	80	Magnesium (mg)	375
Thiamin (mg)	1.1	Iron (mg)	14
Riboflavin (mg)	1.4	Zinc (mg)	10
Niacin (mg)	16	Copper (mg)	1
Vitamin B6 (mg)	1.4	Manganese (mg)	2
Folic acid (µg)	200	Fluoride (mg)	3.5
Vitamin B12 (µg)	2.5	Selenium (g)	55
Biotin (µg)	50	Chromium (g)	40
Pantothenic acid (mg)	6	Molybdenum (g)	50
		Iodine (g)	150

The declared nutritional data shall be average values based on the manufacturer's analysis of the food; a calculation from the known or actual average values of the ingredients used; or a calculation from generally established and accepted data. The presentation of nutrient declaration shall be as shown in Table 3, and shall be expressed per 100 g or per 100 ml. When provided, the declaration on vitamins and minerals shall also be expressed as a percentage of the reference intakes. The particulars shall be included in the same field of vision, presented together in a clear format and shall be presented in tabular format, if there is enough space.

Table 3. Expression and presentation of nutritional declaration (Regulation (EU) No 1169/2011)

Energy	kJ/kcal
Fat **of which**	g
- **saturated**	g
- **mono-unsaturated**	g
- **polyunsaturated**	g
Carbohydrate **of which**	g
• **sugars**	g
• **polyols**	g
• **starch**	g
Fibre	g
Protein	g
Salt	g
Vitamins and minerals	The units specified in Table 2

This Regulation establishes which foods are exempted from the requirement of the mandatory nutrition declaration. These are unprocessed products with a single ingredient or category of ingredients; processed products have been subjected to is maturing and comprise a single ingredient or category of ingredients, waters intended for human consumption, herbs and spices, salt, table top sweeteners, coffee extracts and chicory extracts, whole or milled coffee beans, herbal and fruit infusions, tea or fermented vinegars, among others.

The energy value and amounts of certain nutrients may be voluntarily repeated, using other forms of expression presented using graphical forms or symbols in addition to words or numbers provided. This highlighted nutrition information can help consumers make healthier food choices. Figure 6 shows different forms of nutritional expression. Graphical expression in Figure 6A is without colors, and Figure 6B shows a traffic light label, from green, which is good, amber, which is caution, or red, which is not good.

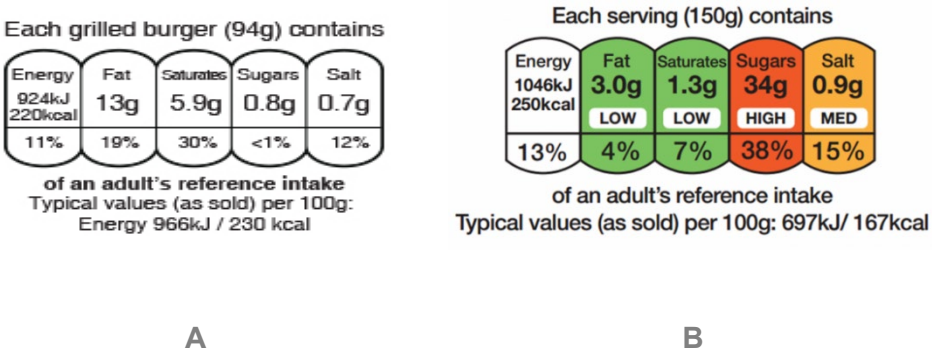


Figure 6. Different forms of nutritional expression.
A https://labellingtraining.food.gov.uk/module5/overview_4.html
B https://sidlaurea.com/2021/03/20/game-changers/

The Nutri-Score is a voluntary front-of-pack nutrition label that converts the nutritional value of products into a code based on a five-colour scale going from dark green to red, associated with letters from A (being a preferable score) to E (being a detrimental score), respectively. This nutritional scoring method was developed by the British Food Standard Agency. Each product is awarded a score based on a scientific algorithm taking into account the nutrients to avoid (energy, sugars, saturated fatty acids, salt) and the positive ones (proteins, fibre, percentage of fruit, vegetables, nuts, rapeseed oil, walnut oil and olive oil). The algorithm gives points for each element in the nutrition table (per 100 g or ml), and the subtraction of the positive points from the negative ones converts the result to the Nutri-Score code (Figure 7).

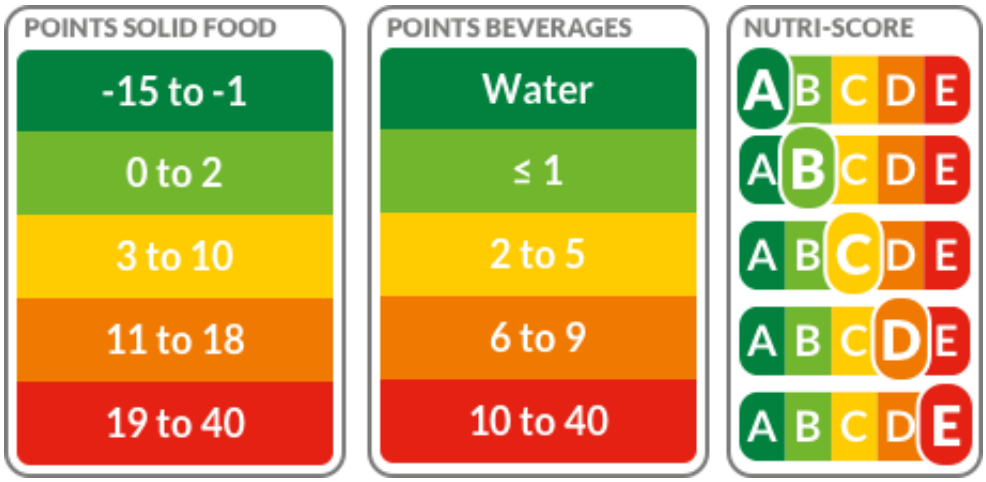


Figure 7. Nutri-Score voluntary front-of-pack nutrition label
https://nutriscore.colruytgroup.com/colruytgroup/en/about-nutri-score/

3.2.1. Databases on food composition

Food composition databases are essential tools for food research, nutritional health care, food industry and for those fields where the information on nutritional composition of foods is required (Kapsokefalou et al., 2019). Detailed documentation concerning foods and their components is required. Hence, a constant effort is needed to keep the values up-to-date, improve their quality, and to extend the databases with new foods, new components and other food characteristics (Westenbrink et al., 2021; Ocké et al., 2021).

Important databases are:

- **BEDCA – Spanish Food Composition Database**: http://www.bedca.net/
- **European Union**: http://www.efsa.europa.eu/en/data/food-composition
- **EuroFIR – European Food Information Resource**: https://www.eurofir.org/food-information/food-composition-databases/

- **INFOODS – International Network of Food Data Systems:** http://www.fao.org/infoods/infoods/tablas-y-bases-de-datos/bases-de-datos-faoinfoods-de-composicion-de-alimentos/es/
- **USDA – Food Composition Database**: https://fdc.nal.usda.gov/ndb/

3.2 | Food composition

Nutritional content can be affected during the growing, harvesting, storage, processing and cooking of food. Processes that expose foods to high levels of heat, light or oxygen cause the greatest nutrient loss. On the other hand, there is an important waste of valuable nutrients through food losses and waste (HLPE, 2014; Gustavsson et al., 2011). In this case, “nutrient loss” refers to the nutrient content embedded within FLW (Spiker et al., 2017).

Regarding nutrient loss, and considering that different food items differ widely in their nutritional content, quantifying the food waste in caloric terms, as usually practised, does not provide the true extent of damage done, so the losses of essential macro and micronutrients should also be considered (Chen et al., 2020). As an example, a project funded by the European Commission Framework Programme, examined waste of nine indicator food products (apples, tomatoes, potatoes, bread, milk, beef, pork, chicken, and whitefish) in European Union member countries, reporting substantial losses of vitamin A, beta carotene, vitamin C, fibre, iron, zinc, n-3 fatty acids, lysine, and methionine (FUSIONS, 2016).

It has been observed that the food waste of high-income countries of North America and EU embed many times higher nutrient losses on a per capita level than low-income countries (Chen et al., 2020). All the world's hungry people could be lifted out of energy or protein malnourishment on less than a quarter of the wasted food in the USA, UK, and Europe (Stuart, 2009). Reducing FLW may, thus, present a great opportunity in enhancing the sustainability of the food system and simultaneously improve food security and nutrition (Lindgren et al., 2018).

4.| Food spoilage

Food spoilage may be defined as a process or change which renders a product undesirable or unacceptable for consumption (Nychas and Panagou, 2011). This complex ecological phenomenon results when microbiological, chemical, or physical changes occur. These mechanisms are not necessarily mutually exclusive since spoilage caused by one mechanism can stimulate another (Amit et al., 2017). Different factors will define the mechanism that will dominate this process.

From the above considerations it follows that in general, the term spoilage is regards as negative. However, some process conducting to food spoilage are also needed for acquiring the characteristic food sensorial properties. In this context, it must be underlined that spoiled food can be safe but not fit for consumption. Conversely, it is also possible that food with appropriate organoleptic and nutritional properties represents a risk to public health.

To avoid food spoilage it is necessary to understand the causes and mechanisms conducting to food deterioration, which are described below.

4.1 | Factors affecting food spoilage

Factors affecting spoilage of foods may be divided into intrinsic factors that are endogenous to the food and extrinsic parameters that refer to those in the environment in which a food is produced and/or stored.

Intrinsic factors include food structure and composition, water activity, pH and redox potential.

- Therefore, some foods may pose some **structures** such as skin of fruits and vegetables, testa of seeds, and the shell, cuticle, and membrane of egg, which act as mechanical barriers protecting them from deterioration (Lianou et al., 2016). In the same way as food structure, **food composition** is a key parameter in relation to food spoilage. In fact, nutrient formulation may determine among others the water content, pH value, and also influences the growth of the most suitable species of microorganisms.

- **Water activity (aw)** is an indicator of the amount of free water in food, that is, the water in a food that is not bound and so it is available to supports microbial growth and to participate in and supports chemical and enzymatic reactions and spoilage processes.

  Microorganisms have a limiting water activity level below which they are not able to grow. The optimum for most microorganisms is in the range 0.9950.980. By comparison, water activity of food may vary from less than 0,60 in dehydrated products to more than 0,98 in fresh ones. These

values are used to predict the survival of microorganisms in a food product. However, the aw of a food may not be a fixed value; it may change over time, or may vary considerably between similar foods from different sources (FDA, 2012).

- **pH (hydrogen ion concentration, relative acidity or alkalinity)** is related to the concentration of hydrogen ions, releasing from the acids ingredients that dissociate in water. On one side, pH values in foods vary according to their composition. On the other side, microorganism only can grow at certain pH values. In that way, induced or naturally-occurring acidification of food is used for controlling the growth of undesirable microorganisms.

- **Redox potential**, is related to the growth and survival of the microorganism as affected by the availability of oxygen.

  At this concern, aerobic microorganisms are those growing in the presence of atmospheric oxygen whereas anaerobic microorganism do it in the absence of free oxygen.

Extrinsic parameters are factors in the environment in which a food is processed and stored, notably temperature and relative humidity or atmosphere composition. Other factors such as exposure to light will be named along with the mechanisms of spoilage

- **Temperature** strongly influences microbial growth. There is a 'Danger Zone' which in general allows most microorganisms to grow rapidly. This zone refers to temperatures between 8°C and 60°C. When in the 'Danger Zone' bacteria can double in number every 20 minutes. After food being at this temperature for hours, the number of bacteria may be high enough to have severe consequences.

  Apart from that, temperatures may produce chilling injury in some foods.

- Relative **humidity (RH)** refers to the moisture content of the atmosphere and it directly affects the moisture content of food. The difference between the RH of the surrounding environment and the water activity (aw) of the food determines whether a food gains or loses moisture during storage. The higher the difference between aw and RH during storage, the more potential for moisture migration to or from the environment until equilibrium is reached (Kong and Singh, 2016).

- With regards to the **atmosphere composition** and according to what it has been explained before, the composition of gases in the environment surrounding the food can also have an effect in the microbial growth and the chemical reactions occurring in food. In this sense, elevated

concentrations of carbon dioxide (CO_2) tend to slow the growth of microorganism.

To know more … (2)

4.2 | Food spoilage mechanisms

4.2.1. Physical spoilage

- **Physical injury** is a very important cause of loss in fruits and vegetables. Damage in these products may be produced by different forces such as surface abrasion or handling of packaging at which food products may be subjected (Kong and Singh, 2016).

  One of the most important food components is water and changes in water content is a common cause of degradation of food products. Moisture loss causes fresh produce to wilt and shrivel, and to experience increased senescence. For frozen foods, moisture migration from the inside to surface could cause freezer burn (Kong and Singh, 2016). Moisture exchange is as well a frequent cause of changes in texture of food. Examples include dried foods such as breakfast cereals and chips becoming soggy instead of crunchy after gaining moisture while soft texture foods becoming hard and brittle when decreasing their water content.

  Since many reactions need water to be done, increasing food water content not only affects its sensory attributes but also can promote chemical changes or microbial growth.

  Other substances may be transferred from or to food resulting in undesirable food changes as for example the loss of CO_2 in carbonated drinks or the adsorption of flavourings coming from packaging materials.

- **Crystallization** is an important thermo-physical phenomenon through which a substance precipitates due to supercooling or supersaturation conducting to the formation of a crystalline lattice structure (Kiani and Sun, 2011).

- Some crops, specially tropical fruits and vegetables are sensitive to **chilling injury**, which generally occurs at temperatures of 5-15 ºC. Effects of chilling injury include pitting, water soaking, discoloration, development of off-flavours, accelerated senescence, or ripening/over-ripening (Singh and Anderson, 2016).

4.2.2. Physical spoilage

Chemical and biochemical food spoilage occurs when different components in the food react with each other or with some added component which alter the food's sensory characteristics. The most important ones include: oxidation; hydrolysis, enzymatic browning and non-enzymatic browning.

- **Oxidation** occurs when food comes in contact with oxygen in the air. This immediately begins the decaying process, affecting the food's taste, colour, and nutritional value. Many essential nutrients are oxidized in the presence of air resulting in their reduced efficacy.

- **Hydrolysis** of a chemical compound consists of the fragmentation of their molecules under suitable conditions, in the presence of water. Different hydrolytic reactions may cause food deterioration. For example, in carbonated drinks containing aspartame, hydrolysis reactions under ideal pH and temperature will reduce sweetness.

- **Non-enzymatic browning**, which is also known as Maillard reaction, is an ubiquitous reaction taking place in heat-treated foods and also those foods stored during long time at room temperature. It is desirable in products where a brown colour and a special aroma are expected, such as coffee, bread, and cooked meat but it is also a primary cause of food spoilage in others, like milk. Thus its contribution to the quality of the product is product-dependent.

- The **Enzymatic browning** suffered by many fruits (peeled and sliced apples and bananas) and vegetables (cut lettuce and mushrooms) is one of the most important reactions that occur in these products. When food products are cut, peeled, diseased, or exposed to any abnormal conditions, cells lose their compartmentation, which brings about the release of enzymes from subcellular structures and phenolic compounds from the vacuole. Therefore it may occur the enzymatic oxidation of the phenolic compounds (substrate) initiated by several related enzymes, mainly the enzyme polyphenoloxidase (PPO), also known as phenolase. The reaction usually resulting in negative effects on colour (browning), taste, flavour, and nutritional value and is perceived as undesirable by consumers so it limits the shelf life of these kind of products.

4.2.3. Microbial food spoilage

Foods, particularly those with a high water and nutrient content and neutral pH values, are substrates ideally suited for the growth of microorganisms. Microbial food spoilage is the outcome of the biochemical activity of specific groups of microorganisms (molds, yeasts, or bacteria) resulting in final products with an inadequate shape or appearance, despite of they be safe. Microbial food spoilage is an important cause of food waste accounting for up to 25% of the post-harvest food supply. The microorganisms most often

associated with food spoilage are varied and depend highly on the type of food that is spoiled and the way that it has been processed and stored.

- **Bacteria** are responsible for some of the most rapid and evident spoilage events of proteinaceous foods such as meat, poultry, fish, shellfish, milk, and some dairy products (Petruzzi et al., 2017).

- **Molds and yeasts** can affect a wide range of products which have low pH or water activity (aw). Spoilage caused by molds and yeasts is often manifested by their visible growth on the surface of foods such as cheese and meat, as well as by fermentation of sugars in liquid and semiliquid products to produce acid, gas or alcohol or the development of off-odours and off-flavours (Huis in't Veld, 1996; Lianou et al., 2016)

  Mould spoilage can also be a food safety issue due to the production of mycotoxins or allergens by these moulds.

To know more …. (3)

5.| Food hazards

Safety is an intrinsic quality attribute of foods and it is strictly related to their suitability for human consumption. Unsafe food is a threat to human health and economies globally. Over 200 diseases are caused by eating food contaminated with bacteria, viruses, parasites or chemical substances such as heavy metals. This growing public health problem causes considerable socioeconomic impact though strains on health-care systems lost productivity, and harming tourism and trade (WHO, 2020).

Unsafe food is due to the presence of food hazards, that is, any agent with the potential to cause adverse health consequences for consumers. There are different type of food hazards that need to be considered: biological, chemical, physical, allergenic, nutritional and/or biotechnology-related. Food safety hazards may occur naturally, be unintentionally or intentionally introduced. They can also be introduced at any stage of the food chain. In any case, there are often no visual indicators regarding their presence in foods despite of they may lead to serious health impairment or fatality. As explained before, it is possible that food with appropriate organoleptic and nutritional properties represents a risk to public health.

The term **"contaminant**" that is frequently used to refer to food hazards is defined in legislation (Regulation (EEC) No 315/93) as any substance not intentionally added to food which is present in such food as a result of the production (including operations carried out in crop husbandry, animal husbandry and veterinary medicine), manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food or as a result of environmental contamination.

- **Biological hazards** are microorganisms such as bacteria, viruses, yeasts, molds and parasites or they may produce toxin in the food chain that pose a threat to human health. The also include other biological hazards as prions. Biological hazards are of great concern to food industry because they are responsible for most of foodborne illness outbreaks.

To know more … (4)

- **Chemical contamination** of food can lead to acute poisoning or long-term diseases, such as cancer. Of most concern for human health are naturally occurring toxins including mycotoxins, marine biotoxins, cyanogenic glycosides and toxins in poisonous mushrooms. Also important are environmental contaminants such as the persistent organic pollutants (POPs) dioxins, which are unwanted by-products of industrial processes and waste incineration, and polychlorinated biphenyls (PCBs). Pollution of the air, soil and water is also responsible for contaminating

food with heavy metals such as lead, arsenic, cadmium and mercury. Also relevant are food contact materials, cleaning agents, processing-induced chemicals, food additives, pesticides and veterinary drug residues.

- **Physical hazards** involve glass, packaging, jewellery, pest droppings, screws, etc. which usually result from accidental contamination and /or poor food handling practices.

Chemical and biological hazards substantially differ in their characteristics, persistence, survivability and adverse health effects. In this way, microbiological pathogens are able to multiply in under favourable conditions, while this is not possible for chemical hazards. Moreover, microbiological pathogens can be eliminated or reduced after processing, while most often this is not the case for a chemical contamination.

