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MEANS AND METHODS TO REDUCE FOOD WASTE IN THE MANUFACTURE OF FLOUR PRODUCTS

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Material edited within the project
„Methods to reduce food waste in flour products
by developing the specific competence of specialists in the sector
- Stop Waste to VET”
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CONTENT

Chapter 1

Definitions of food loss and waste

1.1. Terms and definitions

Because currently, the reduction of food waste along the entire food chain, from farm to consumer is imperative, it is necessary to adopt a strategy regarding the concrete actions required, at European and national level, with the aim

- to limit food waste both on technological production flows
- but also to make the food supply chain more efficient for the population

For a unitary approach, we will define the terms that appear in this circuit, regarding food waste, because there are confusions regarding expressions such as food waste, food loss and biological waste and not only that.

We make it clear that the purpose of developing this course is to align with the general trends of reducing food waste (FW) in the food chain in two distinct stages.

- processing stage in the milling, bakery and flour products industry: we define ***food waste on the technological flow (food waste FW)*** as the sum of food losses recorded during the technological process (food loss FL) to which is added the waste generated during the technological process.
- the stage of storage/marketing to the final consumer for milling, bakery and flour products : we define ***food waste in the chain of storage and marketing to the final consumer*** as the food waste resulting from the stages of food storage and sale.

1.2. Other definitions

In the report regarding avoiding food waste „Strategies for increasing the efficiency of the food chain in EU (2011/2175(INI)) we define:

- **„food waste”** food waste as representing all food products removed from the food supply chain for economic reasons, due to improper appearance or due to exceeding the validity period; these are still perfectly edible and can be destined to the consumption and which, in lack of other possible alternatives for use are eliminated, having negative effects both ecologically but also regarding the economical costs and of income losses for the enterprises;

Because an harmonised definition doesn't exist for food waste in Europe, we wish to define the tipology „food waste" and, in this context, to establish also a separate definition for „food waste for biofuels" or „biological waste", which is a separate cathegory of conventional food waste, because they are reused with the purpose of producing energy.

The Food and Agriculture Organization (FAO) of the United Nations defines **food loss and waste** as the decrease in quantity or quality of food along the food supply chain.

Within this framework, UN Agencies distinguish **loss** and **waste** at two different stages in the food supply chain:

- **Food loss (FL)** occurs along the food supply chain from harvest/slaughter/catch up to, but not including, the sales level;
- **Food waste (FW)** occurs at the retail and consumption level.

Thus, food loss (FL) reffers to waste resulted during harvesting and industrial pprocessing of the food raw materials. Food waste (FW) reffers to waste from the selling and consum stages of food.

For a clarification of the definitions, the following clarifications should be taken into account:

Important components of this definition include:

- Food redirected to non-food chains (including animal feed, compost, or recovery to bioenergy) is not counted as food loss or waste.
- Inedible parts are not considered as food loss or waste (these inedible parts are sometimes referred to as unavoidable food waste)

https://www.fao.org/policy-support/policy-themes/food-loss-food-waste/en/

Under Sustainable Development Goal 12, the Food and Agriculture Organization is responsible for measuring food loss, while the UN Environmental Program measures food waste.

European Union

In the European Union (EU), **food waste** was defined as "any food substance, raw or cooked, which is discarded, or intended or required to be discarded" since 1975 until 2000 when the old directive was repealed by Directive 2008/98/EC, which has no specific definition of food waste. The directive, 75/442/EEC, containing this definition was amended in 1991 (91/156) with the addition of "categories of waste" (Annex I) and the omission of any reference to national law.

https://www.eu-fusions.org/index.php/about-food-waste/280-food-waste-definition

In **Romania** according to the provisions of **Law no. 217/2016** on the **reduction of food waste**, food waste means the situation after which food leaves the circuit of human consumption due to degradation and is destroyed, according to the legislation in force.

In **Italy food waste** means "the set of products discarded from the agri-food chain, which for economic, aesthetic reasons or due to the proximity of the consumption deadline, although still edible and therefore potentially intended for human consumption, are destined to be eliminated or disposed of".

The Waste Resources Action Program (WRAP) proposes a definition of food waste that distinguishes *food waste* into:

- avoidable (food and drinks that end up in the trash but are still edible, such as pieces of bread, apples, meat, etc.);
- possibly avoidable (food and drink that some people consume, for example bread crusts, and some people do not; but also food that can be consumed if cooked, for example potato peeling);
- unavoidable (meat bones, egg peels, pineapple peels, etc.).

(https://www.sprecozero.it/waste-watcher/)

In **Estonia** there is no specific legislation on this theme.

United States

The United States Environmental Protection Agency defines **food waste** for the United States, such as "uneaten food and food preparation wastes from residences and commercial establishments such as grocery stores, restaurants, produce stands, institutional cafeterias and kitchens, and industrial sources like employee lunchrooms.

The states remain free to define food waste differently for their purposes, though many choose not to. According to the Natural Resources Defence Council, Americans throw away up to 40% of food that is safe to eat.

The inclusion of food that goes to non-food productive use in definitions of food waste, such as that of the EU an earlier definition from the Food and Agriculture Organization (before its 2019 revision), come under criticism. According to Bellemare, M. F. (2017) in the study ”On The Measurement of Food Waste” published in the American Journal of Agricultural Economics, this is flawed for two reasons:

-First, if recovered food is used as an input, such as animal feed, fertilizer, or biomass to produce output, then by definition it is not wasted. However, there might be economic losses if the cost of recovered food is higher than the average cost of inputs in the alternative, non-food use.

- Second, the definition creates practical problems for measuring food waste because the measurement requires tracking food loss in every stage of the supply chain and its proportion that flows to non-food uses." The authors of the study argue that only food that ends up in landfills should be counted as food waste.

According to the Institute of Food Science and Technology the definitions of food loss and food waste are:

Food loss (FL):

“The decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers.”

*The proposed definition for **food waste (FW)** is as follows:*

Food waste (FW) is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea). *FUSIONS Definitional Framework for **Food Waste***

Using the general system of resource flows FUSIONS proposes:

- clear boundaries for the "food supply chain", and
- a definition of "food waste" based on the food supply chain and destinations of resource flows.

The FUSIONS technical framework is based on the following definitions:

Food: "Food means any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be consumed by humans. Food includes drink, chewing gum and any substance, including water, intentionally incorporated into food during its manufacture, preparation or treatment". As inedible parts of food are excluded from this definition, they have been separately brought out, and included in the framework.

https://www.eu-fusions.org/index.php/about-food-waste/280-food-waste-definition

Food Supply chain: The food supply chain is the connected series of activities used to produce, process, distribute and consume food. The food supply chain starts when the raw materials for food are ready to enter the economic and technical system for food production or home-grown consumption. This is a key distinction in that any products ready for harvest or slaughter being removed are within scope, not just those that are harvested and subsequently not used. It ends when the food is consumed or 'removed' from the food supply chain.

1.3. General information

Food waste has reached such an important dimension that it can be considered a global problem that has repercussions on all links in the food supply chain, from the field to the consumer.

According to data recorded from 1974 to the present, it is estimated that food waste worldwide has increased by 50%.

Food waste occurs in agricultural fields, in the processing industry, in distribution companies and in the homes of consumers; food is wasted in industrialized and developing countries. Food waste gives rise to a chain parallel to that of production and which generates a long series of negative effects.

The issue of food waste runs counter to the fundamental issue of food supply, which is severely compromised by a number of factors, including limited natural resources in relation to a growing global population and reduced access to food of the poorest population groups.

This results in a series of analyzes and reflections on how we use the food available to us.

According to the FAO study ”Global food Losses and food waste – Extent, causes and prevention” alarming data are highlighted, particularly in the industrialized world: European and North American citizens waste between 95 and 115 kg of food per capita each year, compared to those in sub-Saharan Africa , who lose between 6 and 11 kg.