Ensuring food safety is a public health priority and an essential step to achieving food security. Effective food safety and quality control systems are key not only to safeguarding the health and well-being of people, but also to fostering economic development and improving livelihoods by promoting access to domestic, regional and international markets.

Legislation on the general principles of food law (Regulation (EC) No 178/2002) makes it illegal to place unsafe food on the market. In order to achieve the general objective of a high level of protection of human health and life, a general obligation is placed on food business operators to ensure that all stages of production, processing and distribution of food under their control satisfy the relevant hygiene requirements laid down in Regulation (EC) No 852/2004 and any specific requirements provided for in Regulation (EC) No 853/2004 which lays down specific hygiene rules for food of animal origin. Prevention is the ultimate goal of food control and is only possible if food producers and food businesses are correctly implementing effective programmes of food safety management.

In addition food shall comply with the relevant requirements of food law regarding to the maximum contents of some specific hazards in food. Therefore microbiological criteria give guidance on the acceptability of foodstuffs and their manufacturing processes. (Regulation (EC) No 2073/2005). Food must also comply with maximum limits for contaminants as well as for pesticides, food additives and veterinary drug residues as it is depicted in their respective regulations (Regulation (EC) No 396/2005; Regulation (EC) No 1881/2006; Regulation (EC) No 1333/2008; Regulation (EC) No 37/2010).

According to these criteria, food injurious to health or unfit for human consumption and so considerer to be unsafe, must be deemed. Therefore not complaining with food regulations is contributing to FLW. With that in mind, preventative actions, such as the application of Good Hygiene and Manufacturing Practices (GHP, GMP) and the Hazard Analysis Critical

Control Point (HACCP) principles contribute not only to achieve food safety but also to prevent FLW.

6.| Food preservation strategies

Although it is not possible to completely prevent spoilage of foods, different strategies can be found to delay this process and to minimize its impact. Food preservation may be defined as the processes or techniques undertaken to maintain internal and external factors which may cause food spoilage and contamination. Factors controlling food safety and food spoilage, especially those related to microbial growth, are often the same. Therefore, the following is a summary of the food preservation strategies that allow to delay food quality loses, food spoilage and/or food contamination so that food maintain the desired properties or nature for as long as possible. As food preservation technologies helps to increase the shelf life of food they have an important role in reducing food waste.

Food processing can be classified according to different criteria. The most commonly used preservation methods are summarized, although technological advances are constantly being developed. Around the world, development practitioners in public, private and non-governmental organizations are constantly designing and implementing innovative solutions to address these challenges.

6.1. | Physical processing technologies

Food can be preserved by physical methods like:

• **Drying**

Drying or dehydration is one of the oldest methods of food preservation. It is the process of removing water in food by means of evaporation to reduce water activity, slowing down by this way the growth of germs and the chemical-enzyme action. It also reduces weight and volume of foods, facilitates foods storage, packaging, and transportation, and also provides different flavours and smells (Amit et al., 2017). From ancient times drying of food has been made under the sunlight. However, nowadays there are many types of drying methods to dehydrate foods which may be done with a variety of sophisticated equipments. Food items, such as fruits, vegetables, meats, and fishes, are processed by drying. Instant coffee and tea are also produced by spray drying or freeze drying.

• **Thermal food preservation**

Heat processing of foods is mainly designed to result in a specific reduction in numbers of foodborne pathogens or elimination of food spoilage organisms, thus ensuring microbiological safety and increased shelf life. Thermal inactivation is safe and chemical-free and provides tender, cooked flavours and taste. Heat treatments may also have some drawbacks such as undesirables flavours and texture changes when overcooking or nutrients loos. There are different types of heat treatment and duration of time.

Pasteurization is a physical preservation technique in which food is mild heat treated so that non-spore forming pathogenic bacteria are inactivated. Pasteurization kills most spoilage organisms and deactivates enzymes which increases the shelf life of food.

The efficiency of pasteurization depends on the temperature–time combination which is mostly based on the thermal death-time studies of heat-resisting microorganisms. On the basis of temperature and heat exposure, pasteurization can be categorized as VAT or LTLT (low temperature long time), HTST (high temperature short time) and UHT (ultra-high temperature); the latter being more effective to inactivate thermo-resisting spores. Therefore UHT pasteurized products have a longer shelf life than other pasteurized products, although once the package is opened, then it must be kept inside the refrigerator.

Thermal sterilization at temperatures exceeding 100°C is a heat treatment process that completely destroys all the viable microorganisms resulting in a longer period of shelf life. In reality, viable spores may persist in the product, but they are prevented from growing by other factors such as low pH (pH <4.5), low water activity and preservatives such as nitrite and salt.

• **Freezing**

Freezing changes the physical state of a substance by forming ice from water below freezing temperature. It reduces the amount of liquid water in the food and diminishes water activity (Amit et al, 2017). Freezing inhibits the growth of spoilage and pathogenic microorganisms while both, enzymatic and non enzymatic changes continue at much lower rates. Therefore, during frozen storage there is a slow progressive change in the organoleptic quality of food (Rahman, 2007). In addition microorganisms remain alive tough not active. Therefore, they will easily grow when food is defrosted. In general, slow freezing of food tissues results in the formation of larger ice crystals in the extracellular spaces, while shorter freezing time produces small ice crystals distributed throughout the tissue and therefore cause less damage to cell structure or texture of the food.

• **Chilling**

In chilling process, the temperature of foods is reduced and maintained between 1 and 8 C to store the food products for a few days or a more prolonged period of time depending upon the food type. The cold temperature reduces the rate of biochemical and microbiological changes extending the shelf life of fresh and processed foods.

6.2. | Biological processing technologies

Fermentation is a typical example of biological preservation of food trough the growth of microorganisms. Fermentation can be spontaneous or induced by addition of known microorganisms. The process generate a number of beneficial products which minimizes food spoilage. Bacteria, yeasts, and

molds are the most common groups of microorganisms involved in fermentation of a wide range of food items, such as dairy products, cereal-based foods, and meat products (Amit et al., 2017). Accordingly there are different techniques such as alcoholic fermentation which results from the yeast action on sugar converting this into alcohol and carbon dioxide; vinegar fermentation that is produced after alcohol fermentation or the lactic acid fermentation due to bacteria. In fact, lactic acid bacteria (LAB) are the main microorganisms used for fermenting food. LAB renders several compounds as organic acids, which are capable to exert antimicrobial properties as well as imparts unique flavour and texture to the food products. Fermentation enhances as well nutritional value, healthfulness, and digestibility of foods.

6.3. | Chemical processing technologies

Food preservation using chemical reagents is a well-known method used since ancient times. Wide varieties of chemicals or additives are used in food preservations both natural and synthetic. At any case, they must be safe to consume under the intended conditions of use and must accomplish some desired function in the food to which they are added.

Organic acids are natural constituents of many foods that are produced or added for preserving them for deterioration. Effectiveness of organic acids as food preservatives depends on many factors such as the type of acid used and its concentration or the product storage temperature and water activity and pH values. As example, acetic acid is used to lower the pH in the water phase of foods, restricting microbial growth; sorbic acid, that naturally occurs in some fruits, and benzoic acid are both effective antimicrobials against yeasts and moulds; many others as for example propionic acid, fumaric, malic, succinic and tartaric acids are frequently used.

Adding salt or sugar to food is a common method of preserving food products. Sugaring is mostly used for the preservation of fruits such as peaches or strawberries with which jam or syrup can be made. Salty is used to preserve food products by dry curing (meat, fish, etc.) or wet curing (vegetables). Both, salt and sugar draw the water out of microorganisms and retard their growth.

In addition, a variety of natural or synthetic chemical substances can be added to enhance food preservation. Food additives are used intentionally during processing, packaging, or storage of foods to bring desired changes in food characteristics. However, there is as a current renewal interest in natural occurring antimicrobial and antioxidant compounds as a response to consumers' requirements for fresher and more natural additive-free food products. Food preservation using chemical reagents is a well-known method used since ancient times. Wide varieties of chemicals or additives are used in food preservations both natural or synthetic. At any case, they must be safe to consume under the intended conditions of use and must accomplish some desired function in the food to which they are added.

6.4. | New preservation techniques

The preservation methodologies explained are those consider traditional and have several advantages since they are economical, safe and well known. However, they also have some drawbacks such as lack of uniformity in treatment and changes that occur in food quality attributes.

Nowadays, there is a consumer's demand of healthy, safe, free of synthetical chemical preservatives and quickly prepared food. For this reason the development of innovative non-thermal food processing technologies resulting in food that is safe from a microbiological point of view, healthy, and better maintaining the properties of the fresh product have received growing attention.

The most important emerging technologies are based on irradiation; pulse electried field (PEF); high hydrostatic pressure or ultra-high pressure processing (HPP) which is the most developed one; new ways of applying heat and/or packaging, in addition to various antimicrobials; and applications of nanotechnology. In addition, combined processes or 'hurdle technologies' are frequently used. It consist of the combination of different preservation technologies, increasing inactivation while reducing the treatment intensity of each process, and thus decreasing food quality losses.

6.5. | Food preservation at home

The greatest amount of FLW in the food supply chains of developing and developed economies, are produced at home. This is why consumer food waste has been identified as a major challenge.

Consumer's responsibility includes proper food handling, storage, and at-home preparation. Doing this is important not only for preserving the quality, nutritional and organoleptic properties of food products, but also to keep food safety. As regards, in addition to all the personal hygiene measures that must be applied to avoid food contamination (frequent washing of hands and working areas, having hair tied back, not sneezing or coughing on food, regular changing of kitchen cloths, storing garbage in containers with lids placed away from food handling areas, etc..) it is important to follow the indications below.

During shopping, products that do not need cold temperatures should be collected first (can, drinks,...); then follow by the refrigerated ones (fruits, vegetables, meats, yogurts,...) and finishing with the frozen food. By purchasing the products needing cold temperature at the end, we will prevent the cold chain from being broken avoiding to reach temperatures that facilitate microorganisms to grow.

Consumers have to choose the products according to their needs. As we have seen before, labelling provide information which may help to do a more logical and coherent purchase within our needs.

Shopping carts must be properly organized. Therefore, food must be separated from toxic products (cleaning products, insecticides, etc.). When bagging, food should be separated while maintaining the same organization as during the selection of products: grouping foods that do not need cold, placing the refrigerated ones together and isolating frozen ones in isothermal bags. In addition, foods that may contaminate others (e.g. raw meats or fish with fruits and vegetables) shouldn't be together. As for, it is advisable not to place raw meat and fish on top of other products, as they could drip and contaminate them.

During transport, foods that need cold for preservation (dairy, meat, fish, etc.) will increase their temperature and this can lead to the multiplication of microorganisms. When buying products that need refrigeration or freezing, the transport home should be carried out as soon as possible, especially in summer. Perishables should be placed in the coolest part of the car during the trip home.

Once at home foods must be rapidly classified according to their temperature requirements. Labelling usually provide information about the most appropriate way for food preservation and they should be carefully read. The packaging of the products shouldn't be thrown away without making sure that the way of conservation and use is completely known.

As regards, it should be highlighted how important food packaging is to prevent food from becoming contaminated and isolated from the environment. Properly designed and manufactured packaging, allow food products to be stable for longer and to maintain their quality characteristics. But if the packaging is damaged, neither their quality nor the safety can be guaranteed. Therefore, it is particularly significant to dwell on the analysis of packaging. Specifically, bumps that can generate pores at the junction points of canned packaging must be avoided and supervised.

Bacteria that may contaminate food are very active at room temperature. Between 5ºC and 65ºC, most potentially pathogenic microorganisms grow rapidly and multiply in a very short time. Despite cold doesn't kill microorganisms, it slow down or stop their development.

Although microorganisms can be partially or totally inactivated with good cooking, until the time comes to cook, food must be kept at an appropriate storage temperature. As rapid growth of microorganisms can occur, foods needing cold for preservation should be quickly stored and never being allowed to remain at room temperature for more than two hours, or even less in the summer time. It is particularly important in certain foods such as poultry meat, minced meats, fish, foods containing raw egg such as sauces and

mayonnaises, unpasteurized milk and dairy products or foods that will not undergo further treatment (cut fruits and vegetables, cooked food....) which should be carefully handled and preserved.

However, cold should be avoided in some foods that do not freeze well. Further information about food storage conditions is summarized below.

Regarding at-home food preparation, we should first be attended to the food labelling instructions related to “mode of preparation”. Besides that, marinating food should be done in the refrigerator so to avoid bacteria growing rapidly at room temperature. Marinade liquid never should be used later as sauces, unless they boil quickly first. Cooking process should ensure that food reaches 70 °C in all its parts.

Once cooked, foods that are not going to be immediately eaten must be kept cold. Putting hot food in the refrigerator can negatively affect the temperature of others. Therefore, cooked foods should be cool before putting them in the freezer or in the refrigerator. When reheating a previously cooked food that has been refrigerated or thawed, we must ensure that all parts of the food, including the centre of it, reach at least a temperature of 70 ºC, for at least 15 seconds.

Finally, to prevent food waste and save money it is important to fully understand the terms “Best Before” and “Use By” dates on food packaging. As it has been explained before, any food after expiration of the “use by” date must be uses. However, “Best before” dates appear on a wide range of refrigerated, frozen, dried (pasta, rice), tinned and other foods (vegetable oil, chocolate, etc.). In those cases it is recommended to check if the packaging is intact, and if the food looks, smells and tastes good before throwing away food past its “best before” date. Once a food with a “best before ”date on it has been opened, follow any instructions such as “eat within three days of opening”, when applicable.

6.5.1. Food storage. FIFO and FEFO systems

Non refrigerated foods

Foods that do not need to be refrigerated must be kept in a dry, cool and dark place. In particular, it is not recommended to keep cold some fruits and vegetables and consumers should be awareness about how to store them to stay fresh longer inside or outside the refrigerator. Many fruits give off natural gases as they ripen, making others to spoil faster. Store bananas, apples, and tomatoes by themselves. Also outside the fridge is recommended to keep citrus (limes, lemons, oranges, mandarins, grapefruits), whole melon, watermelon, pineapple and pomegranate. Low temperatures shouldn’t be used as well for exotic fruits and fruits needing ripen. Vegetables no needing cold include cucumbers, beets, peppers, garlic, onion, potatoes, sweet potatoes, pumpkin or ginger.

Though there are some fruits that may ripen at room temperature, afterwards it is recommended to keep them cold. Some examples are avocados, kiwis, nectarines, peaches, pears or plums.

If any canned product is opened and not consumed in its entirely, the original container should be removed and transferred to an airtight container for storage in the refrigerator.

Refrigerated foods

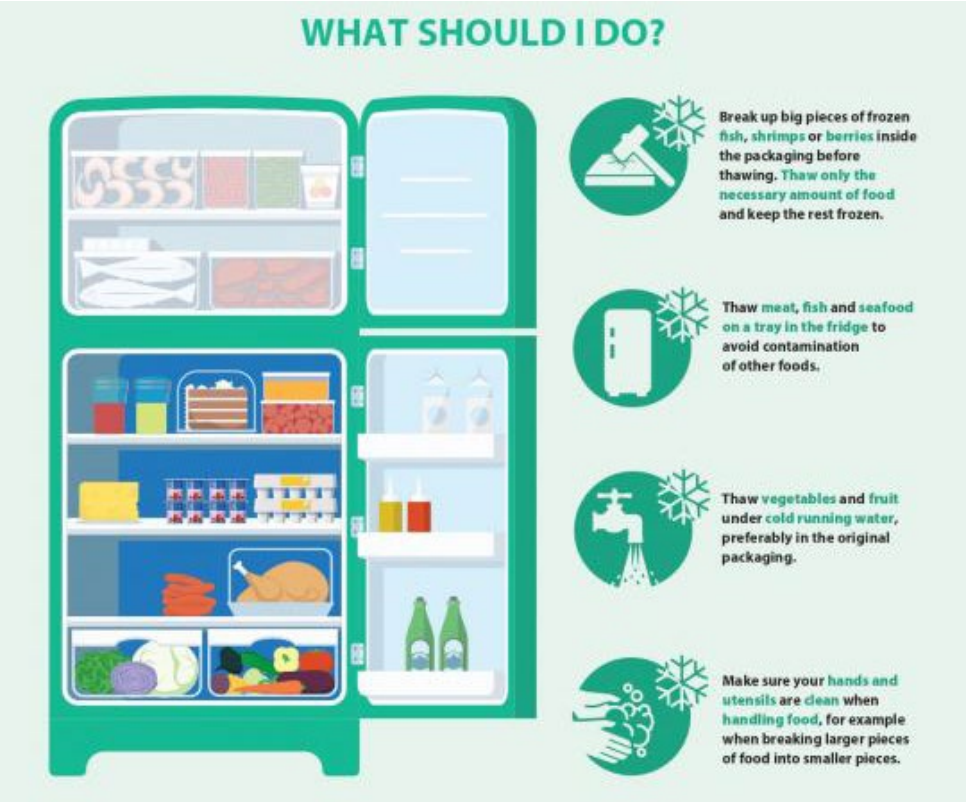
Some of the bacteria that cause food poisoning can multiply at room temperature in a very short time, and one of the best ways to avoid this is to refrigerate food at the right temperature.

The ideal cooling temperature must range between 0 and 5 °C. A thermometer to control the temperature of the refrigerator and freezer, can be a good tool to adjust the cooling power in relation to the load. Leave the door open for the shortest possible time. The capacity of the refrigerator must be appropriate to the number of people it must serve.

Not only temperature is important but also how food products are distributed may affect their shelf-life. The refrigerator should not be overloaded and leave air space around the containers or packages. This allows cold air to circulate and helps to ensure rapid cooling. To prevent some foods from contaminating others, raw food should be always separated from processed or cooked food. For this reason, packaging and lids must be simultaneously used. Freezer wrap and freezer-quality plastic bags may also help to reduce dehydration and quality loss.

It is also important to place the food in the fridge according to their preservation needs:

- On the top shelf: cooked food (packaged food leftovers, container with canned goods not used in their entirety, etc.).
- On the centre shelf: eggs, dairy products and sausages
- On the bottom shelf: raw foods: meat, poultry and fish always packaged and separated properly, and products thawed, so we will avoid the exudate that gives off falling on top of other foods.
- At the door: drinks or foods with frequent consumption, such as milk, soft drinks or juices.
- In the greenish: Fruits and vegetables needing cold. They should be placed in different bins. It is recommended not to wash berries until eating them in order to prevent mold.



https://www.efsa.europa.eu/en/infographics/defrosting-food-safely

Frozen food

Freezing food is a very common preservation methodology recommended, among others, to keep foods that will not be consumed in the coming days, such as fish or meat no matter weather they are raw or cooked as well as vegetables previously scalded or cooked. However, freezing is not suitable for some products such as those made of rice, potatoes or pasta since their texture is modified in an undesirable way. Neither it is recommended for vegetables that are eaten raw (lettuce, tomatoes,….), nor for whole fruits unless they be used afterwards to make smoothies or similar products. Foods with a high fat content, such as cream and some sauces, tend to be cut when frozen. Dairy products also do not withstand freezing well.

Freezing should be done very quickly and at low temperatures. The lower the temperature is, smaller ice crystals will be created and that will affect food texture to a lesser extent.

It is advisable packaging food products in small portions. This not only facilitates their freezing, but also allows a better organization of the rations. Airtight plastic bags for freezing are very useful for packaging. They should be used only once and as much air as possible should be removed. On the other hand, it must be taken into account that when food is frozen it expands, so it will be necessary to leave a proportional space to prevent the containers from bursting.

The duration of the food in the freezer will be determined by the stars of the domestic freezing apparatus:

- 1 star: -6 °C minimum temperature, so they will be freezers to keep a few hours the food.
- 2 stars: -12 °C minimum temperature. Food can be frozen for up to about three days.
- 3 stars: -18 °C minimum temperature. Food lasts for months frozen.
- 4 stars: -24 °C freezing is faster and allows you to freeze more food and for longer.

Also depending on their nature, food products can be kept in the freezer for longer. It is recommend not to exceed a storage period of two months for minced meat; three months for bread, prepared or cooked food, fatty fish and seafood; six months for pork and lean fish; ten months in the case of vegetables and chicken and game meat. Freezer should be at -18ºC and food must not be refreeze, because successive freezes detract from the quality of food and make it easier to contamination.

Finally it is advisable to clean frequently the inside of the refrigerator and whenever spills or drips occur. Additionally, pantries, fridges and freezers should be periodically cleaned and revised. The maxim must be adhered to: **"First in, First out"** or **"first in is first out"**. In this way, we will first consume those products with a closer expiration date. Not to leave forgotten foods at the bottom of the freezer it is recommended to mark the freezing dates with a marker. In the fridge it is recommended putting the foods we just have bought behind the ones already inside.

7.| Food safety in the redistribution of food

Food donation or food redistribution is part of the strategy to reduce food waste. The primary focus of food waste prevention should be to act at the source by limiting the generation of surplus food at each stage in the food supply chain, but when food surpluses occur, the best destination is to redistribute them for human consumption, which ensures the highest value use of edible food resources (European Commission, 2017; Agencia Catalana de Seguridad Alimentaria, 2019).

Surplus food may arise for a variety of reasons: foods which do not meet manufacturer and/or customer specifications (e.g. variations in product color, size, shape, etc.); difficulties in managing supply and demand that lead to over-ordering and/or cancelled orders; or issues relating to date marking may also prevent foods from being sold and distributed through the usual retail channels.

Food business operators may donate surplus food through redistribution organizations (such as food banks), gleaning networks and other charity organizations or directly to consumers. In all cases, surplus food shall be redistributed with the guarantee that is fit for human consumption and compliant with all food safety requirements. In this sense, foods suitable for food donation may include, for instance, products which are time-marked and have passed the “best before” date but can still safely be consumed; have been collected and/or confiscated by regulatory authorities for reasons other than food safety, etc. (FAO, 2015; European Commission, 2017).

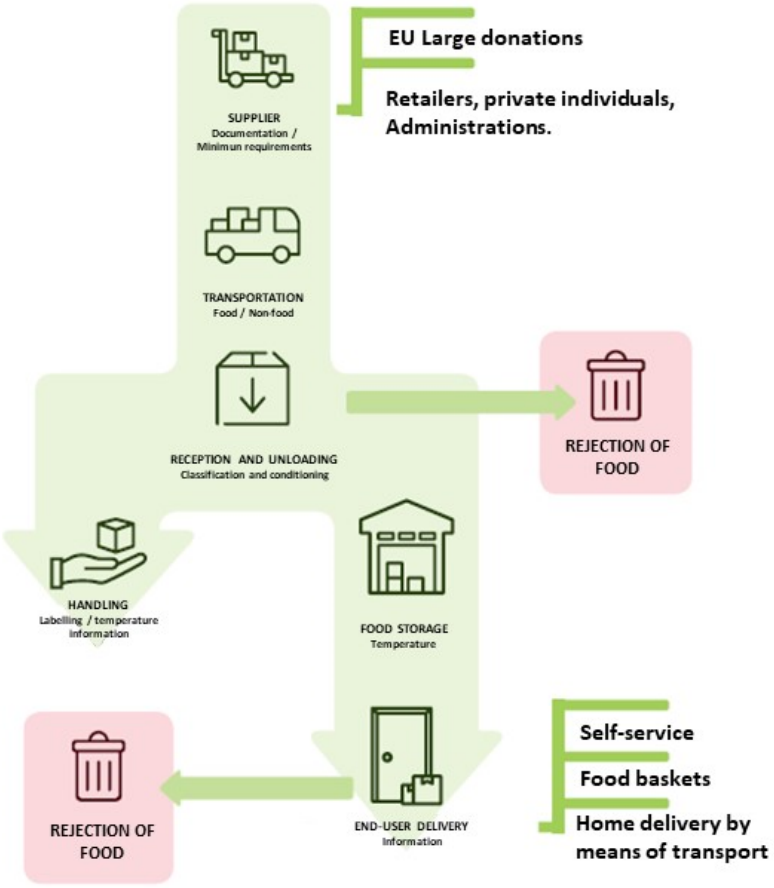


Figure 8. Flow chart of food donation activities (Agencia Catalana de Seguridad Alimentaria, 2019). Translation: ZERO_WASTE project

Food business operators may redistribute food for the purpose of food donation subject to the following conditions (Regulation (EU) 2021/382):

- They shall routinely check if food under their responsibility is not injurious to health and is fit for human consumption by taking into account at least:
  - the date of minimum durability or the “use by” date, ensuring sufficient remaining shelf-life left to allow for the safe redistribution and use by the final consumer.
  - the integrity of the packaging.
  - the proper storage and transport conditions, including applicable temperature requirements.
  - the date of freezing (when applicable).
  - the organoleptic conditions.
  - the assurance of traceability.

- If the check carried out is satisfactory, they may redistribute food in accordance with the following:
    - for food for which a “use by” date is applied, before the expiry of that date.
    - for food for which a date of minimum durability (“best before”) is applied, up to and after that date.
    - for food for which a date of minimum durability is not required, at any time provided.

The activities around the redistribution of surplus food does not change or replace the normal legal requirements that apply to the provision of food. Volunteers handling food, the social organization's facilities and food products shall satisfy the general hygiene requirements laid down in Regulation (EC) No 852/2004, as well as requisites of traceability, among others (Agencia Catalana de Seguridad Alimentaria, 2019).

Requisites for food handlers

- Volunteers shall maintain a high degree of personal cleanliness.
- No person suffering from a disease likely to be transmitted through food is to be permitted to handle food.
- They must wash and dry their hands thoroughly before handling food, and wash and dry them again frequently during work.
- Not smoke, chew gum, spit, or eat in a food handling or food storage area. Never cough or sneeze over food.
- They must cover all cuts and wounds with a wound strip or bandage.
- Disposable gloves need to be changed regularly.

Establishment and facilities requisites

- Design and layout of food establishments should permit good food hygiene practices, including protection against cross-contamination between and during operations with foodstuffs.
- Structures should be soundly built of durable materials and be easy to maintain, clean and where appropriate, able to be disinfected.
- Depending on the nature of the food operations undertaken, adequate facilities should be available for heating, cooling, cooking, refrigerating and freezing food, for storing refrigerated or frozen foods, monitoring food temperatures, and when necessary, controlling ambient temperatures to ensure the safety and suitability of food.

Requirements for foodstuffs

- When surplus food is redistributed, end beneficiaries must have access to the same information that is required and provided when food is purchased in store. The minimum essential information on the label must be the following: identification of the food product identification; identification of food business operator; minimum durability date (“best

before") or "use by" date; the list of ingredients, including allergen information; and storage conditions.

- Food products shall not evidence signs of spoilage.
- Foods need to be stored at adequate temperatures:
  - -18 ºC Frozen foods
  - 4 C Poultry meat, fish and refrigerated meals with a shelf life of more than 24 hours
  - C Fresh pork, veal and lamb
  - 8 C Refrigerated meals with a shelf life of less than 24 hours
  - 6 C Hot meals
- Unpackaged food must be protected with packaging that insulates it from outside contamination.

To know more

(1) Food composition

Proteins

Proteins are polymers of amino acids linked via -peptide bonds. When consumed, proteins are digested in the gastrointestinal tract, absorbed as small peptides and free amino acids, and then used for the resynthesis of proteins in cells. Nine amino acids are considered nutritionally indispensable or essential in humans because the body is not able to synthesize them: leucine, valine, isoleucine, histidine, lysine, methionine, threonine, tryptophan, and phenylalanine (Watford and Wu, 2018).

Meat, seafood, eggs, and milk are all considered excellent sources of high-quality protein. Some plant-based foods, most notably legumes such as beans, peas, and lentils, but also nuts, seed and soy products do contain substantial amounts of this macronutrient (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015; Watford and Wu, 2018).

Lipids

Lipids comprise a group of polar and nonpolar compounds, that includes triglycerides, diglycerides, monoglycerides, fatty acids, phospholipids, and sterols (such as cholesterol). Lipids have many roles in the organism including a source of readily available and stored energy, a structural and functional component of all cell membranes in addition to helping with the absorption of fat-soluble vitamins and other food components (Field and Robinson, 2019).

Triglycerides comprise 90–95% of the lipids in the diet and body. A triglyceride is composed by three fatty acids linked to a glycerol molecule. The three types of fatty acids that compose triglycerides are saturated, monounsaturated and polyunsaturated fatty acids (e.g. omega-3 and omega-6). The ingestion of saturated fats must be avoided because they are the main reason of high LDL cholesterol (or bad cholesterol) levels in the organism. This type of fats are found in many animal products such as butter, cheese, whole milk, ice cream, cream and fatty meats as well as in some vegetable oils such as palm and coconut oils. Eating unsaturated fats can help lower blood cholesterol. Foods with high levels of monounsaturated fats include vegetable oils such as olive oil, canola oil, peanut oil and sesame oil, avocados, and a variety of nuts and seeds. Foods that contain polyunsaturated fats include many vegetables oils and fatty fish such as salmon, mackerel, herring and tuna.

Carbohydrates

Carbohydrates are the body’s main source of energy, and are subdivided into the following categories on the basis of the number of sugar units and how are chemically bonded to each other: sugars, starches, and fibres.

Sugars are intrinsic in diverse foods such as fruits and milk products, but also are added to sweeten foods and beverages to improve their palatability.

Many sugar-added food products provide calories but insignificant amounts of vitamins, minerals or other essential nutrients. Complex carbohydrates, called polysaccharides, include starches and fibre. Starches are found in many foods, including vegetables, legumes, and grains. They are broken down during digestion to form sugars that provide energy. Fibre, that is present in all plant foods, unlike most starches, cannot be broken down by digestive enzymes and pass relatively intact into the large intestine.

Vegetables, fruits, whole grains, milk, and milk products are the major food sources of carbohydrates (Slavin and Carlson, 2014).

Vitamins and minerals

Vitamins are organic dietary constituents that are divided into two categories: water soluble, which means the body expels what it does not absorb, and fat soluble where leftover amounts are stored in the liver and fat tissues as reserves. The water-soluble vitamins are the eight B vitamins (B-1 or Thiamin, B-2 or Riboflavin, B-3 or Niacin, B-5 or Pantothenic acid, B-6 or Pyridoxine, B-7 or Biotin, B-9 or Folic acid, and B-12 or Cyanocobalamin) and vitamin C. The fat-soluble vitamins are A, D, E, and K (Costa-Pinto and Gantner, 2020).

Minerals are inorganic substances that are divided into major minerals (macro-minerals) and trace minerals (micro-minerals). Major minerals are calcium, magnesium, potassium, sodium, chloride, phosphorus and sulphur, while trace minerals are iodine, zinc, selenium, iron, manganese, copper, cobalt, molybdenum, fluoride and chromium (Gharibzahedi and Jafari, 2017).

A broad healthy diet ensures to get a variety of vitamins and minerals, and in the proper amounts. This involves an emphasis on fruits and vegetables, whole grains, beans and legumes, low-fat protein, and dairy products.

(2) Factors affecting food spoilage

Intrinsic factors

Food structure and composition

In general, microorganism can easily grow in fluid and semi-solid foods that rapidly spoil as compared to solid foods than tend to spoil from their outside surfaces inwards, these being the first surfaces to become contaminated (Petruzzi et al., 2017).

Additionally, most solid and semi-solid foods (sausages, margarine, etc.) do not have a homogeneous and uniform structure. Therefore, the physical and chemical factors influencing microbial growth and also chemical and

biochemical reactions, can vary according to the location in the food (Man, 2004).

As for food composition, many examples of how it influences food spoilage can be cited. As examples, a high content of acetic acid in pickled food and non pasteurized sauces provides stability and prevents from microbial growth whereas the fat content of butter and margarine also prevents microbial spoilage.

Apart from that, different agents either naturally present in foods or formed or added during processing, have been assessed for their efficacy against chemical reactions and microorganisms conducting to food spoilage. Some examples of chemical agents commonly used in the food industry are organic acids, sodium or potassium salts. Plant extracts as clove, mint, oregano, rosemary, and thyme as well as spices have demonstrated to have antimicrobial and antioxidant properties (Burt, 2004; Tajkarimi et al., 2010).

Water activity

The lowest aw at which the vast majority of food spoilage bacteria will grow is about 0.90. Yeasts and molds can grow in foods with lower water activity, above 0.85 and 0.80 respectively, with the lower limit for growth of osmotolerant species of 0.60 (ICMSF, 2002).

pH (hydrogen ion concentration, relative acidity or alkalinity)

The pH range of a microorganism is defined by a minimum value (at the acidic end of the scale) and a maximum value (at the basic end of the scale) at which it may grow. The optimum growth pH is the most favourable pH value for the growth of a microorganism. Moving away from this value in either direction slows microbial growth. Acidification of food may be carried out by direct addition of organic and other appropriate acids but also by fermentation process as in yoghurt manufacturing.

It is important to take into account that food may start with a pH value that precludes bacterial growth, but as a result of the metabolism of other microbes (yeasts or molds), pH shifts may occur and permit bacterial growth (FDA, 2012).

Redox potential

Redox potential generally represents how easily a substrate loses or gains electrons. Oxidation involves the loss of electrons; an element or compound losing electrons oxidizes. Oxidation also occurs when an element or compound reacts with oxygen. Therefore, the availability of oxygen affects the oxidation-reduction (redox) (Eh) in a food product.

Despite of aerobic and anaerobic microorganism, there are others capable of aerobic respiration in the presence of oxygen or fermentation in the absence of oxygen. They are facultative anaerobe. In addition,

microaerophilic microorganism require low concentrations of oxygen for growth.

Extrinsic parameters

Temperature

Values for microbial growth, have a minimum and maximum range with an optimum temperature for maximal growth. The optimum growth temperature determines its classification as a thermophile, mesophile, or psychrophile. The rate of growth at extremes of temperature determines the classification of an organism (e.g., psychrotroph, thermotroph) (FDA, 2012).

(3) Food spoilage mechanisms

Physical spoilage

Moisture transfer can cause changes in **glass transition temperature (Tg)** a property that reflects the level of molecular mobility in food. It significantly affects the stability and shelf life of food products. In terms of molecular structure, there are three forms of powders: crystalline, amorphous, and the mixture of the two. The amorphous matrix may exist either as a very viscous glass or as a more liquid-like rubber. Tg is the temperature range where food polymers undergo a phase change from rigid/glassy to rubbery or soft. Many low-moisture foods, including sugar-based products such as hard candy, dried products as milk and whey powder, starch-based products like bread or crackers and frozen foods are in the amorphous metastable state. These foods can be in an amorphous glassy state or an amorphous rubbery state, depending on temperature and moisture content. Increase in temperature can cause transition of a food from a glassy to a rubbery state. Changes in water content also affect this parameter. As example, dry food products such as crackers are expected to be crisp. However, it they are stored in a high humidity environment, they will absorb water (lowering Tg) and undergo glass transition to become tough and soggy. Conversely, soft bakery products are expected to be moist and chewy; however, these products tend to lose moisture (raise Tg) to the point where they undergo glass transition and become glassy, hard and brittle (Kong and Singh, 2016; Singh and Anderson, 2016; Amit et al., 2017). Another effect of glass transition is caking of dry powders when gaining moisture.

Crystallisation

This process consists of two main successive stages; nucleation and crystal growth. The interaction between these two steps determines the crystal characteristics. In many products, the goal of crystallization is to generate a certain texture or appearance that makes the product acceptable. Thus, nucleating many crystals that remain small within the product itself is often the goal. The crystals also must have the proper shape and/or polymorph to enhance stability of the product during storage and distribution (Hartel, 2002). However, crystallization is undesired in others. This is the case of foods with a high sugar content that can undergo sugar crystallization either

by moisture accumulation or by increasing temperature. As a consequence, sugar comes to the surface from inside, and a grey or white appearance is noticed (Amit et al., 2017). Additionally changes in the crystal structure in terms of shape, size and crystal size distribution may result in undesired texture and sensory properties of food. Therefore, large ice crystal growth during freezing process can also contribute to food degradation. Different techniques may be used to prevent crystallization or to avoid changes in crystalline structures that may occur during freezing and storage.

Chemical spoilage

Oxidation

Lipid oxidation is one of the most common spoilage reactions in oils and foods containing fats such as nuts, fried foods, meats or milk powder resulting in non desirable rancid odours and flavourings. The **oxidative rancidity** is a free radical chain reaction that involves abstraction of a hydrogen from the fatty acid chain followed by a series of reaction with oxygen, rearrangements, and chain cleavage. Fat is oxidized and decomposes into compounds with shorter carbon chains such as fatty acids, aldehydes, and ketones all of which are volatile and contribute to the unpleasant smelling compounds. Oxidative rancidity leads also to the formation of toxic compounds

Because of the 'spontaneous' nature of the reaction the process is frequently referred to as autoxidation. Rancidification can be catalysed by the presence of metal oxides and exposure to light increases the reaction rate.

Oxidation also affects other food components such as pigments, leading to changes in colour, as is the case of fresh meat by the oxidation of oxymyoglobin and myoglobin to produce metamyoglobin. The sensitivity to oxygen of some vitamins, such as vitamins C (L-ascorbic acid) and B1 (thiamine) or the fat-soluble A and E vitamins, can lead to a decrease in the nutritional food value.

Hydrolysis

Hydrolytic rancidity causes lipid degradation by the action of lipolytic enzyme lipases catalysing lipolysis. This reaction implies the cleaving of free fatty acids from triglyceride molecules in the presence of water. These free fatty acids have rancid flavours or odour. The released volatile free fatty acids have shorter chain lengths, and sometimes stiff mal odour and taste.

Hydrolytic rancidity mainly affects products containing lauric oils such as palm and coconut oils. The fatty acids released include capric, lauric and myristic acids, which have a differential soap aroma. For this reason it may also called soap rancidity. Lipases are also found in cereals and milling products that may also suffer from this spoilage process.

Non-enzymatic browning

Non-enzymatic browning, is an extremely complex process and is the reaction between reducing sugars and proteins by the impact of heat. The Maillard reaction also takes place at room temperature but at a much slower rate and occurs at its slowest by low temperatures, low pH, and low aw levels.

Colour darkening, reducing proteins solubility, developing bitter flavours, and reducing nutritional availability of certain amino acids are the common outcomes of Maillard reaction. It is also responsible for the development of harmful compounds.