The causes of food waste are not always the same; they differ depending on the stage of the food supply chain, the type of product and where the food is wasted. If the food chain is divided into five sectors (agricultural production, management and storage, processing, distribution and consumption), it can be seen how various behaviors in each sector lead to the elimination of perfectly edible food: starting with losses recorded during harvesting and storage, to unsafe transport, labeling mistakes and bad habits of end consumers when buying and using food.

As for industrialized countries, most of the food waste occurs at the final stages, i.e. at the distribution and consumption stages, mainly due to the overabundance of food produced, while in developing countries the waste of food shortage occurs mostly in the early stages, due to the lack of advanced agricultural technologies, efficient transport systems and infrastructure (e.g. uninterrupted maintenance at a low temperature) and the possibility of safe food storage.

These data highlight the fact that currently produced food can actually be reused for food purposes instead of being disposed of as waste, which has significant ecological and economic effects and ethical implications.

Indeed, the production of surplus food that we do not consume implies a high cost in ecological terms, from the use of energy and natural resources (primarily water), as well as gas emissions into the atmosphere; it is estimated that the approximately 89 million tons of food thrown away in Europe annually produce the equivalent of approximately 170 million tons of CO2. Along with the environmental damage caused by the production of food that is not subsequently consumed, the costs of processing and disposing of food waste and the loss of income suffered by the production enterprises must also be taken into account.

Combating food waste must become a priority on the European political agenda; The Commission, the Council and the Member States must develop concrete strategies and measures to halve the amount of food wasted along the entire supply chain by 2025, increase the efficiency of the industry and raise public awareness of the issue ignored in many ways.

Citizens must be informed not only about the causes and consequences of food waste, but also about the ways in which it can be reduced; a scientific and civic culture based on the principles of sustainability and solidarity must be promoted in order to encourage more virtuous conduct.

Experience shows that the spontaneous initiatives of the associations, be they voluntary or professional, to promote and materialize a culture to combat food waste, have registered significant success in the areas where they took place. (https://www.fao.org/3/i2697e/i2697e.pdf)

The Committee on the Internal Market and Consumer Protection recommends to the Committee on Agriculture and Rural Development the inclusion of the following suggestions in the proposed resolution to be adopted:

1. Stresses that food waste involves ecological and ethical issues, as well as economic and social costs, which create challenges in the internal market, both for businesses and consumers;

2. emphasizes the fact that political will is needed to find solutions to food waste;

3. urges the Commission to prioritize all aspects of food waste in the European political agenda;

4. asks the Commission to establish, after consultation with the Member States, objectives for reducing food waste;

5. calls on Member States and all parties involved to take practical measures to achieve those objectives;

https://www.europarl.europa.eu/doceo/document/A-7-2011-0430_EN.html

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4. https://www.fao.org/policy-support/policy-themes/food-loss-food-waste/en/
5. https://www.eu-fusions.org/index.php/about-food-waste/280-food-waste-definition

Chapter 2

Legislation at national and european level regarding the food waste (FW) along the food supply chain (FSC) in the flour product industry

2.1. The food supply chain

The *food supply chain* is defined as the movement of products and services along the value-added chain of food commodities aimed at achieving better value for the customer while minimizing costs (Folkerts and Koehorst, 1998).

The food supply chain differs from other types of supply chains because it involves complex issues such as the perishable nature of a food commodity, interaction with other products, and cross-sector influence (Mithun Ali et al., 2019).

The complexity associated with the food supply chain connects with concerns about safety, sustainability, quality and process efficiency. The researchers illustrated the food supply chain in terms of globally relevant stages, which include:

(i) farm production,
(ii) handling and storage
(iii) processing
(iv) distribution and
(v) consumption (Dumitru, O.M. et al., 2021).

The global food supply chain

From small-scale farmers to big international enterprises, the global food supply chain is a large and complicated network of participants. According to the categories of products, (Van der Vorst, J., 2006) the food supply chains are divided between those that are involved in producing processed foods and those that grow fresh agricultural items. Growers, auctions, wholesalers, importers, exporters, retailers, and specialty stores fall under the first category.

Waste in the food supply chain

According to OECD/Eurostat (2005), *waste* in the food supply chain can be defined as: "*...materials that the generator (producer) discards and intends to abandon because they are not considered to be primary products (i.e., goods manufactured for the market), or is obliged to trash because he has no further use for them in his own production, transformation, or consumption. Waste can be produced during any process, including the extraction of raw materials, the transformation of raw materials into intermediate and final goods, the consumption of finished products, and any other process*".

https://ec.europa.eu/eurostat/documents/3859598/5889925/OSLO-EN.PDF

Effective waste management is essential to raise profitability levels among chain members in an industry with historically poor margins, particularly by reducing the consumption of energy and raw materials and enhancing recycling and re-use operations. Through more efficient use of natural resources and a decrease in trash going to landfills, this will directly affect the environment. It will help ease global concerns about food security (Mena et al., 2014).

In Figure 2.1, a schematic view of all the stages in the food supply chain where food waste may occur is presented.

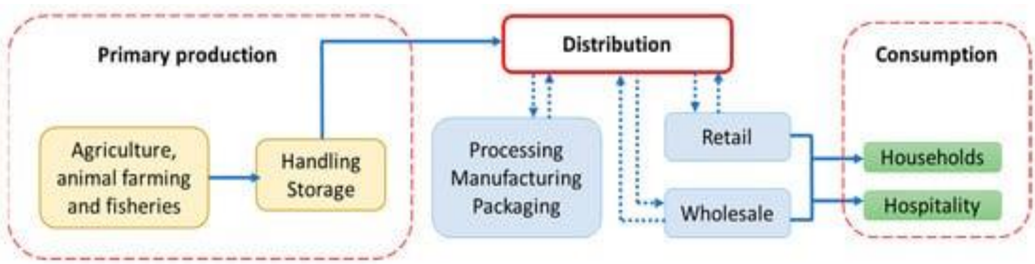

Fig. 2.1. Food waste occurrence in different stages of food supply chain (Dumitru et al.,2021)

2.2. Specific legislation

European legislation:

• Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste

• Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives

• Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste

• Directive (EU) 2018/850 of the European Parliament and of the Council of 30 May 2018 amending Directive 1999/31/EC on the landfill of waste

• Commission Delegated Decision (EU) 2019/1597 of 3 May 2019 supplementing Directive 2008/98/EC of the European Parliament and of the Council as regards a common methodology and minimum quality requirements for the uniform measurement of levels of food waste

Legislation in Romania

• Law no. 217 of November 17, 2016 regarding the reduction of food waste

• HG decision no. 51/2019 - Methodological norms for the application of Law no. 217/2016 on the reduction of food waste.

Legislation in Italy

• Gadda Law no. 166/2016 that focuses on the redistribution of food surplus to those in need

• The Good Samaritean Law No 155/2003 that simplifies the food donation procedures supporting non-profit organizations in the distribution of food charities.

Legislation in Estonia

• Food Act, RT I 1999, 30, 415, Entered into force in accordance with § 66, describe definitions regarding food, its production and handling, import and export of food, food quality and sampling, implementing of provisions

• Waste Act, RT I 2004, 9, 52, Entry into force 01.05.2004, defining waste, by-products and scope of application

• Directive 2008/98/EC of the European Parliament and of the Council, 19 November 2008 which deals with the content, scope and definitions regarding waste management

2.3. The "Farm to Fork Strategy" of the E.U.

Commission aims to create food systems fair, healthy, and environmentally friendly. The end-to-end method of "Farm to Fork" is portrayed by the food life cycle (handling, storage, processing, distribution, and consumption). Food loss and waste are generated at each step of this life cycle (European Commission, COM (2020); Dumitru et al. 2021)

According to Ishangulyyev et al. (2019), developing countries have relatively high food loss **(FL)**, while developed countries have a higher portion of food waste **(FW)**.

Moreover, in developing regions, 29% of **FLW** (food loss and waste) occurs during the first two stages (production, and handling and storage) while in developed countries, **FL** (food loss) occurs less in the production stage compared to developing regions, but FL in developed countries occurs due to the excessive loss of the embedded resources. In both regions, the most resource-intensive stage is the production stage. That is why food sustainability models (Environmental Protection Agency's Food Recovery Hierarchy) emphasize the reduction of food surplus generated during the production stage. FW at the consumption stage in developing regions is significantly lower due to limited household income and poverty, as source reported.

Food loss and waste (FLW) is an environmental, social and economic problem. Countries are permanently looking for strategies to prevent and reduce FLW.

The European Union is willing to help the member states to solve the food loss and waste issue. Since 2016 at European level the Platform on Food Losses and Food Waste was established.

It has several subgroups:

• Sub-group on Action & implementation

• Sub-group on Date marking and food waste prevention

• Sub-group on Food donation

• Sub-group on Food loss and waste monitoring

• Sub-group on Consumer food waste prevention

The European Union is functioning towards reducing waste by 30% by 2025. The purpose of the Directive 2008/98/EC ist o establosh a legal framework for dealing with waste in the European Union (EU), designed to protect the environment and the human health, underlining the importance of adequate management techniques, recovering and reciclying waste to reduce excessive use of resources in order to improve their use.

As part of a package of measures on the circular economy, Directive (EU) 2018/851 amends Directive 2008/98/EC it strengthens rules on waste prevention and generation.

Regarding waste generation, the EU Member States must take measures to:

• support sustainable production and consumption models;

• reduce food-waste generation as a contribution to the United Nations Sustainable Development Goal to reduce by 50% the per capita global food waste at the retail and consumer levels

• reduce food losses along production and supply chains by 2030;

Moreover, further amendments are related to requirements for measuring, monitoring, and reporting food waste within the EU as follows:

• Article 3 (4a) defines *food waste* as all food that has become waste as defined in European food law (Regulation (EC) No 178/2002).

• Article 9 (1g) explicitly commits to Sustainable Development Goal (SDG) and calls for the implementation of food waste reduction measures along the entire food value chain;

• Article 9 (1h) encourages food donations and other forms of redistribution of food primarily for human consumption and next for animal feed or reprocessing into nonfood products. Annex IVa (3) further recommends providing fiscal incentives for food donations as a possible economic instrument;

• According to Article 9 (5), member states shall monitor food waste based on a common methodology established in Delegated Decision (EU) 2019/1597 (EC delegated decision 3211 Final).

• Until 31 March 2019 the commission proposed to adopt the Delegated Decision that establishes a common methodology and minimum quality requirements for the uniform measurement and reporting of food waste levels (Article 9 (8) and Article 37 (7);

• Article 29 (2a) requires member states to adopt specific food waste prevention programs

• Article 37 (3) obliges member states to report annually on their food waste quantities and trends, starting with the reference year 2020 (Leverenz et al., 2021)

Among others EU member states, Italy (PINPAS), France (ANTI-GASPI) and Spain (Mas Alimentos, Menos Desperdicio) approved a National Plan for Food Waste Prevention and Reduction. Italy and France have approved national comprehensive laws against food waste in 2016. Instead, in other EU countries, initiatives against food waste have been implemented through more fragmented actions, for example waste management plans at the municipal level (Austria, Czech Republic and Poland), action plans for food loss and waste reduction (Netherlands, Sweden and Scotland). (Giordano et al., 2020). A project funded by the European Commission Framework Program 7, is FUSIONS (Food Use for Social Innovation by Optimizing Waste Prevention Strategies).

The main objectives of FUSIONS are:

(1) to harmonize FW monitoring

(2) to examine the feasibility of social innovative measurements for optimized food use in the FSC

(3) to create a Common FW Policy for EU. (Ishangulyyev et al., 2019)

Food waste is defined by the FUSIONS, as "the fractions of *food and inedible parts of food removed from the food supply chain* to be recovered or disposed (including-composted, crops ploughed in/not harvested, anaerobic digestion, bioenergy production, co-generation, incineration, disposal to sewer, landfill, or discarded to sea)". Moreover, in order to achieve a stronger governance impact of the circular economy and waste regulation on decreasing food waste, a minimum and a clear quantifiable objective, and sanctionable reduction target for food waste might be set for all Member States. (Garske et. Al. 2020).

Recently, the results of the PROM project (Developing a system for monitoring wasted food and an effective program to rationalize food losses and reduce food waste) successfully implemented in Poland, laid the foundation for an useful manual addressed to producers of bread and bakery products, to help them develop food loss management programmes, but also various organisations in the institutional environment of this industry, to be used as an educational and information tool. "The manual title is Handbook of Good Practices for Limiting Food Losses and Wastage in the Baking and Confectionary Industry" (Gorynska-Goldmann et al. 2021)

To conclude, the EU legislation strongly supports the concept of waste prevention as a first and necessary step for waste management, as well as reducing food waste along production and supply chains.

Also, there are in force in this moment:

- EU Directive 2018/850 of the European parliament and the Council from 30 May 2018 amending the Directive 1999/31/CE regarding waste depots.
- Resolution of July 6, 2010 regarding the Green Paper of the Commission on the management of biological waste in the European Union

2.4. Curent situation in partner countries

ROMANIA

The Romanian Law 217/2016 concerning the decrease of food waste (amended in 2018) includes several measures to reduce food waste across the food supply chain. Following its evaluation in 2019, “the law was modified to facilitate the donation of surplus food, by simplifying the donation contracts and by clarifying the type of food business operators that can redistribute food. Donated foodstuffs are excluded from the application of VAT, if redistributed within 10 days before the expiration of their date of minimum durability". (EU Food Loss and Waste Prevention Hub-Member State Page: Romania)

Recently, the impact of food waste along food chain in Romania was investigated in the study conducted by Dumitru et al. (2021), which aimed to assess by analysis the data obtained from quantitative impact studies, carried out in a project funded by the Romanian Ministry of Agriculture and Rural Development . A total of 852 companies were interviewed in the study, with a turnover of almost 6.5 billion euro and a number of over 69 thousand employees, including 273 primary production enterprises, 270 food processing units, 171 distribution/retail units, and 138 HoReCa units.

From the primary production sector, most of the responding entities are acting in cereal cropping (53%) and from processing units' sample responding 34 % was represented by the bakery sector. Primary production has significant losses in cereals (34%). As the reported data showed, food processing has higher losses in the bakery products (6%), pastry (3%) and confectionery (5%), it was also significant.

The results obtained define an interval in which the food waste generated throughout the chain falls, indicate a placement close to the European average of 20% and a general level of waste in a range of 14.56% to 21.94%. (Food chain maximal level of FW-21.94%, of which: Input from primary agricultural production sector (4.2%), input from food processing sector (3.63%), input from food distribution sector-0.79%, input from HoReCa sector-7.89%, input from urban household's consumers-5.43%) (Dumitru et al. 2021).

Many authors confirm the complexity of the quality management process in bakery and pastry production (Garske et. al. 2020). According to recent studies, in Romania the most consumed bakery products are the cheapest, such as white bread and bagels, while those with a higher nutritional value were preferred as incomes increased (Ladaru et al., 2021). Moreover, in terms of sustainability, understanding environmental impacts of complete FSC is important for the food industry to help devise strategies for reducing the impacts of current and future products (Ladaru et al. 2021). In this context, waste reduction measures along the FSC in this sector represent a very important issue.

The results of a recent research carried out in Romania regarding the food waste behavior among Romanian consumers and prevention indicate the need to continue the awareness and education campaigns initiated at governmental and civil society level (Pocol et al, 2020).

In Romania currently there is in force the Government decision no. 51/2019 - Methodological norms for the application of Law no. 217/2016 on the reduction of food waste.

https://www.madr.ro/risipa-alimentara/reglementari-europene-si-nationale-referitoare-la-risipa-de-alimente.html

There is a lack of information in order to determine the amount of food waste generated in the food industry on the basis of available data.