Microbial food spoilage

Bacteria

Bacteria related to food spoilage are divided for convenience into broad categories (Huis in't Veld, 1996):

- Gram-negative rod shaped bacteria: Most raw or fresh foods are typically spoiled by the growth of Pseudomonas spp., during aerobic storage producing slime and odours as the main signs of spoilage. Aeromonas, Photobacterium, Shewanella and Vibrio may also grow rapidly at chill temperatures and spoil foods. At a temperature above 5- 10°C enterobacteriaceae generally dominate over Pseudomonas spp. and become responsible for spoilage.

- Gram-positive spore forming bacteria, capable of surviving the pasteurization process may be significant in food spoilage. This includes aerobic Bacillus spp. Best recognised B. cereus may grow at low temperatures (5 °C or less) and produce enzymes which result in 'sweet curdling' and 'bitty cream' in milk. Clostridium spp. do not usually grow at refrigerator temperatures (i.e. 5°C or less), but at slightly higher temperatures may produce gas resulting in 'late blowing' of hard cheeses during maturation.

- Lactic acid bacteria (LAB), encompassing Lactococcus, Lactobacillus, Leuconostoc, Weissella, and Carnobacteria species, are frequently associated with spoilage. Undesirable changes caused by LAB include greening of meat and gas formation in cheeses (blowing), pickles (bloater damage), and canned or packaged meat and vegetables (Petruzzi et al., 2012)

- Other Gram-positive bacteria. Brochotrix thermosphacta may be occasionally present on fresh meats. The increased use of modified atmosphere packaging and vacuum packaging will often allow this microorganism to dominate the microflora. Micrococcus spp are able to grow in the presence of salt and may be responsible for the spoilage of

cured meat products such as bacon producing slime, souring or pigmented growth. These microorganisms also often predominate in freshly collected milk.

Fungi

Fungi frequently linked to spoilage of foods and beverages, and mainly fruits and fruit-based products, include Aspergillus, Mucor, Penicillium, and Rhizopus species. With reference to yeasts, in view of the wide diversity of taxa and the frequently ambiguous character of yeast taxonomy, correct identification of species is often a challenge. Nevertheless, the yeast species that have primarily been associated with spoilage of products such as soft drinks, syrups, dips, salad dressings, and olives, are members of the genera Candida, Lachancea, Saccharomyces, Torulaspora, and Zygosaccharomyces. Yeasts may also contribute to the spoilage of foods of animal origin such as meat and dairy products, albeit to a much lesser extent compared to bacteria (Lianou et al., 2016).

(4) Food hazards

Biological hazards

According to WHO (2020), the major foodborne diseases causes are named bellow:

- Bacteria: *Salmonella*, *Campylobacter*, and *Enterohaemorrhagic Escherichia coli* are among the most common foodborne pathogens that affect millions of people annually, sometimes with severe and fatal outcomes. In particular, campylobacteriosis has been the most commonly reported zoonosis in the European Union since 2005, representing 50% of all the reported cases whereas *Salmonella* remained the most detected agent in the foodborne outbreaks reported (EFSA and ECDC, 2021). Raw milk, raw or undercooked poultry and drinking water are the foods mainly involve in foodborne cases with *Campylobacter*. Examples of foods involved in outbreaks of salmonellosis are eggs, poultry and other products of animal origin.

- Disease occurrence from *Listeria monocytogenes* is relatively low though it may have severe and sometimes fatal health consequences, particularly among infants, children and the elderly. This microorganism can grow at refrigeration temperatures and it is found in unpasteurised dairy products and various ready-to-eat foods.

- Most common viruses infections are caused by norovirus or hepatitis A virus often being food handlers the source of food contamination.

- Parasites such as *Anisakis* spp. are only transmitted through food while others as *Taenia solium*, may also infect people through direct contact with animals. *Cryptosporidium*, *Entamoeba histolytica* or *Giardia*, enter the food chain via water or soil and can contaminate fresh produce.

Evaluation section

1. | Multiple choice questions

1. Food quality assurance along the food chain rely on:
a) primary production stage
b) food industry
c) consumers
d) all statements are true

2. Say what is true regarding food chains nowadays.
a) have been simplified thanks to technology
b) due to globalization are all the same worldwide
c) decisions made at any stage have implications for others
d) don't rely on primary production stage

3. Say what is true with regards to perishability of food:
a) deterioration of food is mainly dependent on food factors
b) sugar and flour are examples of perishable food
c) perishable products usually have a high water content
d) semiperishable food products may be preserved up to several days

4. Choose the false statement related with nutrition and food composition:
a) Nutrients are classified into macronutrients (proteins, lipids and carbohydrates) and micronutrients (vitamins and minerals)
b) Eating saturated fats can help lower blood cholesterol
c) Declaration of saturated fats is mandatory in the nutritional food label
d) Processes that expose foods to high levels of heat cause a great nutrient loss

5. Say what is true regarding to food spoilage:
a) it always represents a risk for human health
b) food composition is a key parameter in relation to food spoilage
c) physical injury is possibly the most important cause of loss in meat and fish
d) bacterial spoilage of butter is of concern

6. Say what is true regarding chemical spoilage:
a) exposure to light increases lipids rancidity
b) enzymatic browning of apples is known as Maillard reaction
c) lowering sweetness in carbonated drinks with aspartame is due to oxidation processes
d) maillard reaction is an undesirable reaction in cooked meat

7. Say what is true regarding microorganisms:
a) they grow easier in solid foods compared to fluids

b) acidification enhance microbial growth
c) growing of microorganisms is not possible at low concentrations of oxygen
d) yeasts and molds can grow in foods with lower water activity than bacteria do

8. Regarding food spoilage say what is not true:
a) enzymatic browning take place in heat treated food
b) moisture exchange is as well a frequent cause of changes in texture of food
c) chilling injury generally occurs at temperatures of 5-15 ºC
d) hydrolytic rancidity is also called soap rancidity

9. Say what is not true. The rate of microorganism grow in food depends on:
a) pH value
b) temperature
c) food composition
d) lipid oxidation

10. Say what is true about food safety hazards
a) processing technologies are used to destroy chemical hazards in food
b) contaminants are hazards not intentionally added to food
c) disease occurrence from Listeria monocytogenes is high
d) chemical hazards are responsible for most of foodborne illness outbreaks

11. Regarding food labelling, indicate the false statement:
a) The indication of the lot to which a foodstuff belongs facilitates traceability
b) Allergens shall be emphasised on the food label
c) It is important to observe in the food label the storage conditions and/or time limit for consumption once the package is opened
d) “Best before” and “Use by” dates mean the same

12. Regarding food processing technologies, say what is true:
a) UHT pasteurized products have a longer shelf life than other pasteurized products
b) freezing kill microorganisms
c) factors controlling food safety greatly differ from those controlling food spoilage
d) adding salt or sugar to food is a common method of biological preservation of food products

13. Which of the following is the correct statement regarding “Best before” date:
a) It refers to quality rather than safety. The food will be safe to eat after this date but may not be at its best
b) The food will not be safe to eat after this date

c) It is appropriate for foods which, from a microbiological point of view, are highly perishable
d) It will be marked on food that goes off quickly, such as ready-to-eat salads

14. What temperature should your fridge be at?
a) 0-5 °C
b) -2- 2 °C
c) -2-8 °C
d) 5-10 °C

15. What temperature should your freezer be at least?
a) -6 °C
b) -12 °C
c) -18 °C
d) 25 °C

16. Choose the correct statement:
a) Shelf-life studies are only focused on microbiological analysis of foods
b) The nutritional declaration Nutri-Score is mandatory in all food labels
c) Food donation or food redistribution is part of the strategy to reduce food waste
d) Foods suitable for food donation may include those products that have passed the “used by” date

17. The “Use by” date…
a) It should be applied on foods which are highly perishable
b) After the ‘use by’ date a food shall be deemed to be unsafe and must not be eaten
c) It shall be followed by a description of the storage conditions of the food product which must always be observed
d) All statements are true

18. Which of the following definitions is wrong:
a) Open life is the period of time during which a food will remain safe and suitable for consumption from its production until packaging
b) Nutrient reference values (NRVs) are a set of values used in nutrition labelling derived from authoritative recommendations for daily nutrient intake
c) Lot means a batch of sales units of a foodstuff produced, manufactured or packaged under practically the same conditions
d) Traceability means the ability to trace and follow a food, feed, food-producing animal or substance intended to be incorporated into a food or feed, through all stages of production, processing and distribution

19. Which is the proper temperature for the redistribution of hot meals?
a) At least 40 ºC
b) 20 ºC

c) < 4 ºC
d) 6 C

20. The “Use by” date is appropriate in the labelling of:
a) Canned fish
b) Minced meat
c) Breakfast cereals
d) Dry-cured ham

2. | Activities/optional exercises

- Choose five food labels and justify the meaning of the "Best before" or "Used by" date marked. Indicate which information appear in each food label that will help the consumer to prevent food waste.

3. | Multiple choice answers

1	d	**6**	a	**11**	d	**16**	c
2	c	**7**	d	**12**	a	**17**	d
3	c	**8**	a	**13**	a	**18**	a
4	b	**9**	d	**14**	a	**19**	d
5	b	**10**	c	**15**	c	**20**	b

Key concepts and vocabulary

Customary name means a name which is accepted as the name of the food by consumers in the Member State in which that food is sold, without that name needing further explanation.

Date of minimum durability of a food means the date until which the food retains its specific properties when properly stored;

Descriptive name means a name providing a description of the food, and if necessary of its use, which is sufficiently clear to enable consumers to know its true nature and distinguish it from other products with which it might be confused.

Food includes drink, chewing gum and any substance, including water, intentionally incorporated into the food during its manufacture, preparation or treatment. It includes water after the point of compliance as defined in Directive 98/83/EC. 'Food' shall not include: (a) feed; (b) live animals unless they are prepared for placing on the market for human consumption; (c) plants prior to harvesting; (d) medicinal products (2); (e) cosmetics; (f) tobacco and tobacco products; (g) narcotic or psychotropic substances; (h) residues and contaminants (Regulation (EC) No 178/2002).

Food business means any undertaking, whether for profit or not and whether public or private, carrying out any of the activities related to any stage of production, processing and distribution of food.

Food business operator means the natural or legal persons responsible for ensuring that the requirements of food law are met within the food business under their control.

Food information means information concerning a food and made available to the final consumer by means of a label, other accompanying material, or any other means including modern technology tools or verbal communication.

Food redistribution is a process whereby surplus food that might otherwise be wasted is recovered, collected and provided to people, in particular to those in need.

Labelling means any words, particulars, trade marks, brand name, pictorial matter or symbol relating to a food and placed on any packaging, document, notice, label, ring or collar accompanying or referring to such food.

Legal name means the name of a food prescribed in the Union provisions applicable to it or, in the absence of such Union provisions, the name provided for in the laws, regulations and administrative provisions applicable

in the Member State in which the food is sold to the final consumer or to mass caterers.

Lot means a batch of sales units of a foodstuff produced, manufactured or packaged under practically the same conditions.

Microbiological criterion means a criterion defining the acceptability of a product, a batch of foodstuffs or a process, based on the absence, presence or number of microorganisms, and/or on the quantity of their toxins/metabolites, per unit(s) of mass, volume, area or batch.

Microorganisms are microscopic organisms as bacteria, viruses, yeasts, moulds, algae, parasitic protozoa or microscopic parasites.
Nutrient loss refers to the nutrient content embedded within food losse and food waste.

Nutrient reference values (NRVs) are a set of values used in nutrition labelling derived from authoritative recommendations for daily nutrient intake. These recommendations are based on best available scientific knowledge of the daily amount of energy or nutrient needed for good health.

Open life is the period of time during which a food will remain safe and/or of a suitable quality for consumption after the primary product packaging has been opened and it is stored as instructed.

Prepacked food means any single item for presentation as such to the final consumer and to mass caterers, consisting of a food and the packaging into which it was put before being offered for sale, whether such packaging encloses the food completely or only partially, but in any event in such a way that the contents cannot be altered without opening or changing the packaging; 'prepacked food' does not cover foods packed on the sales premises at the consumer's request or prepacked for direct sale.

Principal field of vision means the field of vision of a package which is most likely to be seen at first glance by the consumer at the time of purchase and that enables the consumer to immediately identify a product in terms of its character or nature and, if applicable, its brand name. If a package has several identical principal fields of vision, the principal field of vision is the one chosen by the food business operator.

Ready-to-eat food (RTE) means food intended by the producer or the manufacturer for direct human consumption without the need for cooking or other processing effective to eliminate or reduce to an acceptable level microorganisms of concern.

Shelf-life is the period in which a food remains safe to consume and/or retains its quality in reasonable foreseeable distribution, storage and usage conditions.

Traceability means the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution.

Useful resources

Useful resources

https://www.eufic.org/en/healthy-living/article/understanding-nutrition-information-infographic

https://ec.europa.eu/food/system/files/2016-10/labelling_legislation_infographic_food_labelling_rules_2014_en.pdf

https://ec.europa.eu/food/safety/labelling_nutrition/labelling_legislation_en/food_labelling_information_system/start/select-countries

http://www.fao.org/3/Y4358E/y4358e00.htm

https://www.who.int/publications/i/item/9789241594639

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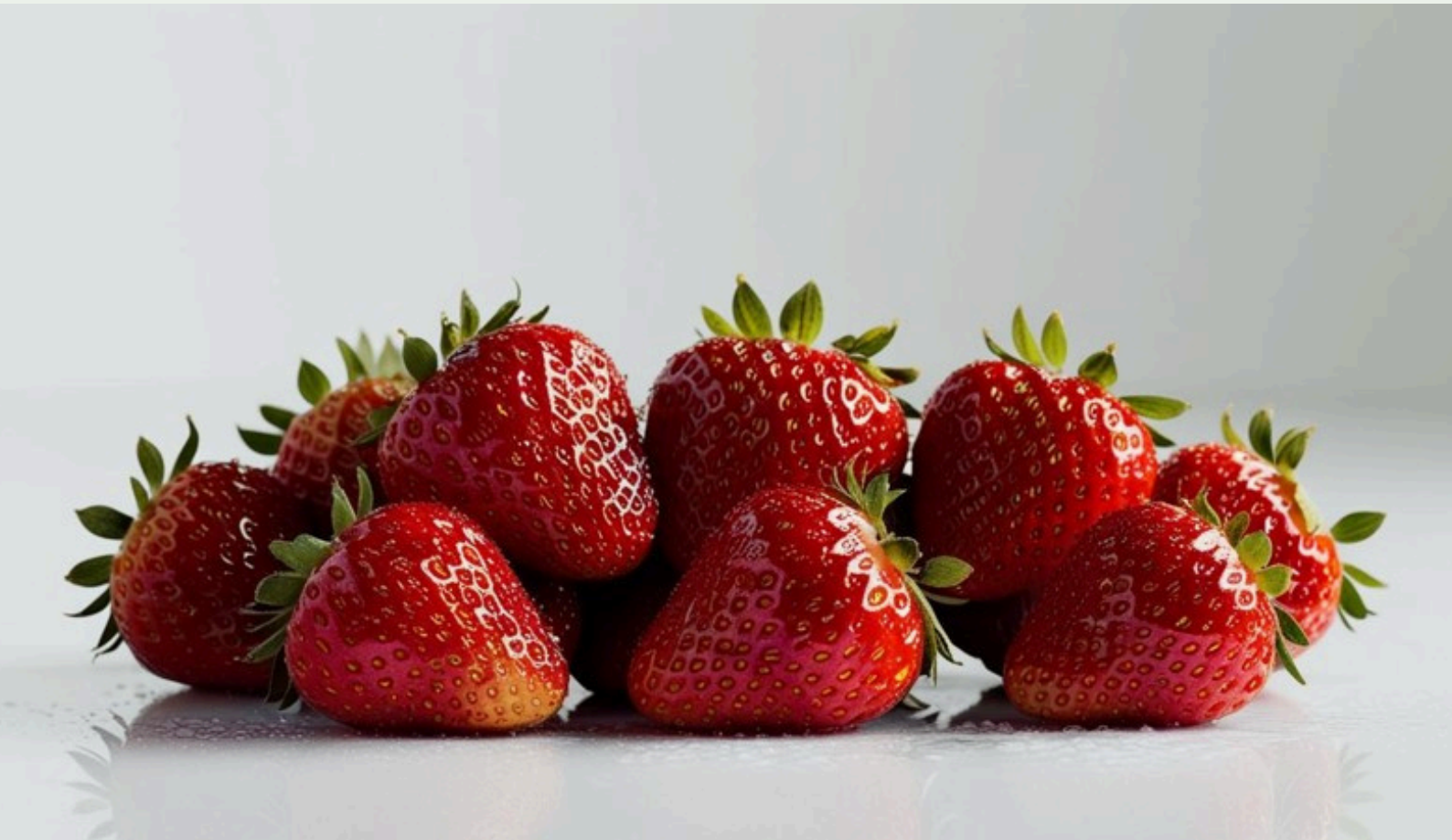
Zero WASTE

AWARENESS FOR THE REDUCTION OF FOOD WASTE

MODULE 2B: KNOWLEDGE

Sales and consumption aspects and their relationship to food waste



Instituto Universitario de Investigación Mixto Agroalimentario de Aragón
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Universidad Zaragoza

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General information. Module 2B KNOWLEDGE

Title:
Sales and consumption aspects and their relationship to food waste

Authors:
Mª Teresa Maza and Pilar Uldemolins

Duration:
6 hours – The duration of this module is four hours of the lesson and two hours the practice of the exercises.

Introduction:
This module describes different factors related to consumer behaviour that influence food waste. First, it is established that the concept of food waste is related to the latest stages of the Food Supply Chain (FSC) and it is generally associated to retailers and consumer's behavioural issues. The main sections of the chapter address consumer behaviours that influence food waste at household level, factors that determine food waste away from home, and finally the types of waste that occur in the distribution and sale of food.

Understanding consumers' attitudes, values and behaviours towards food would contribute to find the underlying motivations and behaviours of food wastage. That knowledge can help policymakers or social marketers in finding effective solutions and initiatives against it.

Learning outcomes
On successful completion of Module 2B participants should be able to…

Knowledge
- Understand consumer motivations and behaviours that lead to food waste in the household.
- Know the factors that influence food waste in extra-domestic consumption.
- Recognize the types of waste that occur at distribution level and business strategies that can cause the most waste.

Technical skills
- To recognize all those psychological factors, lifestyles, habits and socio-demographic variables that determine food wasting behaviour both at household level and away from home.
- To adopt a more critical attitude towards commercial distribution practices that lead to greater food waste.

Soft skills
- Increasing consumer awareness of the serious problem of food waste
- To reflect on how our individual behaviour can be part of the solution.

Main contents

1.| Waste or loss, where consumer can make a difference?

Food losses and waste represent a severe issue that is compromising our planet's sustainability. Every year over one-third (around 1,300 million tons per year) of global food production get lost or wasted along the food supply chain (FSC) causing economic, environmental and social impacts (Gustavsson et al., 2011, p.56 cited by UNEP, 2021). Reducing these losses could bring important benefits for all:

- it could save money for farmers, companies and people
- it could alleviate hunger, save water and land
- it could reduce the global greenhouse gases emissions and consequently climate change impacts.