Almost all sectors of the food industry also produce significant amounts of so-called by-products, which are generally not reflected in waste accounting.

ESTONIA

In the study executed by SEI - Stockholm Environment Institute reported that in 2019, an estimated 31,622 tons of bio-waste (biowaste or kitchen canteen waste, animal origin waste, edible oil and edible food waste) was collected in food industry enterprises in Estonia, of which more than half (52%) was produced in the vegetable industry, 13% in the meat industry and 9% in cereal production. The cereals industry covered the production of flour and cereals as well as pasta and the production of vegetable oil. The production volume of the grain industry in Estonia was in 2019 more than 144,000 tons.

According to Estonian Waste Data Management System (WDMS), an estimated 2,821 tons of food waste was generated in grain processing companies (in the production of flour products, cereals and vegetable oil) in 2019. The majority of this was plant tissue waste (90%). However, a large part of production residues is also considered as by-products. For example, in the production of flour and cereals, bran is produced as a by-product, which is partly used as a food supplement, but still mainly as animal feed. But there are certain regulations in order to use the by-products of the cereal production for food and feed products.

https://www.sei.org/wp-content/uploads/2022/05/policy-brief-the-generation-of-food-waste-and-food-loss-in-the-estonian-food-supply-chain.pdf

According to the Ministry of Environment of Republic of Estonia, in September 2015, the goals of sustainable development for the next 15 years, i.e. until 2030, were globally agreed upon. United Nation member states, including Estonia, are expected to follow these goals when formulating policies. Sustainable Development Goal 12.3 addresses food waste as follows: "To reduce food waste generated by retail trade and consumers by half per inhabitant. Reduce food loss in the production and supply chain, including post-harvest losses by the year 2030."

Although a comparison of the amount of food waste generated at different stages of the Estonian food supply chain with similar data from more economically developed European countries shows that Estonian consumers and also companies in the food supply chain generate relatively less food waste, Estonia also plays a role in global food waste and it is necessary to take measures to reduce the generation of food waste in general.

Source: https://envir.ee/ringmajandus/jaatmed/toidujaatmed

There are many initiatives and programmes to prioritise the food issues and to diminish the food loss and waste. Here are some examples:

- "Wise food consumption" ("Tarbi toitu targalt") - Instructional materials for schools on preventing and reducing food waste has been completed. It can be used as educational material on the topic of reducing and preventing food waste, but at the same time it also provides schools with a broader knowledge of how to contribute to a sustainable food system.
- Life-cycle of food (Toidu eluring) – Target groups according to age and education level: 2nd level (4-5 grade), 3rd level (6-9 grade), adults; The program gives and overview, how to assess the impact of human activity on the natural environment, analyze the causes of food waste and find solutions to the problem of

food waste. The program is structured as practically as possible in order to have knowledge that can be taken into everyday life.

- Sincerely, food! Thank you for saving. (Väärtustades toitu) – Global learning approach on food waste in non-formal education. Project targets households, educational workers and staff, students. The main aims are (1) to raise consumer awareness of the possibilities of reducing food waste in households, including sharing food tips, explaining food labels used in commerce, preparing educational materials, conducting thematic seminars and trainings for adults and lessons in schools, etc. (2) to draw the public's attention to the global effects of food waste and the importance of reducing food waste, including through public media and information campaigns.
- Eat climate-friendly food! (Söö kliimasõbralikku toitu!) – This initiative promotes to eat more plant-based and less animal-based food, to prefer and to consume more local food products, organic food or grow your own food, to be sustainable when preparing and cooking food, to avoid food waste and to promote recycling and sorting of different types of waste.
- Prevention and reduction of food waste and food loss in schools (Toidujäätmete ja toidukao vältimine ja vähendamine koolides) – The purpose of the instructional material is to raise the awareness of students, school caterers and school cafeteria workers about the possibilities of preventing and reducing food waste and food loss, which helps guide them to reduce food waste generation in all educational levels. Materials provided by Stockholm Environment Institute in Tallinn.
- The environmental impact of food (Toidu keskkonnamõju) – Posters about environmental impact of food to all educational levels.
- Respect food completely! (Austa toitu jäägitult!) – General instructions and advise, what can a single person do to respect food completely and contribute to reducing food waste.

The environmental, economic and social effects related to food waste and food loss are under increasing attention both globally, at the level of the European Union and in Estonia. According to the Food and Agriculture Organization of the United Nations, one third of all food produced for human consumption in the world is wasted

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every year. Food waste is accompanied by greenhouse gas emissions, unnecessary use of water and agricultural land, and loss of biodiversity.

The action plan for the transition to a circular economy of the European Union stipulates that the member states will start reporting data on the generation of food waste every year, and in 2023 European goal will be set to reduce the generation of food waste. By December 31, 2023 at the latest, separate collection of biowaste from the point of origin or composting at the point of origin must be organized.

ITALY

Italy has adopted a law, named Gadda Law 166/2016 that focuses on the redistribution of food surplus to those in need.

With this law there was also established the National Observatory of Food Surplus, Recovery and Waste (Osservatorio sulle Eccedenze, i Recuperi degli Sprechi Alimentari (OERSA)). OERSA has two main priorities:

- collecting data from the primary production sector and at the consumer level
- establishinig educational programs and awareness campaigns.

In 2013 Italy adopted The Good Samaritean Law No 155/2003 that simplifies the food donation procedures supporting non-profit organizations in the distribution of food charities.

Other steps were taken by introducing the Law no. 166/2016 that encourages food and pharmaceutical surplus redistribution as social solidarity actions by simplifying the bureaucracy, tax deductions from public or private donors.

The main objectives of this law are:

➢ promoting the recovery and donation surplus food, primarily to humans in need

➢ reducing the environmental impact of FLW through actions that aim to decrease waste and to increase the life cycle of products by reusing and recycling

➢ supporting research activities and increasing consumer and institution awareness, focusing on educating young people.

Also, the Ministry of Agricultural, Food and Forestry Policies coordinates a Food Waste Permanent Table (FWPT) that organizes different activities in order to reduce food waste at the national level.

The main purpose of the organized activities is knowledge dissemination and sharing data among the key actors in the production system, scientific experts and society as a whole.

FWPT includes representatives from all actors of the supply chain (primary sector, manufacturing, industry, retail and food services) and also representatives from different Ministries (Health, Environment and Economic Development), charitable organizations and non- governmental organizations.

One of the main aims of OERSA is to *reduce the food losses*, to have a better management of food surplus and also to reduce the environmental impact of the supply chain. (Grant F., Rossi L., 2022)

From 2013 is also active the Waste Watcher International Observatory on food and sustainability which plans annual monitoring of domestic food waste and the habits of Italians in relation to the management and use of food.

The Observatory aims to provide the community with tools for understanding the social and behavioral dynamics and lifestyles that generate and determine household waste - an Observatory capable of generating common knowledge, to guide prevention policies and actions of food waste by public and private actors. Waste Watcher is a research carried out with a scientific method, based on opinions and perceptions.

Studying the causes of food waste makes it possible the planning of actions (public or private) aimed at reducing household food waste. Over the years, the work of punctual analysis and periodic monitoring has allowed us to broaden the field of observation on issues related to domestic food waste from a perspective of circular economy and sustainable development.

(https://www.sprecozero.it/waste-watcher/)

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Chapter 3

Possible causes of food waste (FW) at the handling and storage stage of flour products. Degradation and spillage according to product characteristics. Storage infrastructure

3.1. Causes of food waste (FW) at the handling and storage stage of flour

Flour is the basic raw material and is the main ingredient of bakery and flour products. Wheat flour is mainly used and, only for some types of bread, other types of flour are added. Depending on the processing technology, flour is classified into whole wheat flour which includes bran, germ and endosperm and refined wheat flour which includes only endosperm. Whole wheat flour, due to its composition, is an important source of dietary fibre, vitamins, minerals and phytochemical compounds. Depending on the protein content, flours can be divided into low gluten, medium gluten and high gluten wheat flours.