Europe generate around 14% of these losses, what means almost 90 million tons of food that have an approximate value of 143.000 million euros. Looking at the absolute numbers, the countries with a larger wastage compared to those around them are United Kingdom, Germany, The Netherlands, France, Poland, Spain and Italy (Lorenzo, 2020).

Due to the importance and magnitude of the phenomenon, the reduction of food losses and waste has been included within the 17 Sustainable Development Goals (SDGs) promoted by the UN for the Agenda 2030 with the aims of ending poverty, protecting the planet and to ensure wealth for all. In particular, the SDG 12-Ensure sustainable consumption and production patterns, includes the food waste issue in its third target: "by 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" (SDG 12.3, UN, 2015).

Figure 1. The 17 Sustainable Development Goals (SDGs).

European citizens throw away an average of 20% of the food they purchased (Lorenzo, 2020). Before explaining how consumers' behaviours influence food waste, it is necessary to distinguish between food losses and food waste

and stablish in which of them consumers can play a role. Up to this point, we have spoken of them indistinctly; however, they are not synonyms, although there is no unanimity in their definitions.

The FAO has proposed that food losses occurs during the first stages of the FSC, usually referring to the decrease in the food quantity or quality (pests and diseases, limited harvesting techniques, price volatility), which makes it unfit for human consumption. Food waste is related to the latest stages of the FSC and it is generally associated to retailers and consumer's behavioural issues (Griffin et al., 2009; Parfitt et al., 2010; Gustavsson et al., 2011). Some authors include the intentionality dimension to these definitions and refer to food loss as the accidental reduction in the quantity and quality of food before consumption whilst food waste is defined as the intentional discard of food suitable for human consumption (Santeramo, 2021). See Figure 2.

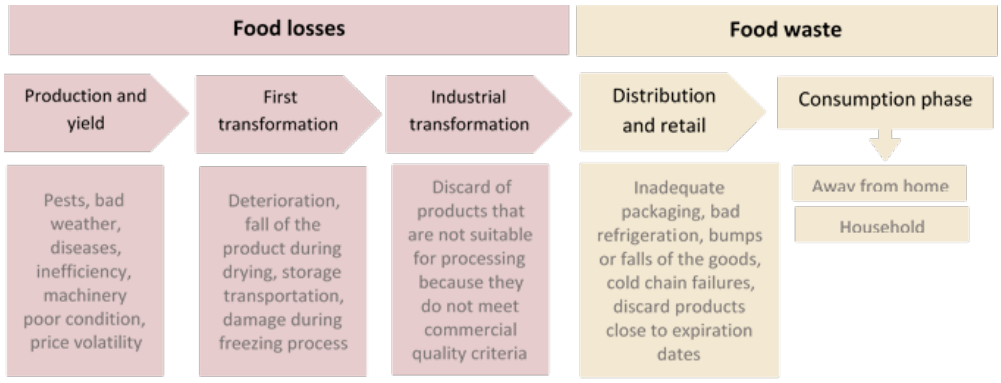

Figure 2. Stages of food losses and food waste and causes.
Source: own elaboration from Principato (2018); Cleva and Casares (2017).

Another FAO definition links food waste only to consumer level and food losses to any stage before the consumer level, regardless of the real underlying explanatory cause. This definition does not consider food waste as the losses that occur at retail and distribution level, but only focus on the food purchased by the consumer's within any type of store, restaurant, or catering service, and was not eaten.

The most recent classification by the United Nations in their report Food Waste Index (UNEP, 2021), make a distinction in their definition of "food waste" between food and the inedible parts removed from the human food supply chain at retail, food service and household levels. These inedible parts are supposed to end in the following destinations: landfill; controlled combustion; sewer; litter / discards / refuse; co / anaerobic digestion; compost / aerobic digestion; or land application. See definitions in Figure 3.

Definitions

- **Food waste**: appropriate food for human consumption discarded or left to spoil at retailer or consumer level -regardless of the cause.
- **Food losses**: a decrease of food, originally intended for human consumption, at all stages of the food chain prior to retailer and consumer level, regardless of the cause.
- **Food**: any substance –whether processed, semi-processed or raw – that is intended for human consumption. It includes drink, and any substance that has been used in the manufacture, preparation or treatment of food.
- Food waste includes:
    - Edible parts: parts of food that are intended for human consumption.
    - Inedible parts: components associated with food that are not intended to be consumed by humans. For example, bones, rinds and pits/stones.

We will focus on the food waste issue as defined by UNEP (2021) that consider food waste occurring at retail and consumption level, and is divided into household and away from home consumption (see Fig. 4).

The avoidable and possibly avoidable food waste, represent the largest amount in volume of food waste generated by household (WRAP, 2009b; WRAP, 2013a) and it is mainly caused by consumer's attitudes and behaviours (Parfitt et al., 2010; Principato et al., 2015).

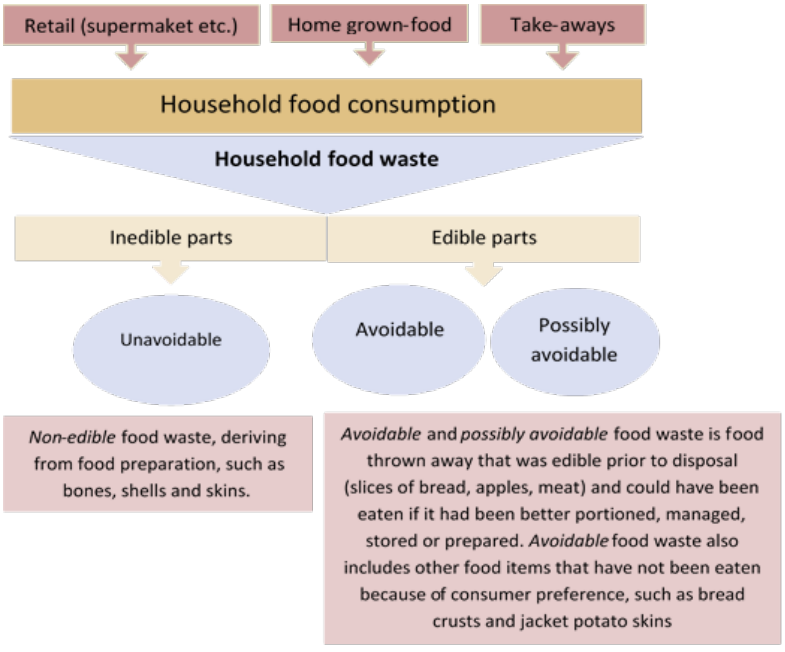

Figure 4. Origin of food consumption and distinguishable parts of food waste.
Source: Own elaboration from Waste Resources Action Programme-WRAP, 2013b, p. 4; WRAP, 2009a; Parfitt et al., 2010.

Considering the away from home definitions we will focus on avoidable and possibly avoidable food waste that occurs in:

(i) The restaurant industry, which includes restaurant, bars and cafeterias that offer table service.

(ii) Catering services, that is food served within private or public canteens, catering and hotels.

(iii) Counter service and fast food.

In particular, food waste in the away from home phase occurs at two levels: preparation and service (or consumption phase) (Risku-Norja et al., 2010; Papargyropoulou et al., 2016). Therefore we consider food waste as the avoidable and possibly avoidable food discarded during the preparation/processing of the meals as well as spoilage and expiration, and also food wasted from the client's plate (food scraps or leftovers) (Marthinsen et al., 2012; Pirani and Arafat, 2015).

2.| Consumer behaviours that influence food waste at household level:

The UNEP's first Food Waste Index report estimates that around 931 million tonnes of food waste was generated in 2019, 61% of which came from households, 26% from food service and 13 % from retail (Figure 5). This suggest that 17% of global food production may be wasted (11% in households, 5% in food service and 2% in retail).

Figure 5. Percentages of food waste generate in household, food service and retail.

Household per capita food waste generation is broadly similar across country income groups, suggesting that action on food waste is equally relevant in high, upper-middle and lower middle-income countries. This diverges from earlier narratives concentrating consumer food waste in developed countries, and food production, storage and transportation losses in developing countries (UNEP, 2021).

Understanding consumers' attitudes, values and behaviours towards food, contribute to find the underlying motivations and behaviours of food wastage. That knowledge can help policymakers or social marketers in finding effective solutions and initiatives against it.

Several researchers have started to study food waste from a behavioural perspective using the Theory of Planned Behaviour proposed by Azjen in 1991 (Graham-Rowe et al., 2014; Block et al., 2016; Mondejar-Jiménez et al., 2016; Stancu et al., 2016; Visschers et al., 2016). According to this theory, intentions are good predictors of human behaviour, and can be influenced by three important factors: subjective norms, perceived behavioural control and attitudes.

Food waste is considered under individual control when consumers are conscious of why they waste food (they have the intention to reduce food waste) and on the other hand, it is considered unintentional when there is

underlying factors like habits or emotions that make consumer unaware of food waste (Block et al., 2016; Russell et al., 2017).

Principato (2018) took into consideration the consumer decision making process and modified it according to food waste peculiarities. Indeed, some individual's factors like psychological, social, situational, demographic and socio-economic can drive wasteful behaviour. These factors influence both wasteful behaviours and food management process: planning, pre-acquisition, acquisition, preparation, consumption and disposition. Principato (2018) called this process the household food waste journey (see Figure 7). Every phase of the household food waste journey could contribute to some extent to wasteful behaviour.

2.1 | Psychological Factors

Among these factors, we can cite some non-cognitive determinants of food waste behaviour like emotions and habits, but also food waste knowledge and food waste involvement, intended as the level of concern regarding its impacts.

a) Emotions

The emotional experience is determined by the meaning and value that the subject attributes to an event and it is not the event itself that activates the emotion (Amato, 2019). Emotions can be primary or secondary. Primary emotions are innate, all individuals, regardless of their culture, have the same primary emotions, which determine the same facial expressions (fear, anger, surprise, sadness, and disgust). Secondary emotions (resignation, forgiveness, envy, shame, jealousy, nostalgia) are more complex, they are built through social learning and interaction, and they are strongly influenced by culture and contexts (Amato, 2019). Emotions play an important role in driving food waste behaviour. Some authors have hypothesised that emotions can have an indirect and direct effect on behaviour because they provide a motivational impetus (Rusell, 2017). Researchers have found that, commonly, individuals associated negative emotions to food waste (anger, shame, disgust, sadness, anxiety). However, when consumers associate emotions like joy and gaiety to food waste that could be explained by the feeling of wealth that often is coupled to food abundance and it is seen as a necessary consequence of the abundance feeling. Some studies suggested that using guilt emotion as a motivational tool could promote pro-environmental behaviour (Amato, 2019). Social marketing has studied emotions as a mean to increase the intention to reduce food waste using messages framed with "gratitude for having" (Septianto, 2020).

b) Attitudes

Thoughts and feelings (e.g. guilt) towards food waste reflect how problematic a person finds to do or avoid it (van Geffen, 2016). In order to analyse attitude, it seems interesting to have a look into the study conducted by Aecoc (2019) in Spain. On it, they were analysed 32 attitudes toward food waste and planning. Sample consist of 2000 consumers that were classified

into five groups (see Figure 6): “food taster”, “food-waste generators”, “eco-friendly”, “price-driven”, and “re-users”. Each group showed different attitudes towards food waste. Food-waste generators had a higher perception of being throwing food away (50% vs. 30% sample mean). Re-users showed a higher positive attitude towards saving leftovers to cook other dishes compared to sample mean. Groups also presented differences in their habits. Re-users throw away less food (22% of them did not produce any food waste and 54% generated few food waste), while food-waste generators seems to be the highest food wasters. Food-waste generators did not consider safe the best before date (18% vs. 9% the rest of groups), so they throw food away once the recommended date was expired.

Another attitude explaining food waste is the idea of «throwing away is cheaper than reusing». When people think that food is not worth enough to be reuse or store beyond expiration date, food waste increase. Usually this group of food are fruit, vegetables, bread and precooked dishes (Cleva and Casares, 2017).

Figure 6. Consumer segments and food waste.

Taster

When they go grocery shopping, they buy more than they planned.
They think food is becoming more expensive
They don't like to cook
They don’t like to prepare recipes with leftovers
They like looking at new products in grocery stores
They try to indulge themselves every day

Food waste generators

They don't feel bad when they throw food away
They often have to throw out products from the pantry because they are out of date
They keep leftovers in the fridge but usually become spoiled and they have to throw them away
At home we throw out more food than they wish
At home they don't have time to cook
We usually cook more quantity than needed and if there are leftovers we throw them away
We buy food online more frequent

Eco-friendly

I prefer local products that have grown close to where I live
I am committed to collaborating with the problems of my community
I would be prepared to live with less
Promotions make me waste food
I follow a Mediterranean and traditional diet
I prefer to make small and more frequent purchases

Price driven

They have reduced the amount spent on food
When they go on excursions they take food from home
They don't like to cook
They don't like trying new flavors and products
They think that food is becoming more expensive

Reusers

Before throwing food away I think about it a lot
I prefer to make large and less frequent purchases
I like to try new recipes with the leftovers I have in the fridge
I try to save the leftovers to cook other dishes
More a more I look for offers in food

c) Perceived behavioural control

Perceived behavioural control is defined as the degree to which people perceive their ability, and the possibility to perform a particular behaviour. For example, “I am able to reduce my food waste”. Some recent work acknowledged attitudes and perceived behavioural control as predictor for consumer food waste behaviour (Principato et al., 2015; Visschers et al., 2016).

d) Food waste concern-awareness

Drawing on marketing field, two important psychological factors influencing the consumer purchase decision are product knowledge and product involvement.

- Product knowledge: people knowledgeable about food waste issues are more likely to avoid the phenomenon (Barr, 2007). Other research has shown that the more aware youths are about food waste the more likely it is that they can reduce their wasteful behaviour (Principato et al., 2015).

- Food waste involvement: individuals with high environmental and civic sense, waste less food (Barr, 2007; Parfitt et al., 2010; Williams et al., 2012).

Since food waste behaviour is also driven by more automatic and less-conscious routines, we should definitely take into account habits (Verplanken and Holland, 2002; Steg and Vlek, 2009;), as well as emotions (Triandis, 1977; Bamberg and Möser, 2007; Quested et al., 2013).

e) Social norms

According to the food waste literature (Graham-Rowe et al., 2014; Mondejar-Jiménez et al., 2016; Stancu et al., 2016; Visschers et al., 2016), social norms play an important role in influencing wasteful behaviour and the household food waste journey. For social norms we intend the social pressure to engage in a particular behaviour, or in other words, they represent the extent to which individuals perceive wasting food as a behaviour disapproved by people important for them (Lapinski and Rimal, 2005). For instance, “my family does not like to throw away food”.

These psychological factors not only influence wasteful behaviour directly, but also indirectly through their effect on some phases of the household food waste journey. To make an example, a greater awareness on the consequences of food waste phenomenon increases the likelihood that youths will draw a shopping list (Principato, 2018).

When individuals believe, throwing away food is wrong and does not match with their self-image, the amount of food they waste decreases. In addition, individuals who shop responsibly, and buy as much as they need, report less food waste (Aydin and Yildirim, 2021).

2.2 | Lifestyle and Habits

People often lack time to perform food waste preventing behaviours due to demanding lifestyles. They feel pressure to balance life goals such as raising children, work, social activities and housework. Researchers have found that experiencing time pressure is linked to higher waste levels (van Geffen, 2016). Food-related habits and practices play key roles in food provisioning and food waste generation (Aschemann-Witzel et al., 2021); here some of these habits and practices are listed:

- Meal as a social event: going out for lunch or dinner regularly and getting easy-to-cook or casual dinner with friends.
- Security and familiarity: only buy and eat foods that are familiar and dislike anything that might change eating habits.
- Self-fulfilment from cooking: the feeling of being an excellent cook and enjoying to create meals from scratch.

- Social relations via meals: for some people the most important thing when eating dinner is being together or having a lovely chat.
- Price-quality relation: comparing prices between product variants in order to get the best value for money.
- Convenience food: when ready-to-eat and frozen foods are a large part of the food products consumed at home.
- Ways for shopping behaviour and price criterion: some people appreciate packaging that keeps products hygienic and safe, or compare product appearance to decide which fruit and vegetables to buy or look for ads looking for store specials discounts.

In the Household Food Waste Journey presented by Principato (2018) and described below (Figure 7), they examined how food related habits could generate wasteful behaviour during the food management processes and pre-consumption routines at home.

Household Food Waste Journey

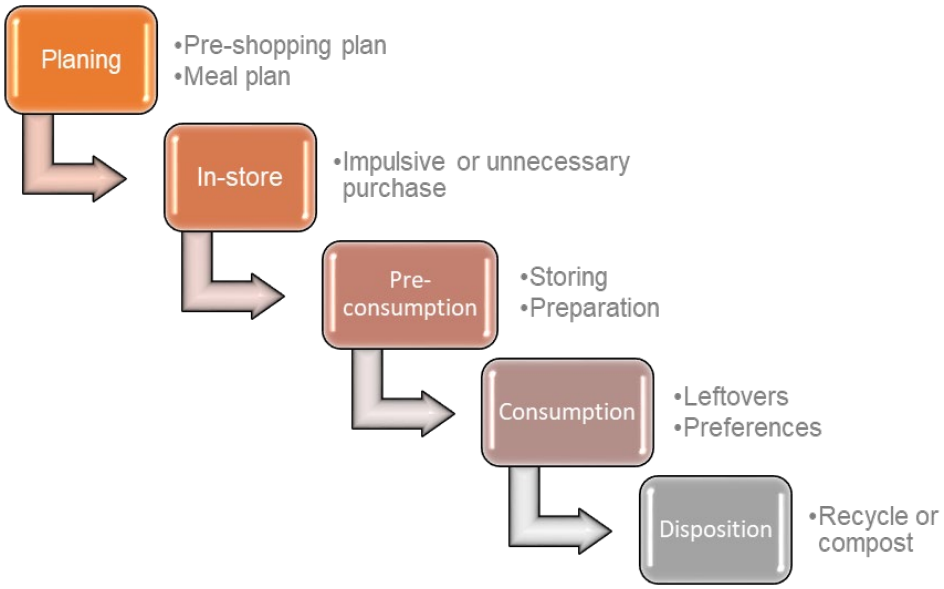

Figure 7. Stages of Household Food Journey.

Planning

The first phase of the household food waste journey is **pre-shopping planning**. The lack of it has demonstrated to influence wasteful behaviours (Exodus, 2006; Lyndhurst, 2007; Gustavsson et al., 2011), since it could result in buying more food than needed and therefore increasing the likelihood of spoilage (Chandon and Wansink, 2006; Quested et al., 2013). **Meal planning** is to decide what food to eat in a determined period (e.g. a week) and could be effective in reducing wasteful behaviour (Van Geffen et al., 2016). Checking storage spaces and doing a shopping list have demonstrated to be effective practice in reducing food waste (Stefan et al., 2013; Principato et al., 2015). Aecoc report (2019), which analysed motives

for conducting household food waste, indicate that the majority of respondents (70%) generated food waste due to the carelessness or laziness of checking the pantry or the fridge regularly.

In-store

This phase takes into account all the behaviours and influences at the point of purchase that drive consumer to waste food. In particular, impulsive purchases, which are often stimulated by marketing strategies result in an increase in food waste levels –like the 3 for 2 promotions that push the consumer to buy more than needed – (Exodus, 2006; Lyndhurst, 2007; Mondejar-Jiménez et al., 2016). The presence of children demanding unnecessary items, or the layout and positioning of foods in stores (visual merchandising strategies) may also influence wasteful behaviours (Exodus, 2006).

Pre-consumption

Principato (2018) divide this phase into two sub-phases: **storing** and **preparation**.

- Storing: correct storing prevents wasteful behaviours. Some people store products sub-optimally for healthy purposes, for example, certain parents use a bowl of fruit instead of putting it in the fridge in order to instil children healthy eating (Evans et al., 2012). The majority of people have a lack of knowledge on how to better store food to prolong its shelf life. Another example is that consumers are not aware of the different fridge shelves that they can effectively use in order to avoid food damage (Cox and Downing, 2007; Graham-Rowe et al., 2014; Aschemann-Witzel et al., 2015). The use by and best before dates has created confusion among consumers driving them to misinterpret date expiration labels (FSA, 2008; Cleva and Casares, 2017). Food safety fear is a top reason of wasteful behaviours (Neff et al., 2015). Therefore, food close to the expiration date is erroneously perceived as less acceptable for consumption (Wansink and Wright, 2006; Sen and Block, 2009). Another important aspect of food storage refers to the sensory skills, understood as the ability of people to understand the freshness of food using their taste, smell and touch. Elderly people tend to use more their senses in order to understand the edibility of a food, while youths rely more on date labels or the period of time the food has been stored for (Terpstra et al., 2005). The use of sensory skills to evaluate freshness is related to less waste. Aecoc report (2019) also confirm that most of respondents take decisions of wasting food based on physical and organoleptic evaluation of food products. The use by and best before dates were just an indicator, but they were not a decisive factor to throw food away. Depending on food's category, consumers give more importance to ones senses than other. In fruits and vegetables, the physical aspect was the most relevant characteristic, in meat and fish, it was the odour and in chilled food, the used by date and the physical aspect were the most reliable factors. Pasta, rice, legume and

dairy products were the most consumed after the use by and best before dates were expired. As Principato et al. (2015) showed the fear of food freshness and food-borne illness increases food waste. Therefore, it is fundamental to educate people, and in particular youths, about the reliability of their senses in assessing the edibility of a food.

- Preparation**:** food cooking and preparation are driven by culinary skills, which has been seen as important in reducing food waste behaviours (Cox and Downing, 2007; Principato et al., 2015; Van Geffen et al., 2016). Among these skills, we can mention (Exodus, 2006; Lyndhurst, 2007; Evans, 2011; Williams et al., 2012):
    - Avoiding some preparation mistakes due to suboptimal culinary skills that could end up in wasting food (as food burned during preparation).
    - Cooking too much food than needed.
    - The ability to prepare leftovers into new meals.

Consumption

During this stage, food waste occurs if individuals leave food scraps on the plate, or if they do not correctly store or reuse their leftovers later (Porpino et al., 2016). Sometimes consumers forget there are leftovers in the fridge and throw them away (Evans et al., 2012). Another aspect refers to food preferences that vary within the household (Block et al., 2016). For instance, families with kids struggle to make them eat some type of food like fruit and vegetables, which could result in higher wasteful behaviour. In order to avoid this, Evans (2011), suggests the routine of deciding a preferred dish to make sure that every day the food is consumed as well by the picky-eaters that some kids are.

Disposition

This stage refers to food waste management. That means how to reuse or not disposed food: giving it to animals, recycling (like home composting), etc.). Individuals who separate kitchen waste tend to throw away less food than those who do not recycle or compost any part of their kitchen waste (Secondi et al., 2015).

2.3 | Situational Factors

Situational factors are external variables that influence in some way an individual's behaviour towards food waste. In particular, contextual variables are associated with food waste, taking into account the geographical environment and the perceptions of the place where individuals reside. The first situational factor considered, is the level of urbanization where individuals live, since people living in urban areas tend to waste more than people living in rural areas (Secondi et al., 2015). Aecoc report (2019) showed that food-taster segment is frequent in capital and big cities. Another interesting situational factor is the perception of the amount of litter where people reside. The perception of living in a clean area is associated with a

virtuous behaviour of the residents. This has relevant implications for policy makers.

2.4 | Demographic and Socio-Economic Factors

From a demographic perspective, **youths** tend to waste more than elders (Osner, 1982; Hamilton et al., 2005; Lyndhurst, 2007; European Commission, 2014a, b; Aecoc, 2019). Concerning the socio-economic variables, the more the **level of education** individuals have, the more the quantities of wasted food (Secondi et al., 2015; Visschers et al., 2016). Aecoc report (2019) found that the price-driven consumers' group tend to present a higher unemployment rate and a lower education level. **Household composition** also play a role: bigger household tend to waste more than smaller household (Quested et al., 2013), although the number of food waste per capita decreases as the members of a family grow (Parizeau et al., 2015). Aecoc report (2019) found that in the group of food-waste generators, single-person households were frequent. Families with children tend to waste more that all-adult households of equal size due to picky-eating and food safety reasons (Quested and Luzecka, 2014). Regarding **gender and income**, there is not consensus. Some studies revealed that females waste more than males (Cox and Downing, 2007; Stancu et al., 2016; Visschers et al., 2016). However, a number of researches stated that men waste more than women (Gallo, 1980; Osner, 1982; Van Garde and Woodburn, 1987; Buzby and Guthrie, 2002; Koivupuro et al., 2012; Stefan et al., 2013; Aecoc, 2019). Aecoc report (2019) showed that the eco-friendly group had a higher income level while price-driven group had a lower income level.

3.| Nutrition. Food composition

Understanding food waste phenomenon away from home is a new research topic. Indeed, research in the field has focused more on household behaviour since the largest amount of spoilage happens in this stage although food waste away from home still represents 21% of the total wastage. According to a study made in the UK (Giorgi, 2013), food waste in restaurants happens during the preparation phase (45%), or food deterioration (21%), or due to client's leftovers (34%). See Figure 8.

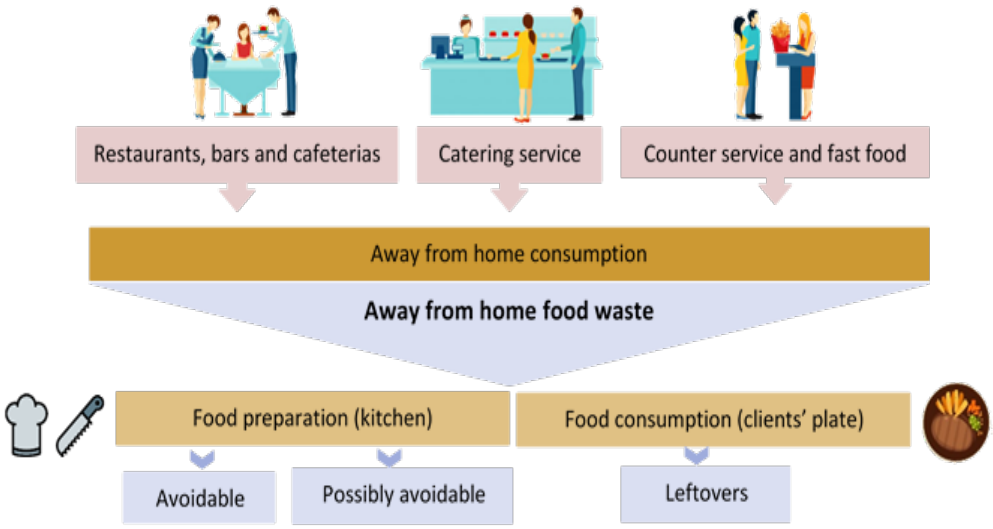

Figure 8. Sources of away from home food waste.

The theoretical framework used to explain food waste at restaurant level focus on two levels where the phenomenon occurs: food preparation and food consumption (Risku-Norja et al., 2010; Sustainable Restaurant Association, 2010; Marthinsen et al., 2012; Betz et al., 2014; Pirani and Arafat, 2015; Heikkilä et al., 2016; Papargyropoulou et al., 2016).

Kitchen food waste happens during the preparation phase for reasons related to "overproduction, peeling, cutting, expiration, spoilage, overcooking, etc."; while client food waste represents customer plate leftovers leave by the customer in the plate, it is the food wasted by customer after the dish has been served (Papargyropoulou et al., 2016, p. 4).

This section analyses the factors and incorrect behaviours that are associated to food waste away from home by focusing on food waste generated in the kitchen (KFW) and those generated by clients (CFW).

Kitchen Food Waste

Considering the managers and chefs' perspective, according to the literature, these behaviours significantly reduce food waste:

- Careful ordering and menu planning (Sustainable Restaurant Association, 2010).
- Avoiding spoilage waste by monitoring used-by-dates and storage conditions (WRAP, 2013a).
- Offering different portion sizes according to client's needs and educating the client to avoid leftovers (Sustainable Restaurant Association, 2010; WRAP, 2013a).

Concerning food waste reuse and redistribution, the best behaviours rest on:

- The possibility of reusing edible food items for making other recipes (Sustainable Restaurant Association, 2010; WRAP, 2013a);
- The donation of kitchen surplus food;
- Offering the customer the chance to take the leftovers home through the adoption of a doggie bag (WRAP, 2013a).

Client Food Waste

From clients' perspective, several factors influence the generation of leftovers in the plate: restaurant configuration, size of food portion, consumers' preferences and the possibility to look and smell the food before serving (Sustainable Restaurant Association, 2010; WRAP 2013a; Matzembacher et al., 2020).

Based on restaurant configuration, Matzembacher et al. (2020) make the following classification:

Variable price buffet: customer selects the type and amount of food that wants to eat, with the possibility of looking and smelling the food during the selection process. Consumers serve themselves and have full control of what and how much is served on the plate. The payment is according to the weight of the plate, the higher the weight the higher the amount paid (Matzembacher et al., 2020).

Fixed price buffet (all you can eat buffets): customers will pay the same price regardless of how much food they choose to put on their plate and the number of times they refill the plate. Customers can choose the amount of food served and they can look the appearance and smell the food during their choice (Matzembacher et al., 2020).

Fixed price table service: includes a la carte restaurants, where consumers choose between some foods options from a menu without looking or smelling the food in the moment of their choice. Based on that, the restaurant's staff prepares and brings food to the consumer's table. The price is fixed, the food quantity is predetermined, and generally, it is not possible to be changed,

although the customer may request to withdraw some component of the meal. It is also possible to order and pay for additional vegetable servings, deserts, rice, fries, among others (Matzembacher et al., 2020).

Similar to fixed price table service configuration, we found fast food or counter service. The main difference is that table service does not exist. In the first case the customer place an order on the counter, takes the food tray, and goes to a dining area, where tables and chairs are available. In the second case, the customer place an order on the counter and either remains seated at the counter to consume the food or takes a food tray and goes to a dining area. The price is fixed and the food quantity is predetermined.

Variable price buffet service presents the lowest level of food waste per plate compared to other restaurants categories, where the main difference is that customer pays for the amount of food served and can look and smell the food before serving it, being saving money a key motivator to reduce food waste (Matzembacher et al., 2020).

The **unavoidable food waste** per plate is almost the same across restaurants configuration. The unavoidable food waste is mostly related to meat bones and fruit peels.

Avoidable food waste: In all restaurants categories, the main wasted product is cheap food (e.d. rice or potatoes). Generally, cheap food is served in large quantities. The second most wasted product is from the meat category. Finally, other carbohydrates, its wastage could be due to preferences for types of food, or even consumer's preferences for diets.

Matzembacher et al. (2020) found in their study that most of consumers perceived that leaving leftovers in the plate was an exception for them, even when most of them had leftovers in the moment of the interview. The most common reason to leave leftovers were:

- Serving too much food on the plate
- They don't like the taste of some food
- The food was cold
- The meat was tough

Concerning how clients could reuse leftovers, the doggie bag seems to be the main option as long as it is available (Sustainable Restaurant Association, 2010; WRAP, 2013a). In Anglo-Saxon countries (like in the US and UK) and in the Northern European countries this practice is widely embraced at any social level, while in the Mediterranean countries the majority of the people still don't ask for it, especially for cultural reasons. For example, although 90% of Italians believe that restaurants waste a large amount of food, 41% of Italians are embarrassed to ask for a doggie bag (Last Minute Market, SWG 2016). Indeed, only one out of three Italians brought leftovers home from restaurants at least once (36%), and 22% believe that asking for a doggie bag represent a rude behaviour and they feel ashamed to do so (Coldiretti, 2017; Sirieix et al., 2017). Other possible

reasons could be that it would not be convenient to carry food in that moment or consumers have no interest to take home that type of food (staples food) (Matzembacher et al., 2020).

Conclusion

The combination of monetary incentives (only pay for the food they are serving), serving incentives (the possibility to influence the serving and choose smaller portions) and sensory incentives (the possibility to look and smell the food before serving it), would be what may avoid food losses when consuming food away from home (Matzembacher et al., 2020).

4.| Food Waste during the distribution and sale phases – retail level

Although we focus on consumer food waste, it is important to see briefly, why food gets lost in the distribution and sale phases and how food marketing and retailing contribute to consumer-related food waste via decisions on date labelling, packaging sizes, design elements, and pricing strategies, encouraging over-purchase, as well as shifting consumer priorities (Aschemann-Witzel et al., 2015).

In general, some global trends have accelerated the possibilities of food losses and waste. The distance between the place of production and final consumption, along with the shift in dietary patterns, especially in the economies in transition, where consumers are increasingly eating meat, fish and other perishable products (Escaler and Teng, 2011).

In the retail industry, food waste refers to unsalable products that need to be discarded or recycled (Teller et al., 2018). During the distribution and sale phases, food waste usually arises from distortions in the demand forecasting, leading to enormous quantities of foodstuffs not sold before the expiration date, or being damaged by natural deterioration. Additional causes at retail level can be:

- Limitation on the technology used to preserve products;
- The possible damage of food during transportation;
- The inadequate professional training of sales staff, not applying stock rotation procedures;
- The recalls of certain products from the market, as they do not meet qualitative and safety standards.

The commitment of internal company guidelines on quality, shelf availability and strategies related to product range, pricing, and (in-store) promotions are important aspects. (Teller et al., 2018). Now, we explain three particular causes related with consume behaviour.

Retailers' quality and safety standards

Wholesalers and retailers operate as powerful gatekeepers between production and consumption, thereby either hindering or encouraging the commercialization and consumption of higher or lower quality standards (Hartmann et al., 2021).

There are differences among different store formats in terms of causes of food waste. That depends on certain characteristics, such as store size, product range, pricing strategy, and the intensity of promotional activities. For example, hypermarkets have high-quality standards imposed by the parent organization (Teller et al., 2018).

The fact that retailers have enhanced more and more their standards for product quality and service provisions, particularly on-shelf availability and product choice alternatives, have led to the increase of customer expectations for quality, permanent availability and frequent in-store promotions. The categories containing a high share of products with limited shelf life, sensitive logistical characteristics, and slow or erratic demand patterns, such as fruits and vegetables, dairy, and bakery products, are the most severely affected (Teller et al., 2018).

The range of product category, the different logistics and marketing strategies leads to different impacts depending on shelf life, product sensitivity, imposed quality standards, and product-specific demand patterns. Higher product allocations during promotional periods and creation of fluctuating demand through marketing and visual merchandising are important causes of food waste at retailers (Teller et al., 2018). See Figure 9.

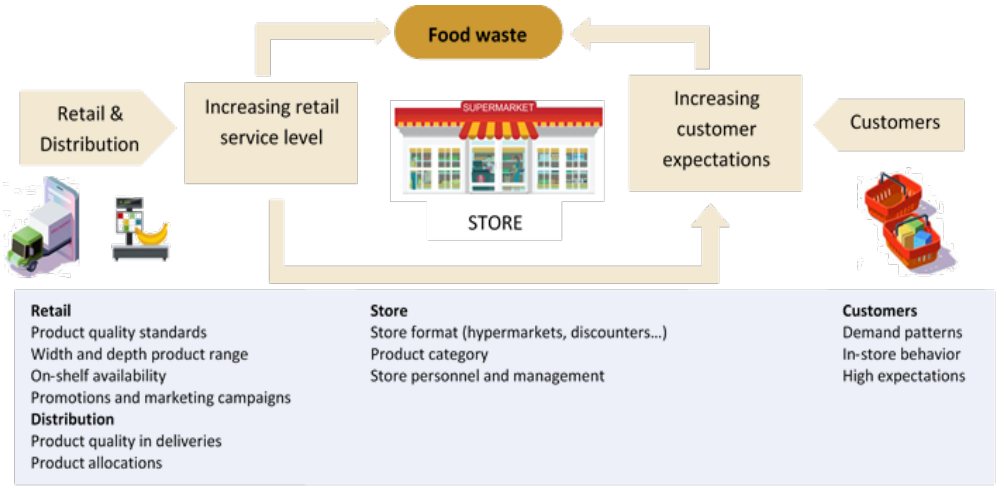

Figure 9: Causes of food waste in retail stores from Teller et al. (2018).

Marketing strategies

From retailers' point of view, the main cause related to customers is **the limited predictability of their demand** and their undesirable behaviour when selecting and handling products in store (e.g., damaging products, choosing "newest" products with a latest expiration date) (Barilla Center for Food and Nutrition, 2012; Teller et al., 2018).

From customer side, several aggressive marketing strategies in retail establishments significantly favour waste. This is the case of promotions "2x1" or "3x2" or extra-large packages. Although at first glance these discounts are beneficial for customers, they encourage consumers to buy large quantities of the same product without having planned for what they will be used for (Mondéjar Jiménez et al., 2016; Cleva and Casares, 2017). Consumers are tempted to impulsive buying or spontaneous decisions in the store (Aschemann-Witzel et al., 2015).

Consumers claim that packages are too large in general. Pricing strategies, such as decreasing price with larger units and price promotions encourage the purchase of large units and greater numbers of units (Dusoruth et al., 2020). Product and package design in terms of portioning or storage suitability, impact food management at home (Aschemann-Witzel et al., 2015).

Aesthetics standards

The retail demanding aesthetic standards have been criticized for potentially exaggerating consumers' wish for homogeneous and appealing offers and accustoming consumers' perceptions of normality to a much narrower range than needed (Aschemann-Witzel et al., 2015).

Appearance is a universal attribute to all products and establishes the first sensory impression of the item, majorly influencing its acceptability by confirming or disconfirming consumers' sensory and hedonic expectations. Industry practices have established consumer expectations for prototypical appearances of fresh produce, where consumers associate quality food with visual appeal. Damages and blemishes that occur post-harvest and appear at the point of purchase affect consumer perception of quality and reduce purchase intention (Dusoruth et al., 2020).

In Europe, 20% and 40% of the fruits and vegetables are thrown away before reaching the stores for aesthetic reasons. The established aesthetic standards make that part of the collected products never reach the supermarkets. Cooperatives or companies make a selection of products and discard foods that do not present a perfect image or size, shape or color, despite preserving their nutritional properties. The most affected food are fruits and vegetables (Cleva and Casares, 2017).