Three types of wheat flour can be used in the manufacture of the products: white flour, semi-white flour and dietary flour. The type represents the maximum ash content of the flour multiplied by 1000 or extraction degree (Zhou, et al. 2022).

In the baking process, the losses that may occur due to the defective quality of the flour refer to its physico-chemical or microbiological properties. A low-quality flour will lead to low-quality bakery products with defects and as a result product losses will increase in different technological phases. Mistakes in the reception of raw materials and incorrect storage conditions of raw materials (wrong temperature, humidity, bad hygiene, poor pest control) may cause significant losses in quality of flour products (Figure 3.1).

The quality of the flour is checked during the reception, before storage, by establishing the sensory and physical-chemical characteristics and comparing them with those provided in the standards. For this purpose, samples are taken from each batch, which are mixed for uniformity, from which the average sample is made up.

The parametrs analysed in order to establish the flour quality are: color, smell, taste, infestation, metal impurities, granulation, wet gluten content, humidity, ash and acidity. Any deviation from the quality of the flour is reflected in the finished bakery product and leads to products with defects that will later become losses and waste. That's why the quality of the flour from a physico-chemical and microbiological point of view is considered a determining factor in avoiding technological losses in the bakery.

The smell, the taste, the infestation and the acidity give indications about the state of preservation of the flour, the metallic impurities about the impurity.

The types of flour differientiate depending of the ash content and the colour of flour differ according to the extraction degree.

Thus, flours of reduced extraction, coming only from the endosperm of the grain, have a white color with a yellowish tint, while those of higher extraction, in the composition of which parts of bran are included, have a white color with a yellowish tint gray or light gray.

The higher the proportion of bran found in the flour, so the degree of extraction is more advanced, the darker the color of the flour. The color of the bakery product largely depends on the color of the flour, because the enzyme tyrosinase oxidizes the amino acid in the flour, with the formation of black compounds called melanins (Alexa, 2008). Bread crust defects are also due to these compounds, a high content causing accentuated browning of bakery products and lead to waste due to the poor quality of the flour.

The grain size of the flour is of great importance in the manufacture of bakery products, as it significantly conditions the development of chemical, biochemical and colloidal process, as well as the rheological properties of the dough, on which the quality of the bakery products depends.

A flour of appropriate granularity, depending on the type of product to be obtained, will lead to bakery products without defects and implicitly to the reduction of losses.

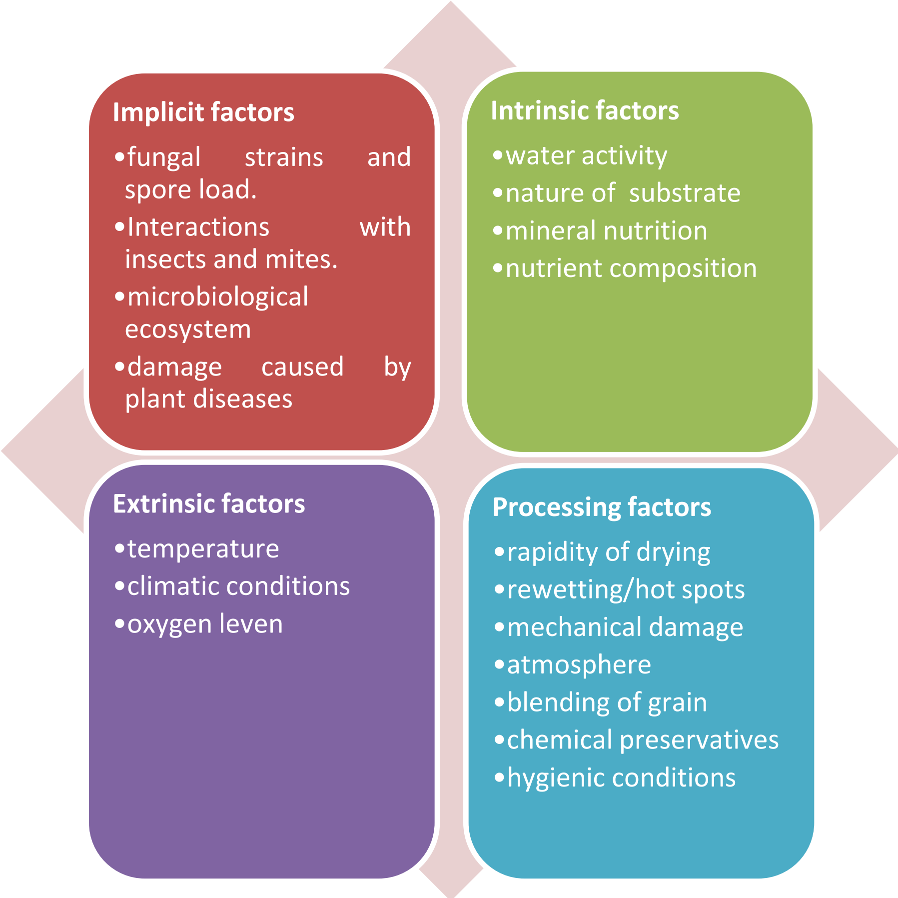

Figure 3.1. *Factors responsible for flour quality in order to avoid losses in storage stage (Magan and Aldred, 2007).*

The deterioration of flour occurs when the storage is done in improper conditions (Table 3.1.) and can result either as a result of natural processes (microbiological and biochemical) that take place in the flour, leading to self-heating and molding, or due to its degradation by insects (pests barn).

The self-heating and moldiness of flour represent the most frequent manifestations of alteration, taking place following the breathing process, which occurs according to the following scheme:

$$C_6H_{12}O_6 + 6\ O_2 = 6\ CO_2 + 6\ H_2O \text{ - with heat release}$$

The more intense the breathing process, the more heat and moisture accumulates, which in improper storage conditions produce self-heating of the flour, accompanied by the formation of lumps (a phenomenon called "hardening"), as well as mold, due to the development of the microflora in flour, in the initial phase, the self-heating gives the flour a stale smell.

The degradation of flour due to insects is primarily its impurity with larvae or adults, as well as the formation of flour lumps due to the viscous threads they secrete.

The most frequent pests are: the mole (*Tenebrio molitor*), also called the large flour beetle, the small beetle (*Tribolium confusum*), the brown beetle (*Tribolium castaneum*), the flour mite (*Acarus siro*) and the moth (*Pyralis farinalis*), infestation of flour with these pests become very fast, due to their vertiginous multiplication.

Table 3.1. Causes of flour degradation at the storage stage

Causes of flour degradation	Parameters to set	Measures
Improper storage conditions **Inadequate humitity and absence of ventilation**	Humidity, ventilation in storage rooms	warehouses should be clean, dry, healthy and well ventilated air temperature of 10-12°C
Improper placement of flour bags	Storage space configuration	- flour sacks must be stored on wooden grates to ensure ventilation of the stacks and on the lower part and not to draw moisture from the floor - between the bag stacks and the walls or between two stacks, a minimum 0.5 m inspection and ventilation space must be left;
Infestation degree	Insects control	Installation of traps for insect control Infested places are disinfected with insecticidal substances Separating the flour from insects by sifting using a suitable sieve, thus removing the larvae, chrysalises and even the adult insects.

		The remains of infested flour, together with the broom, are destroyed by burning. Keeping warehouses in a state of permanent cleanliness, ventilation and their dry state are the most effective measures to prevent the formation of outbreaks of infestation.
Fungal and mycotoxins contamination	Microbiological control	Physical-chemical methods for decontamination

In order to avoid the degradation of flour and the risks associated with handling and storage (Figure 3.2), regarding the appropriate settlement measures are necessary in flour warehouses. The warehouse of flour in bags consists of a room that ensures the following storage conditions: air temperature of 10-12°C, as constant as possible, good ventilation and sufficient natural light, respectively luminosity coefficient 0.12 (this coefficient representing the ratio between the surface of the windows and that of the floor). The bags are arranged in bags of maximum 6 rows in height in the warm season and max. 10 rows in the cold season, being placed in several ways on platforms or grates, which allow the flour to aerate.