Suboptimal food have been defined as food products with an abnormal appearance and/or other deviating product attributes (e.g. feel, smell) as well as products that are close to or have passed their expiration date but which are still unreservedly consumable (Aschemann-Witzel et al., 2015).

Some studies have demonstrated that even respondents with different behavioral profiles respond in a similar way rejecting food that had deteriorated in appearance but are fully edible (Dusoruth et al., 2020). Due

to the dominating effect of abnormal appearance, many consumers remained reluctant to choose *suboptimal food* after tasting fruits with blemished appearance that were objectively optimal in taste (Hartmann et al., 2021).

Consumers expect some form of compensation for suboptimal food, such as price discounts. However, discounts can also reinforce consumers' negative perception thereby lowering their appreciation of suboptimal food since consumers tend to use prices as indicators of quality (Hartmann et al., 2021).

Household composition also affects consumer behavior towards food waste. Small households tend to feel that they would not being able to consume expiring products quickly enough. Households with children (implying bigger households) are found to be less open to buying suboptimal food due to the wish to give children "only the best" (Hartmann et al., 2021).

Increasing the availability of food with heterogeneous appearance would increase consumer familiarity and tolerance to suboptimal products. Some authors indicate that changing contextual factors is more effective in changing consumer behavior than influencing knowledge or attitudes (Hartmann et al., 2021).

Conclusion

Food waste is created due to spillage and degradation, improper storage and transportation between farm and consumer. Food waste occurrence leads to negative impacts on store performance in terms of costs, reduced profit margins and loss of sales and profits. (Teller et al., 2018

Food waste causes at retail level:

(1) Difficulties to properly matching demand. It is necessary an accurate forecasting, ordering, and replenishment;

(2) Trading with fast-turning, perishable products in sensitive packaging;

(3) Customers are increasingly demanding in terms of quality and services. (Teller et al., 2018).

- Excess of stocks and oversupply: consumers expect the shelves to be filled with a wide range of food products available.
- Lack of tolerance of the appearance and quality of products. (Teller et al., 2018

Key concepts and vocabulary

Key concepts and vocabulary

Avoidable and possibly avoidable: edible food waste that have been eaten if it had been better portioned, managed, stored or prepared. Avoidable food waste also includes other food items that have not been eaten because of consumer preference, such as bread crusts and jacket potato skins.

Behaviour: An individual, group, organization or system's external reactions to both internal factors and external stimuli in its environment (National Academies of Sciences, engineering, and Medicine, 2020).

Client food waste: food wasted away from home by customer after the dish has been served.

Edible parts: the parts of food that are intended for human consumption.

Food losses: a decrease, at all stages of the food chain prior to retailer and consumer level, of food that was originally intended for human consumption, regardless of the cause.

Food waste in the away from home phase: the avoidable and possibly avoidable food discarded during the preparation/processing of the meals as well as spoilage and expiration, and also food wasted from the client's plate (food scraps or leftovers).

Food waste: appropriate food for human consumption discarded or left to spoil at retailer or consumer level -regardless of the cause.

Food: any substance –whether processed, semi-processed or raw – that is intended for human consumption. It includes drink, and any substance that has been used in the manufacture, preparation or treatment of food.

Habits: context-behaviour associations in memory that develop as people repeatedly experience rewards for a given action in a given context. Habitual behaviour is cued directly by context and does not require supporting goals and conscious intentions (Mazar and Wood, 2018 cited by National Academies of Sciences, engineering, and Medicine, 2020).

Inedible parts: components associated with a food that are not intended to be consumed by humans. For example, bones, rinds and pits/stones.
Kitchen Food Waste: food waste away from home that happens during the preparation phase for reasons related to "overproduction, peeling, cutting, expiration, spoilage, overcooking, etc."

Motivation (to prevent food waste): A person's willingness to perform actions that reduce the likelihood or amount of food waste being generated.

Relevant aspects of motivation are attitude, awareness, and social norms (Van Geffen et al., 2016).

Norms: Informal rules that govern behaviour in groups and societies. Norms in this context refers to moral norms (i.e., when people feel that doing something aligns with an abstract right or wrong), injunctive social norms (i.e., feelings about what one ought to do), and descriptive social norms (i.e., perceptions of what most people are doing) that are strongly correlated with behaviour (National Academies of Sciences, engineering, and Medicine, 2020).

Retail food waste: unsalable products that need to be discarded or recycled in retail industry.

Sustainable Development Goals: are a collection of 17 interlinked global goals adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity. They recognize that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability (United Nations Environment Programme, 2021).

Unavoidable: Non-edible food waste, deriving from food preparation, such as bones, shells and skins.

Evaluation section

1. | Multiple choice questions

1. **Food losses and food waste have a significant:**
a) Economic impact
b) Environmental impact
c) Social impact
d) All the above are true

2. **In which Sustainable Development Goals has food waste included?**
a) In SDG 3
b) In SDG 12
c) In SDG 10
d) In SDG 14

3. **In what stages does food losses occur?**
a) Production and yield
b) First transformation
c) Industrial transformation
d) All the above are true

4. **In which of the following stages does food waste occur?**
a) First transformation
b) Industrial transformation
c) Consumption phase
d) Production and yield

5. **The inedible parts of household food waste refers to:**
a) Avoidable food waste
b) Possibly avoidable food waste
c) Non-edible food waste
d) Home grown-food

6. **Food waste away from home occur in:**
a) Restaurant
b) Catering services
c) Counter service
d) All above are true

7. **Where the highest percentage of food waste was generated in 2019 according to the first Food Waste Index Report?**
a) In household
b) In fast food
c) In restaurant industry
d) In retail

8. **Psychological factors influencing food waste include:**
a) Perceived behavioural control
b) Lifestyles
c) Situational Factors
d) Demographic Factors

9. **What food related habits could generate wasteful behavior during the food management processes and pre-consumption routines at home:**
a) Pre-shopping plan
b) Meal plan
c) Impulsive or unnecessary purchase
d) Recycle or compost

10. **Related to Kitchen Food Waste (KFW), what behaviours reduce it?**
a) Careful menu planning
b) Monitoring used-by-dates and storage conditions
c) Educating the client to avoid leftovers
d) All the above are true

11. **In your opinion, what is the most common reason to leave leftovers in away from home consumption**
a) Serving too much food on the plate
b) They don't like the taste of some food
c) The food was cold
d) The meat was tough

12. **In your opinion, what is the best incentive to avoid food waste in away from home consumption?**
a) Monetary incentives
b) Serving incentives
c) Sensory incentives
d) Others

13. **In food waste at retail level, what is the reason depending on the format store?**
a) Damage of food during transportation
b) Not applying stock rotation procedures
c) High quality standards imposed
d) Recall of certain products (lack of quality)

14. **At the retail level, food waste is related with consumer behavior through:**
a) Retailers' quality
b) Marketing strategies
c) Aesthetics standards
d) All the above are true

15. What marketing strategies are most related to food waste at the retail level?

a) Product quality standards
b) Width and depth product range
c) On-shelf availability
d) Promoting and marketing campaigns

2. | Activities (optional) / Exercises

What kind of consumer am I?

To find it out, we propose you to answer the following questions:

(*You should give each one a score between 1 and 5, where 1 = strongly disagree and 5 = strongly agree. Then you must add up the points achieved in each block*)

QUESTION BLOCK 1	1	2	3	4	5
❖ When I go grocery shopping, I buy more than I planned	☐	☐	☐	☐	☐
❖ I think food is becoming more expensive	☐	☐	☐	☐	☐
❖ I don't like to cook	☐	☐	☐	☐	☐
❖ I don't like to prepare recipes with leftovers	☐	☐	☐	☐	☐
❖ I like looking at new products in grocery stores	☐	☐	☐	☐	☐
❖ I try to indulge myself every day	☐	☐	☐	☐	☐

TOTAL POINTS: _____

QUESTION BLOCK 2	1	2	3	4	5
❖ I don't feel bad when I throw food away	☐	☐	☐	☐	☐
❖ I often have to throw out products from pantry because they are out of date	☐	☐	☐	☐	☐
❖ I keep leftovers in the fridge but usually become spoiled and I have to throw them away	☐	☐	☐	☐	☐
❖ At home, I throw out more food than I wish	☐	☐	☐	☐	☐
❖ At home, I don't have time to cook	☐	☐	☐	☐	☐
❖ I usually cook more quantity than needed and if there are leftovers, I throw them away	☐	☐	☐	☐	☐
❖ I buy food online more frequent	☐	☐	☐	☐	☐

TOTAL POINTS: _____

QUESTION BLOCK 3

	1	2	3	4	5
❖ I prefer local products that have grown close to where I live	☐	☐	☐	☐	☐
❖ I am committed to collaborating with the problems of my community	☐	☐	☐	☐	☐
❖ I would be prepared to live with less	☐	☐	☐	☐	☐
❖ Promotions make me waste food	☐	☐	☐	☐	☐
❖ I follow a Mediterranean and traditional diet	☐	☐	☐	☐	☐
❖ I prefer to make small and more frequent purchases	☐	☐	☐	☐	☐

TOTAL POINTS: _____

QUESTION BLOCK 4

	1	2	3	4	5
❖ I have reduced the amount spent on food	☐	☐	☐	☐	☐
❖ When I go on excursions, I take food from home	☐	☐	☐	☐	☐
❖ I don't like to cook	☐	☐	☐	☐	☐
❖ I don't like trying new flavours and products	☐	☐	☐	☐	☐
❖ I think that food is becoming more expensive	☐	☐	☐	☐	☐

TOTAL POINTS: _____

QUESTION BLOCK 5

	1	2	3	4	5
❖ Before throwing food away, I think about it a lot	☐	☐	☐	☐	☐
❖ I prefer to make large and less frequent purchases	☐	☐	☐	☐	☐
❖ I like to try new recipes with the leftovers I have in the fridge	☐	☐	☐	☐	☐
❖ I try to save the leftovers to cook other dishes	☐	☐	☐	☐	☐
❖ More a more I look for offers in food	☐	☐	☐	☐	☐

TOTAL POINTS: _____

If the score achieved is higher than…	You can be considered
18 points in block 1	Taster consumer
21 points in block 2	Food waste generator consumer
18 points in block 3	Eco-friendly consumer
15 points in block 4	Price driven consumer
15 points in block 5	Reuser consumer

In which block did you achieve the highest score? _____

3. | Multiple choice answers

1	d	**6**	d	**11**	all
2	b	**7**	a	**12**	all
3	d	**8**	a	**13**	c
4	c	**9**	c	**14**	d
5	c	**10**	d	**15**	d

Useful resources

Useful resources

Zero Waste Europe. Library: https://zerowasteeurope.eu/library/

The Big Waste: Why Do We Throw Away So Much Food? Yale School of the Environment. 360 video. https://e360.yale.edu/features/the_big_waste_why_do_we_throw_away_so_much_food

14 Ways Consumers Can Reduce Food Waste. Institute of Agriculture and Natural Resources. University of Nebraska-Lincoln. https://food.unl.edu/14-ways-consumers-can-reduce-food-waste

Portion distortion page. U.S. Department of Health & Human Services. https://www.nhlbi.nih.gov/health/educational/wecan/eat-right/portion-distortion.htm

Portion distortion quiz. . U.S. Department of Health & Human Services https://www.nhlbi.nih.gov/health/educational/wecan/downloads/portion-quiz.pdf

Sustainable Management of Food Basics. United States Environmental Protection Agency. https://www.epa.gov/sustainable-management-food/sustainable-management-food-basics

Stop Food Waste. Tools and Resources. https://stopfoodwaste.org/resources

Free online courses related to food waste. Reading University. https://www.reading.ac.uk/apd/OnlineCourses/Free_Online_Courses.aspx?

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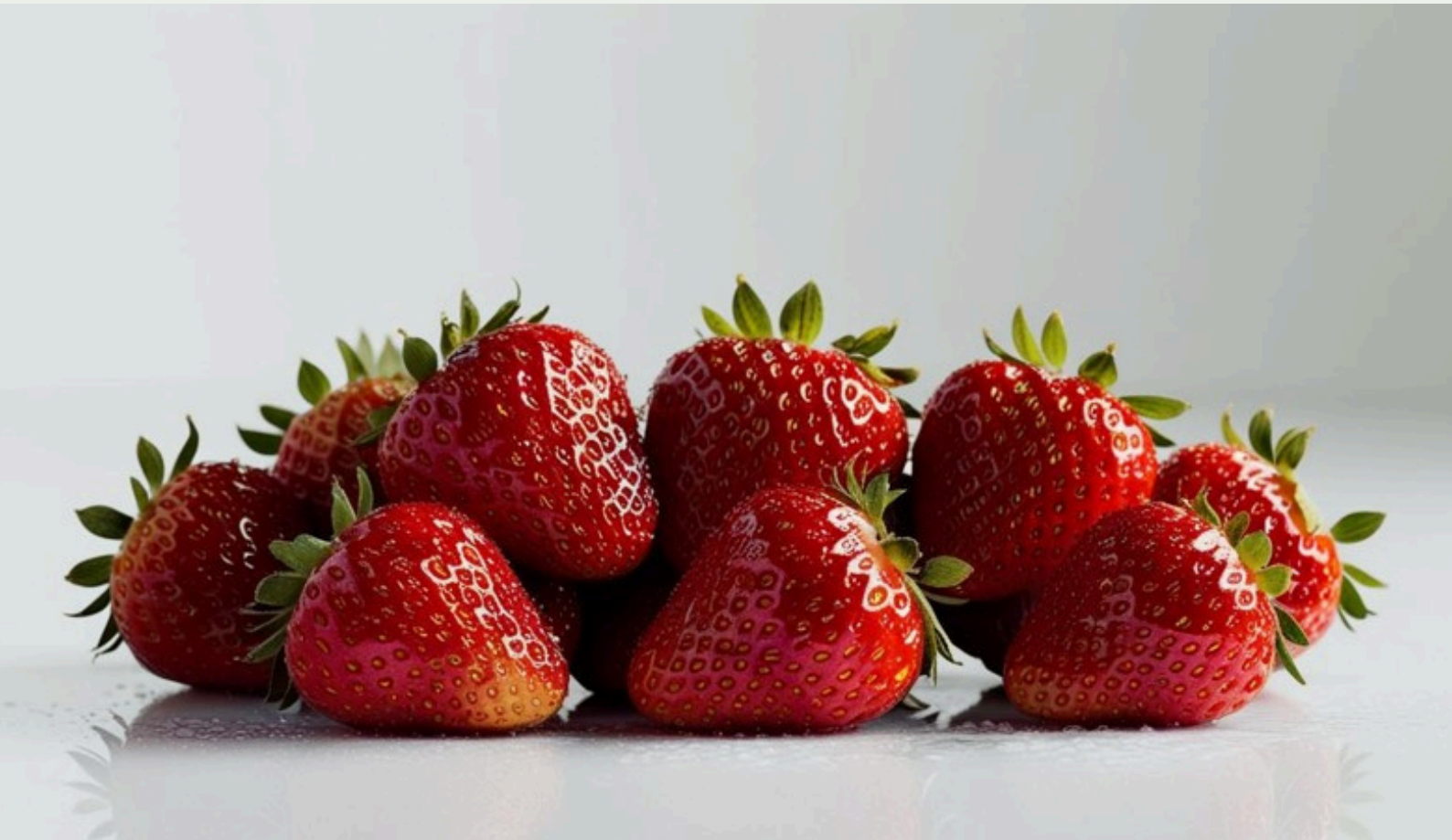
Zero WASTE

AWARENESS FOR THE REDUCTION OF FOOD WASTE

MODULE 3: GOOD PRACTICES

Strategies to reduce food waste



Instituto Universitario de Investigación Mixto Agroalimentario de Aragón
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Universidad Zaragoza

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General information. Module 3 GOOD PRACTICES

Title:
Strategies to reduce food waste

Authors:
Rosa Duarte, Iñaki Iriarte, Vicente Pinilla and Ana Serrano

Duration:
6 hours – The duration of this module is four hours of the lesson and two hours the practice of the exercises.

Objective:
Promote individual responsibility and empowerment through knowledge of the main strategies to reduce food waste.

Introduction:
This module describes the opportunities to reduce food waste in the different stages of the food chain in a general circular approach. It justifies the fight against food waste as a shared responsibility. The module also highlights the target measures, including the role of companies, hospitality industry, consumers and institutions..

Learning outcomes
On successful completion of Learning Unit one participants should be able to…

Knowledge

- Know the concept of circular economy and its implications for food waste.
- Know the concept of the “three r” model.
- Identify the different strategies for the multiple actors involved in the supply chain.
- Acknowledge the opportunities to reduce food waste at home, considering the planning, store and consumption of food products.
- Know the concepts of food banks, soup kitchens and their relevance for reducing hunger and food waste.

Technical skills

- Understand the differences between “use by” and “best before” in food labelling.
- Know the role of the different stages of the food supply chain in food waste.

Soft skills

- Appreciate the complementarities between poverty reduction and food waste reduction.

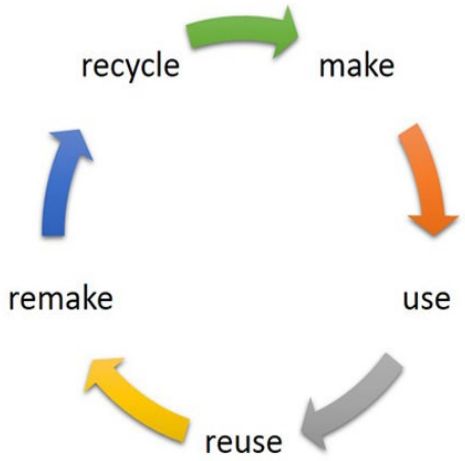
- Raise awareness on the global dimension of food waste and the role of the individual, behaviour, attitudinal actions, along with institutional strategies to fight against it.

Main contents

1.| Motivation / General framework

Reducing the levels of food waste requires making some important changes in our behaviour regarding food. These changes can be guided by following the basic criteria of the so-called circular economy.
In contrast to the “take-make-waste” linear model, a circular economy model proposes to close the cycles of production and consumption as much as possible. It starts from the correct making and using of products and follows with the three “r” model.

The circular economy and the three “r” model



Source: own elaboration

The three “r” model implies: “reuse” products as much as possible, making the most of its usefulness; “remake” products, changing components if necessary, to restore the value of the product and keep using it. Once the product reaches the very end of its life, “recycle” its different parts and materials, reducing the generation of waste as much as possible and reusing everything that can be used.

The circular economy model is a suitable way to achieve a sustainable economy, understood as the avoidance of the depletion of natural resources in order to maintain an ecological balance. It represents a powerful contribution, for instance, to achieving global climate targets, trying to avoid the negative effects of climate change.

The circular economy principles are especially attractive for the problem of food waste. For instance, as consumers, we can start buying and cooking the amount of food that we are actually going to consume. We can also reutilize food scraps, and recycle the no edibles parts of food, depositing

them in the right places so that they can be used as compost for new crops, thus helping to close the food cycle.

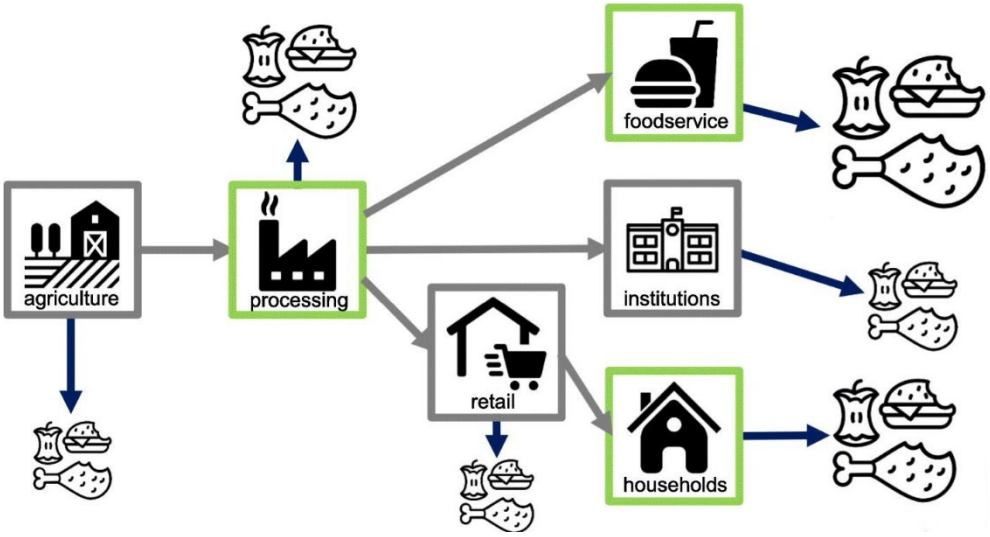
It is necessary to make the food system more sustainable. It requires changes in all the stages of the food chain, transforming as much as possible the ways of producing, storing, manufacturing, distributing, retailing or consuming food. Avoiding food waste is not the only one of the necessary changes to make. However, it helps substantially to achieve sustainability.

2.| Fighting against food waste is everyone's responsibility. Targeting measures at all the stage of the food chain

If making the food system sustainable affects all the links of the food supply chain, so are the measures to reduce the problem of food waste. Avoiding food waste is not just a consumer problem. The rest of the stages involved in the food chain also have to learn, take responsibility and act to face the problem.

If this is not done, we run the risk that the progress in reducing food waste in some links of the food chain will be overshadowed by the absence of improvements or even by the deterioration in others. Fighting against food waste is everyone's responsibility.

The stages of the food supply chain



Source: Read et al. (2020)

Agriculture is circular by nature. Farmers should do their best to maintain this circularity, trying to reduce food losses in the sowing and harvest processes. Maintaining soil fertility and managing the production process is also fundamental for a sustainable agriculture.

Additionally, the store and the first bulk process of the food after harvest is very important to avoid food losses. Disposing of warehouses with the necessary conditions for a good conservation of food is essential. Also, having machinery that makes the most of the food raw material, and packaging systems that keep the product in good conditions are crucial. The load and unload processes in the distribution systems should be very

cautious to minimize losses. Besides, maintaining transport systems at the correct temperature and humidity level is also of great importance.

Likewise, retailers should improve their food management, storing and packaging in good conditions for food conservation, and offering consumers the option to buy the amount of food they need. Restaurants and catering firms should also help in their processes of cooking and delivery.

Finally, consumers should increase their awareness on the problem, following as much as possible the three “r” model of reuse, remaking and recycling their meals and food, and avoiding waste more than the strictly necessary. In this question, every meal matters.

In addition to the sectors involved in the food chain, institutions can help to improve food consumption habits in all sectors, informing about the problem to increase awareness and applying the relevant and necessary regulations. Including these aspects in both educational and health programs can contribute substantially to reducing food waste.

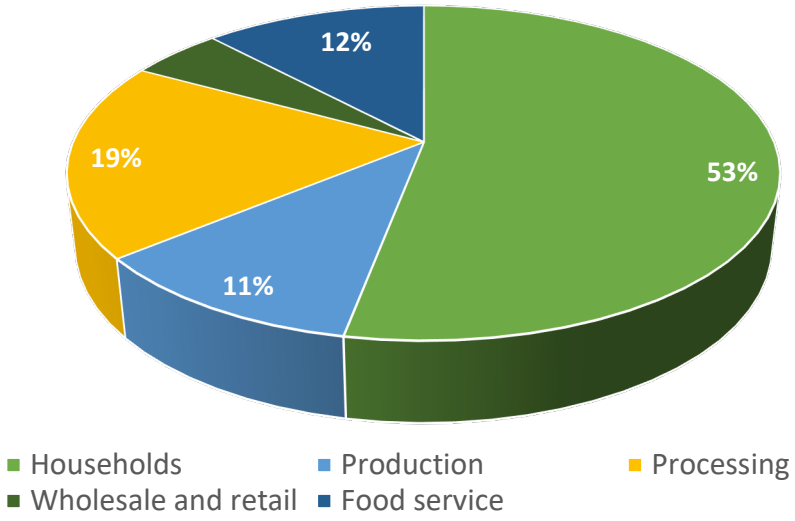
In the rest of the module, we delve into the specific actions that each of the actors involved in the food chain can develop to face this problem.

3.| Reducing food waste at the different stages of the food supply chain

As we have seen in the previous section, reducing food waste needs a comprehensive evaluation of the interdependencies throughout the different steps of the food supply chain. The performance of all the agents involved can affect the decisions and behaviour of other actors upstream and downstream. Thus, an integrated assessment of the food supply chain is essential to reduce food waste. In developing countries, reducing food waste requires significant investments in agricultural infrastructure, technological skills, storage, transport and distribution. On the contrary, in developed economies the largest potential relates to retailers, food services and consumers (Parfitt et al., 2010).

In the following sections, we evaluate how the different actors can contribute to the reduction of food waste.

Distribution of food waste throughout the food supply chain in the EU-28, 2012



Source: own elaboration from Stenmarck et al. (2016)

3.1 | The role of companies

Processing industries

Food processing was responsible for around 19% of the food waste in the EU-28 by 2012 (Stenmarck et al., 2016). In order to avoid food waste, processing companies can:

- Improve packaging, with a clearer labelling about expiration dates, cooking and freezing instructions and easing food dispensing without spoiling the unused food.
- Encourage the consumer's education, providing tips on food packaging and controlling the size of the food portions.
- Forecast adequately the necessary food inputs for the production process, avoiding to waste perishable goods.
- Use ERP (Enterprise Resource Management) software to improve the tracking of lots and to avoid overstocking.
- Remanufacturing in the case of production errors, particularly as for meat, chocolate and pasta production.
- Turn the waste into an income stream through circular collaboration with other businesses.

In sum, the critical issues that processing industries should tackle to achieve the reduction of food waste have to do with its accurate measurement, the coordination among the different business sections (planning, logistics, marketing, etc.) and the organization of the production process (Garrone et al., 2016).

Wholesale, logistics and retailers

Despite food waste at the wholesale and retailer levels only reached 5% in the EU-28 by 2012 (Stenmarck et al., 2016), retailers can influence the agents upstream (producers and manufacturers) and downstream (consumers) the supply chain (de Moraes et al., 2020). Wholesale and retailers could reverse the trend of food waste by:

- Optimizing planning and storage, trying to meet demands with the exact supply of food. They could consider the sales information from previous years or even climatic data. Sharing data and improving transparency would help to achieve it.
- Focusing on avoiding surpluses before its generation, or looking for alternative uses if surpluses have been already generated (Schneider and Eriksson, 2020).
- Optimizing transportation and delivery, shortening the logistic routes, buying goods directly from the farmers and monitoring the temperature in transport.
- Working with suppliers to coordinate the process of food supply.

- Training store employees with specific courses on food waste to increase their awareness.
- Investing in technology (software) to reduce excess inventories and food perishables.
- Simplifying food expiration labels.
- Managing products in the store with, for example, special offers to sell the products close to the expiry date.
- Selling “ugly” products at a lower price.
- Transforming food waste into new products. For instance, selling orange juice made with “ugly” oranges.
- Packaging products adequately to increase their shelf life.
- Collaborating with local entities as food banks to donate unsold food. In this sense, retailers are the largest donors in Europe (FoodDrink Europe, 2019).
- Carrying out information campaigns in the retailer’s website or even in the supermarkets.

In conclusion, wholesalers and retailers can contribute to food waste actions not only directly, but also indirectly as a result of their interconnections with other stages of the food supply chain.

3.2 | The role of hospitality industry

The food service sector represents around 12% of the food wasted in the different stages of the supply chain (Stenmarck et al., 2016). Hotels, restaurants, event and contract catering would be included in this sector. Besides, most food waste stems from leftovers post-preparation. Among the main recommendations to reduce food waste, we can enumerate (FoodDrinkEurope, 2019):

- To measure food waste to reduce production while meeting customer demand, that is, behave as a food auditor.
- To invest in technology capable of predicting food orders in advance.
- To plan menus carefully, changing them frequently.
- To train the staff so they can adequately communicate with customers about portion sizes, menu choice, etc.
- To store food appropriately and at the optimum temperature.
- To use a food in multiple dishes, trying to use the different components of a product into different recipes.
- To cook using seasonal products.
- To ensure that food is clearly labelled and to handle food according to the “first in, first out” criteria.
- To control Inventory days on hand (DOH).
- To move from batch food to cook-to-order preparation.
- To plan how to use the potential surplus food as extra ingredients.
- To use non-edible food scraps into compost.
- To recycle all the packaging.

- To shifting away from disposable to reusable items (napkins, cutlery, etc.).
- To donate food surplus to food banks or charities.
- To run offers and discounts in order to repurpose unused food before it spoils.

To sum up, most actions of the food service sector are related to supply chain efficiency and consumer behavioural changes (FoodDrinkEurope, 2019).

3.3 | The role of consumers

We can distinguish between individual (the things each of us can do) and collective (the things all as society can do) actions.

Individual actions

Households are the most critical stage regarding food waste, as they represent nearly 60% of the total food waste in the supply chain, with an average of 67 kg/person /year in the EU (Stenmarck et al., 2016). Consumer attitudes and behaviour towards food and food waste are determining factors to fight against food waste. Consumer attitudes can also influence how restaurants and market activities deal with and reduce food waste.

The differences between "used by" and "best before" labels

Source: https://ec.europa.eu/food/system/files/2020-06/fw_eu-actions_date-marking_infographic_en.pdf

The changes needed in consumers' behaviour include, among others (FoodDrinkEurope, 2019):

- Adopt healthier diets, with less elaborate products. Including oddly-shaped and ugly fruits and vegetables as they contain the same nutrient properties.
- Buy only what is needed: Plan the food you will include in your basket and calculate the size of the portions. This also will help you to save money.

- Store food properly: Storing the food in the best places (fridge, freezer, cupboard) helps to keep the food fresh longer. Keep the fridge between 1º and 5°C.
- Pay attention to food labelling: “Best before” refers to quality and means that your food will be at its best before the date given. After this date, although it might not be at its best, it will still be safe to eat. ‘Use by’ refers to safety: you must not eat food past the ‘use by’ date.
- Use leftovers for food that you are not going to eat in each meal at home or when you go to a restaurant.
- Buy from local food producers and eat in season. This helps to reduce distances and steps in the supply chain.
- Share and donate the food that otherwise would be wasted to food banks and rescue programs.
-

Way for reducing individual food waste

Source: https://changeforclimate.ca/story/the-problem-of-food-waste

Collective actions

Food banks, soup kitchens and shelters provide food assistance, helping to reduce hunger. At the same time, they contribute to supporting sustainable food systems and reducing food waste through community-based and multi-sector collaborations. The GFBN (2019) highlights the impact of local food bank organizations. Innovation technologies and infrastructure are critical to increase the efficiency of food systems and to reduce food losses and waste.

Food banks emerged in high-income countries to complement the public sector to reduce inequality and food insecurity in vulnerable populations.

Nowadays, food banks have rapidly expanded in middle- and low-income countries

"In Europe, FEBA members collectively sourced more than 756,000 tons of food, providing 4.1 million meals. The Feeding America network of 200 food banks provided more than 4.2 billion meals to people in need and rescued more than 3 billion pounds of food that would have otherwise gone to waste" (GFBN, 2019).

Food banks receive donated food, which mainly comes from surpluses from different steps in the food chain.

The functioning of a food bank

Source: GFBN (2019).

3.4 | The role of Institutions

Reducing food loss and waste requires collaboration of a wide range of actors such households, companies and farmers. Institutions play a central role promoting these collaborative efforts, boosting technological and behavioural changes as well as financing and supporting initiatives and infrastructures to reduce food loss and waste. Public and private institutions, researchers, NGOs and the civil society are key actors to identify and share best practices, provide technical assistance, raise awareness along the supply chain, establish waste reduction targets and work with main stakeholders. Institutions are also responsible for establishing regulatory frameworks in terms of standards, norms and guidelines to reduce food loss and waste in the supply chain (FUSIONS EU Project, 2016).

Some institutional actions to help in the reduction of food waste would be related to:

- The increase of awareness about food waste along the supply chain through the design and implementation of information and communication strategies for producers, households and local and national authorities. These strategies include communication campaigns, public events (festivals, weeks, conferences, competitions…), educational activities targeted to different stakeholders, institutional agreements, among others.
- The regulatory framework: National and international legislation and initiatives on food security and labelling are necessary. Similarly, establishing mandatory targets for food waste prevention, for the separation, collection and recycling of food waste and boosting national legislation to promote food donation would help to reduce food waste.
- Price-based instruments with positive and negative incentives: Positive incentives through subsidies and grants could favour technological improvements, increasing efficiency in the supply chain, surplus donations, the development of strategies for food waste reduction or the reduction of price for consumers (price-reduced for food with a close expiration date or perceived as suboptimal). Negative incentives to internalize the social cost of food wasting would also contribute to the reduction of food waste.
- The cooperation between public authorities, trade associations and food banks to implement logistic and technological solutions.
- The investment for the development of municipal infrastructure to handle food waste (collection and distribution of surplus, etc), urban and vertical farming opportunities.

Evaluation section

1. | Multiple choice questions

1. "The linear economy model is better to achieve sustainability because it is easier to implement than the circular model". This sentence is:

a) True.
b) False.

2. Which of the following questions are true?

a) It is necessary to make the food system more sustainable.
b) All the links of the food chain can be improved to achieve sustainability
c) Avoiding food waste helps substantially to sustainability
d) All of the above are true.

3. "Avoiding food losses and waste is not a question for farmers. Only food consumers are involved in the problem". This sentence is:

a) True.
b) False.

4. "Reducing food waste is a matter for everyone involved in the food chain, from producers to final consumers". This sentence is:

a) True.
b) False.

5. Considering the role of retailers in the food supply chain, we can say that:

a) They can only influence the agents upstream the supply chain.
b) They can influence the agents upstream and downstream the supply chain.
c) They cannot influence any agent in the supply chain.
d) All of the above are true.

6. "In 2012, the largest share of food waste in the EU-28 through the food supply chain was direct responsibility of the food processing companies". This sentence is:

a) True.
b) False.

7. "Turning food waste into an income stream through circular collaboration with other businesses is a good action to reduce the food waste of companies". This sentence is:

a) True.
b) False.

8. Wholesale and retailers could reduce food waste by:

a) Selling "ugly" products at a higher price.
b) Packaging products adequately to increase their shelf life.
c) Focusing on generating surpluses.
d) None of the above are true.

9. "Donating food to local institutions as food banks is a way of incentivising food waste". This sentence is:
a) True.
b) False.

10. In order to reduce food waste, the food service sector should:
a) Cook using seasonal products.
b) Store food at an optimal temperature
c) Recycle all the packaging.
d) All of the above are true.

11. "Replacing batch food for cook-to-order preparation triggers food waste". This sentence is:
a) True.
b) False.

12. The hospitality sector consists of:
a) Hotels, restaurants and logistics.
b) Catering, restaurants and logistics.
c) Catering, restaurants and hotels.
d) Wholesale and retailers.

13. "Households are not responsible for food waste as they are at the end of the supply chain". This sentence is:
a) True.
b) False.

14. "In order to reduce food waste at home, households should "store the food in the best places (fridge, freezer, cupboard) and keep the fridge between 1 and 5°C". This sentence is:
a) True.
b) False.

15. "If today is 14th of July and the label of a product says best before 13th of July, it is dangerous to eat the product". This sentence is:
a) True.
b) False.

16. "If today is 14th of July and the label of a product says use by 13th of July, you should not eat the product". This sentence is:
a) True.
b) False.

17. To increase the awareness about food waste along the supply chain institutions could:

a) Implement education activities.
b) Implement communication campaigns.
c) Sign institutional agreements.
d) All of the above are true.

2. | Activities/optional exercises

- Go to your fridge and take five different products. Look at their label and note the “use by”/” best before” date thinking about their meaning.

- Imagine you are a member of the government. Think which activities you would implement to raise awareness about food waste.

- Now, imagine you own an important agri-food company of your country. Explain its importance in the food supply chain and the actions it can implement to reduce food waste.

- When you go to the supermarket, look for the different food offers. Do you think they contribute the reduction of food waste or on the contrary it aggravates the problem? Explain your answer.

3. | Multiple choice answers

1	b	**6**	b	**11**	b	**16**	a
2	d	**7**	a	**12**	c	**17**	d
3	b	**8**	b	**13**	b		
4	a	**9**	b	**14**	a		
5	b	**10**	d	**15**	b		

Key concepts and vocabulary

Key concepts and vocabulary

"Best before": refers to quality and means that the food will be at its best before the date given. After this date, although it might not be at its best, it will still be safe to eat.

Circular economy: an economic proposal to close the cycles of production and consumption as much as possible, contributing to reduce consumption and emissions and to get a sustainable economy.

First In, First Out: asset-management and valuation method in which assets produced or acquired first are sold, used, or disposed of first.

Food banks: Non-profit, charitable organization aimed at distributing food to vulnerable people with difficulties to purchase food.

Food processing: Transformation of agricultural products into food, or of one form of food into other forms.

Hospitality industry: broad category of fields within the service industry that includes lodging, food and drink service, event planning, theme parks, travel and tourism. It includes hotels, tourism agencies, restaurants and bars.

Inventory days on hand: average number of days you hold inventory before selling it.

Retailer: person or business that sells goods to the public in relatively small quantities for use or consumption rather than for resale.

Soup kitchens: Meal centres where food is offered to vulnerable people usually for free or at a below-market price

Sustainable food chain: food supply chain organization so as all its stages avoid the depletion of natural resources and the generation of emissions and waste in order to maintain an ecological balance in all the steps of the chain.

Three "r" model: is part of the circular economy proposes to get a sustainable food chain, reusing, remaking and recycling materials and food to avoid losses and waste.

"Use by": refers to safety and means that you must not eat food past the 'use by' date.

Wholesale: Business of selling goods in large quantities and at low prices, typically sold on by retailers at a profit at later stage.

Useful resources

Useful resources

http://www.fao.org/international-day-awareness-food-loss-waste

http://www.fao.org/fao-stories/article/en/c/1309609/

https://stopfoodwaste.org/resources

http://www.fao.org/3/i7059e/i7059e.pdf

https://ec.europa.eu/food/food/food-waste/food-waste-communication-materials_en

https://lovefoodhatewaste.com/portion-planner

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