When placing the bags with flour within the warehouse, the following minimum distances are taken into account:

- between the bags and the wall - 0.4 m,
- between two bags - 0.75 m, if there is no traffic
- 1.5-2.5 m, if the space between the bags is also space for circulation (Alexa et al., 2004)

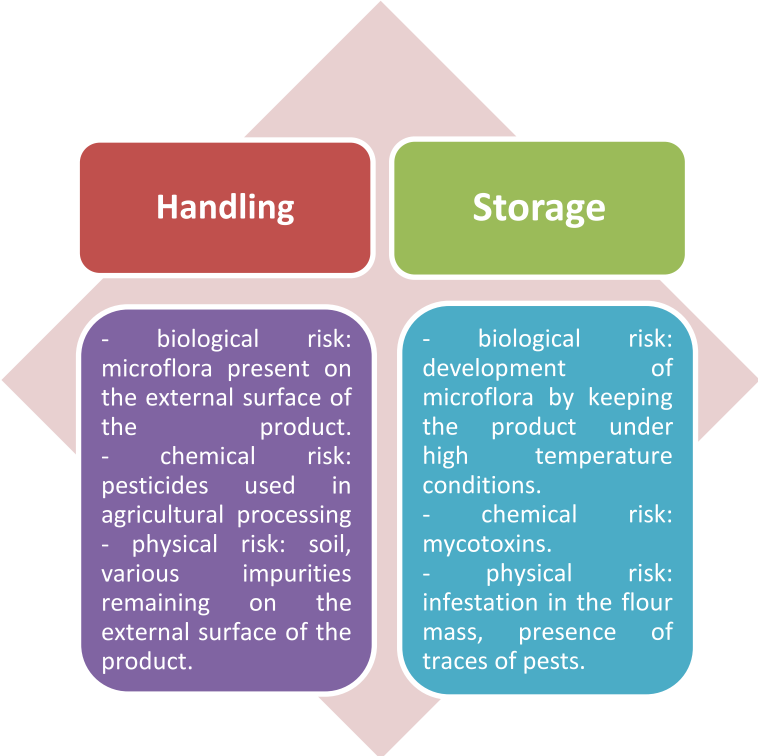

Figure 3.2. *Causes of risks at the handling and storage stage of flour products*

3.2. Causes of FW due to the physico-chemical processes that take place during flour storage

A series of physical, chemical and biochemical processes take place in manufactured and stored flour, which also depend on the storage conditions. These processes can lead either to the improvement of the baking properties of the flour or to the worsening of these properties. All these deficiencies in the production process generated by the quality of the flour lead to product losses and manufacturing waste (Figure 3.3.).

Moisture content

- The moisture content of the flour varies depending on its initial moisture, the storage temperature and the relative humidity of the air. Regardless of whether the humidity of the flour is higher or lower, a balance is established between the humidity of the flour and the relative humidity of the air, a balance also influenced by the temperature in the warehouse.

Color changes

- During normal maturation in storages, the flour lightens in color. A more pronounced opening occurs after a storage of 60-90 days and even after 1-2 years. The cause of the opening in color is due to the unsaturated structure of the carotenoid combinations, which become saturated and colorless through the binding of oxygen.

Carbohydrates content

- The amylolytic activity decreases during the first seven days of storage and then less and less, so that after 30 days charbohydrates contain remains almost constant.

Proteins content

- the total nitrogen content does not change, instead the soluble protein content decreases The wet gluten content decreases by 1-2%.

Lipids content

- flour glycerides are partially hydrolyzed under the action of lipases, releasing fatty acids and glycerin. The hydrolysis of glycerides is more intense if the humidity of the flour and the storage temperature are high. As a consequence of the hydrolysis of glycerides, free fatty acids accumulate, a fact that determines the increase in the acidity of the flour.

Acidity

- the acidity of the flour increases during ripening. In high-extraction flours that contain bran and germs, the acidity of ripening increases.

Figure 3.3. *Processes that take place during flour storage on which the quality of bakery products and FW depends*

The duration of natural maturation of the flour depends on: the initial quality of the flour, its extraction and humidity, the storage temperature, the aeration. The duration of natural maturation of flour is longer if the flour is of poor quality and the temperature in the warehouse is low. It was demonstrated that flour maturation is accelerated at 25-45°C.

3.3. Causes of food waste due to microbial contamination during storage

An important role in maintaining the quality of flour during the storage period belongs to the physico-chemical and microbiological control carried out in flour warehouses.

From a microbiological point of view, the major risk of flour contamination in storage depositions when the conditions are not appropriate and which determine the degradation of the flour is the contamination with mycotoxins. Wheat flours remain the predominant dietary source of mycotoxin exposure by consuming grainbased products. Wheat flour is susceptible to mycotoxin contamination from the field conditions or during storage by toxigenic fungi, such as *Aspergillus spp*., *Fusarium spp*., *Penicillium spp.*, and *Alternaria spp*. Key entry points into processed foods includes via bread and bakery products, breakfast cereals, snacks. The major contamination is produced by *Fusarium* mycotoxins which can enter the food chain in temperate cereals (Figure 3.4).

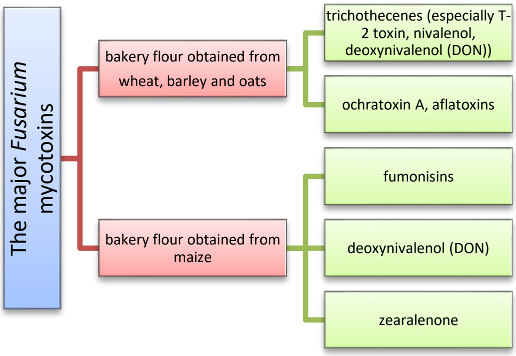

Figure 3.4. *The major Fusarium mycotoxins which can enter the food chain in temperate cereals*

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Bakery products are susceptible to fungal contamination that leads to reduce their shelf-life, resulting in food waste and economic loss. In addition to the aspects related to the losses suffered, fungal contamination also causes health problems considering the toxicity of the generated chemical compounds.

That is why fungal control is the best method for reducing waste in the bakery industry and at the same time to extend the shelf-life of bakery products. Differents methods are applied on reducing fungal and mycotoxins contamination currently focusing on physical methods (radio frequency sterilization, microwave sterilization, drying, pulsedlight, and low-pressure mercury lamp treatment) and chemical preservatives (calcium propionate, sorbate, benzoates, nitrites, and sulfites).

Although physical methods are better at maintaining taste, they destroy the nutritional value of bakery products and are often costly (Liu et al., 2022). European legislation setting the maximum admitted level for mycotoxins in flour and bakery products (Table 3.2.)

Table 3.2. Mycotoxins levels in cereal based products according to COMMISSION REGULATION (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2006.364.01.0005.01. ENG &toc=OJ%3AL%3A2006%3A364%3AFULL)

	Foodstuffs	Maximum levels (µg/kg)	
1	**Aflatoxins**	B_1	Sum of B_1, B_2, G_1 and G_2
1.1	All cereals and all products derived from cereals, including processed cereal products	2,0	4,0
2	**Ochratoxin A**		
2.1	All products derived from unprocessed cereals, including processed cereal products and cereals intended for direct human consumption	3,0	
2.2	Processed cereal-based foods and baby foods for infants and young children	0,50	
3	**Deoxynivalenol**		

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3.1	Cereals intended for direct human consumption, cereal flour (including maize flour, maize meal and maize grits, bran as end product marketed for direct human consumption	750
3.2	Pasta (dry)	750
3.3	Bread (including small bakery wares), pastries, biscuits, cereal snacks and breakfast cereals	500
3.4	Processed cereal-based foods and baby foods for infants and young children	200
4	**Zearalenone**	
4.1	Cereals intended for direct human consumption, cereal flour, bran as end product marketed for direct human consumption	75
4.2	Bread (including small bakery wares), pastries, biscuits, cereal snacks and breakfast cereals, excluding maize snacks and maize based breakfast cereals	50
5	**Fumonisins**	Sum of B_1 and B_2
5.1	Processed cereals-based foods and baby foods for infants and young children	200

A series of physical and chemical processes have been proposed to reduce the fungal incidence in flour and bakery products (Table 3.3-3.4).

Pulsed light is a nonthermal technology for the rapid inactivation of microorganisms. This method has found applicability in the decontamination of flour and bakery products. Microorganisms inactivation during pulsed light treatment is attributed to photochemical and photothermal mechanism.

Cold or nonthermal plasma is generated through electrical discharges to a gas at atmospheric or reduced pressure (vacuum) conditions. Previous studies have shown that treating wheat flour with cold plasma the protein sulfhydryl groups were oxidized, and these processes were reflected in increased of dough viscoelasticity, as well as an improvement of dough strength and optimum mixing time (Lopez and Simsek, 2021).

Radio frequency (RF) heating is an indirect type of electroheating, in which the electrical energy is converted into electromagnetic radiation to then generate heat on the product (Marra et al., 2009).

Calcium propionate and other chemical preservatives can be added directly to bakery products; however, long-term consumption of these preservatives may increase the risk of chronic disease. Biological preservatives, on the other hand, are more consumer-friendly, ecologically sustainable, and have prospectively broad applications in controlling fungal contamination. Lactic acid bacteria (LAB) have gained attention as a potential biological preservative option since they are generally recognized as safe, and produce metabolites that can inhibit fungal growth (Liu et al., 2022).

Guy et al. (2004) showed that brown bread after cleaning and scouring contained about 40–50% of the OTA regardless of starting contamination level. The rest was predominantly in the bran fractions. In white bread production OTA was mainly found in the white flour and bread (20–30%). Overall, the bran and offal flours which are important by-products that enter the food chains contain the highest OTA fractions. Deoxynivalenol is stable in many processes, however up to 50% survives dough fermentation. With regard to zearalenone, 60% has been found to survive in bread and 50% in noodles.

The experimental results carried out on wheat and flour batches indicate that there is no correlation between the organoleptic examination and the result of the mycological examination. The examined samples corresponded from an organoleptic point of view, even in the situation where mycotoxin contamination was advanced, which indicates the need for mycological analytical examination to guarantee the healthiness of cereals and cereal derivatives.

In the baking of bread and cakes with cereals containing ergotoxins, a 59-100% reduction of individual ergolines (ergosine, ergocornine, ergometrine, ergotamine, α-ergocriptine, ergocristine) was observed in wholemeal bread, a reduction of 50-86 % in rye flour bread and a 25-74% reduction in triticale cakes (Sancis, 2000).

In Romania studies were carried out regarding the possibility of reducing ochratoxin A contamination by processing wheat into flour and bread (Alexa et al., 2004). In order to study the reduction of OA contamination through thermal processing, flour contaminated with OA was analyzed by heating at temperatures between 150-200^{0}C, in the presence or absence of steam (Alexa, 2003).

The possibility of reducing the contamination of cereal products with ochratoxin A using physical-technological methods of processing, namely grinding the grains and removing the covering in the form of bran by sieving, was studied by artificially contaminating wheat flour with 20 g ochratoxin A, keeping it in resting for 24 hours and separating the endosperm from the shell by sieving (Cabanes, 2000).

Table 3.3. *Methods for reducing fungal and mycotoxins contamination in different flour during storage*

Contamination	Measure	Conditions	Effect	References
Flour contamination with total bacteria	Dry heating	80-180^{0}C 5sec-15 min		Rose et al., 2012
Wheat flour with Staphylococcus aureus, E.Coli	Dry heating	290^{0}C 5 min	Reducing contamination from 2700 cfu/g until 120 cfu/g	Upreti et al., 2010
Wheat flour with aerobic mesophilic bacteria and Enterobacteria ceae	Chemical treatment	5.0% lactic acid– NaCl	reductions of 3.1 ± 0.1 and 4.5 ± 0.0 log CFU/g,	Sabillón et al., 2019
Flour contaminated with *Saccharomyces cerevisiae*	Pulse	Duration of 0.3 μs, with dose of 0.49 J/cm2	10.1% of *Saccharomyces cerevisiae was inactivated*	Fine and Gervais (2004)
Unbleached wheat flour with *Salmonella*	Pulse	Pulse duration of 10 ms, with 395 nm wavelength	2.48 log CFU/g reduction in Salmonella load	Subedi et al. (2020)
Unbleached wheat flour with *Salmonella*	Pulse	Pulse duration of 10 ms, with 395 nm wavelength	2.91 log CFU/g reduction in Salmonella load	Du et al. (2020)

		applied during 60 min		
Wheat flour contaminated with aerobic mesophiles, thermophiles, and molds	Cold atmospheri c pressure plasma	Power supply frequency was 9 kHz, voltage at 15–20 kV. Treatment time was 60 or 120 s	No reduction levels	Bahrami et al. (2016)
Soft white wheat organic pastry flour contaminated with Salmonella	Radio frequency (RF) heating	0.5 kW, 27 MHz RF heating unit, electrode gaps 90 mm and polystyrene cylinders	7 log CFU/g reductions in Salmonella	Villa-Rojas et al. (2017)
Soft winter wheat organic flour contaminated with Enterococcus faecium Salmonella	Pasteurizati on	6kW, 27.12 MHz RF heating unit. Electrode gap 35 mm. Aluminum test cells and 85°C, 33 min	3.7 log CFU/g reductions in Enterococcus faecium and 5 log CFU/g reductions in Salmonella	Liu et al. (2018)
		6kW, 27.12 MHz RF heating unit. Electrode gap 35 mm. Aluminum test cells and 85°C, 27 min	4.9 log CFU/g reductions in E. faecium	
Soft winter wheat organic flour contaminated with Enterococcus faecium Salmonella	vacuum steam treatment	vacuum steam treatment at 65°C for 8 min	3.57 and 3.21 log CFU/g for E. coli and Salmonella enterica subsp. enterica serovar Enteritidis PT 30, respectively. T	Log5 (2010)

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Wheat infestata cu insect in timpul bulkdepozitarii	Irradiation	Treatment with 1, 10 and 25 kGy of radiation from a ^{60}Co source	1 kGy reduced viable microorganism by 2 logs 10 kGy completely eliminated bacteria	Hanis et al.,(1988)
Flour with microbial load	Ultraviolet radiation combined withozone	20 mg/kg of flour	Microbial load was reduced by ~ 2 logs	Laszlo et al. (2008)
Wheat flour infected with microorganisms	Radio frequency irradiation	Treatment with radio frequency up to temperature of 75-100°C, followed by cooling and cold air	Reduction of 4-7 log in bacteria	Weaves et al. (2011)
Wheat flour contamined with Ochratoxin A (OTA)	Cooking in electric oven	180^{0}C, without steam, 30 minutes	Reduction of OTA content from 10 ppm to 3 ppm	Alexa et al., 2004
		200^{0}C, without steam, 20 minute	Reduction of OTA content from 10 ppm to 0.5 ppm	Alexa et al., 2004
		2500C, fără abur, timp de 30 minute	Reduction of OTA content from 10 ppm to nedetectable value	Alexa et al., 2004

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Table 3.4. *Reducing of mycotoxins contamination using physical methods*

Mycotoxin	Product	Content (%)	References
OTA	brown bread	40 - 50	Guy et al. (2004)
	bran fractions	50-60	
	white bread	20.-.30	
	white flour	20 - 30	
Deoxynivalenol	fermented dough	50	
Zearalenone	bread	60	
	noodles	50	
DON	maize grits	10 – 20%	

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Chapter 4

Possible causes of FW at the processing and packaging stage of flour products. Unavoidable losses-technical inefficiencies and malfunctions - methods and changes in processing

4.1. Research and studies carried out regarding the possible causes of FW in the processing and packaging stage of flour products.

Over time, researchers and companies have tried to find better alternatives to reduce food waste, this being identified as one of the greatest sources of inefficiency in the food system (Tiwari and Khawas, 2021; Gorynska-Goldmann et al., 2021, Svanes et al., 2018). Thus, reducing the scale of food waste is one of the most urgent challenges for food system operators, starting from agriculture to food consumption in the households, especially that food insecurity has deepened during the COVID-19 pandemic (Gorynska-Goldmann et al., 2021).

Agro residues are mainly obtained from agricultural production (harvesting and processing in farm areas) and from agricultural processing industries such as: milling and bakery industry, oilseed extraction, from distilleries and breweries, malt production, from sugar, starch, and confectionary industry as well as fruit and vegetable processing. Studies claim that these food wastes hold tremendous potential source of protein supply for animal feed and can also be converted to biofuels, bioenergy and other products in a way that produces economic value. (Tiwari and Khawas, 2021).

Ajila et al. (2012) has reported that the handling and technologies used for processing of by-products are generally based on their type.

There are few studies on how to reduce food losses in food processing sectors, as most researchers focus on the agro-residues and demand side of the market; it could be noticed a maximum interest in public catering and household consumption. Dumitru et al. (2021) reports in a study conducted in Romania that the food waste in the public catering is 8.63%, and for household consumption 6.50%. Moreover, household consumers represent up to 40.78% of the total FW in Romania.

Regarding the level of FW on the entire food chain, the authors reported the values of 3.79%, while food processing higher losses have been reported for the bakery (6%) and for the meat industry (7%). Also, the authors report that the food processing faces problems related to the capitalization of by-products resulting from technological processes, but also problems related to the oversupply of raw materials and the emergence of defective products. Distribution has significant sources of losses, mishandling of products, and oversupply of certain assortments which are not sold fast enough. The study was carried out between June and September 2020 for the four links of the food chain: public catering - HoReCa, distribution, processing, and primary production, applying 825 questionnaires.

Contacting the respondents and administering the questionnaire were done by an authorized call-center software system. According to the turnover recorded in 2018, Dumitru et al., 2021 chose the leading 800 economic agents in Romania from each link in the food chain. The identified FW-reduction methods for food processing and distribution are shown in table 4.1:

Table 4.1. *Most efficient and implemented FW control measures along the food processing and distribution (Dumitru et al., 2021)*

Measure	Food processing		Food distribution	
	Most efficient measures (%)	Implemented FW control measures (%)	Most efficient measures (%)	Implemented FW control measures (%)
Use of waste as fertilizer	1	0	0	0
Donations	2	1	4	3
Valorization of byproducts internally or by marketing (e.g.,	11	1	3	1

incorporation into other products, animal feed)				
Marketing of products at a reduced price	0	0	2	2
Selective collection	0	0	1	1
Waste to be taken over by a neutralization company	1	0	1	0
Production optimization through new technologies or supply management	1	9	2	8
Other	0	2	0	1
None/Not the case	**63**	**70**	**67**	**64**

Table 4.1 demonstrates that the primary strategy for reducing waste in the food processing industry is internal or external marketing of byproducts (e.g., incorporation into other products, animal feed), accounting for 11% of the total, while the primary strategy for reducing waste in the food distribution industry is donation (4%).

Regarding the implementation of FW control measures along the food chain, the food production and distribution sectors focus on production optimization through modern technologies or supply management (8-9%). However, more than half of the respondents do not know the causes or did not answer.

As a result, the study conducted in Romania by Dumitru et al., 2021, shows that a significant number of food chain operators are unaware of attempts to restrict food waste. Table 4.2 shows that the proportions for the negative answer groups—denial of any measure or ignorance (N/A)-are above 90%:

Table 4.2. *Knowledge of existing FW control measures along food industry (Dumitru et al., 2021)*

Measure	Existing measures for reducing FW on Romanian scale (%)	
	Food processing	Food distribution
Encouraging donations/ Creating food banks	3	4
Awareness campaigns	0	0
Implementing coherent supply system	1	1
Monitoring FW collection/recycling	1	0
Promoting advanced technologies	0	0
Promoting production fit to demands	0	0
Sales campaigns	1	2
Legislative measures	0	0
Other	2	2
None	**69**	**76**
N/A	**20**	**15**

Cereal processing and flour production play an important role in Europe and in the world as well. Processing has often an output by producing secondary raw materials which has gained attention recently in relation to the European Union's commitment to the transition towards the Circular Economic model. Comino et al. (2021) have focused on the use of organic residues obtained by cereal processing, such as wheat dust, conducted by a small-size milling industry to produce bio-based materials.

Regarding the grain flour production, Yanova et al. (2019) have declared the main point to avoid the losses and waste in flour industry – namely by increasing the quality of flour products. The authors show that new technologies in the industry, such as extrusion allows obtaining flour from extruded wheat grain with 96% output, 91% from extruded barley grain, and 90% of flour from extruded oat grain which is higher than using the existing technologies (table 4.3).

Table 4.3. *Percentages (%) of output in the processing of wheat, barley, and oat in terms of existing technologies and proposed technologies (according to Yanova et al. 2019)*

Name of product	Existing technology, %	Proposed technology, %
Wheat		
Wheat flour	77.5	96.0
Fodder flour and bran	18.0	1.4
Fodder grain product	2.9	0.0
Waste and mechanical losses	0.3	0.3
Shrinkage	1.3	2.3
Total	100	100
Barley		
Barley flour	68.0	91.0
Fodder flour and bran	21.0	3.0
Fodder grain product	6.0	0.0
Waste and mechanical losses	3.7	2.7
Shrinkage	1.3	3.3
Total	100	100
Oat		
Oat flour	64.0	90.0
Fodder flour and bran	25.0	3.7
Fodder grain product	5.6	0.0
Waste and mechanical losses	4.0	3.0
Shrinkage	1.3	3.3
Total	**100**	**100**

Using traditional methods in flour production decrease somewhat the nutritional value (minerals, vitamins, proteins) of the flour, and the low-quality grain and flour by-products were used for producing animal feed. But by using the new technologies, the nutritional value of the grain is maintained at maximum level and the flour products have higher quality and produce less waste. Yanova et a. (2019) found that the proposed extrusion technology for grain processing of the main cereal crops can increase the flour output by reducing the amount of waste, bran and mechanical losses in the processing of grain: wheat flour by 18.5 %, barley - by 23%; oat - by 26 %.

Verni et al. (2020) claim that in practice, most of the bread that is not consumed is usually disposed of as food waste. Moreover, as stated by Lebersorger and Schneider (2014), food losses are the total quantity of food items that have not been sold and were returned with different causes, such as packaging defects, the expiry date, or the date of sales.

Research claims that, bread waste can be used for recovery in anaerobic digestion, animal feed, as a substrate for bakery yeast production, and biofuels (Iakovlieva, 2021). However, even if all practical alternatives could compensate for the environmental impact, none of them compensates for the economic losses.

Thus, recently Gorynska-Goldmann et al. (2021) conducted research to estimate the scale of losses in the baking and confectionery industry in Poland, to determine their causes and assess the risk of their occurrence.

Also, research was conducted to identify retrieve points and the ways of reducing and preventing losses. The authors of this research reported losses estimated in the range 1.2–8.5% for the processing level of bakery and confectionary industry.

4.2. Causes of FW identified in the processing stage of flour products

Unavoidable losses - ineffectiveness and technical malfunctions - methods and changes in processing

Gorynska-Goldmann et al. (2021) conducted research over a two-year period (2017–2018) with a focus on reducing food losses and developing more sustainable methods for the management of resources in the baking and confectionery business. The authors believe that increased customer expectations paired with more effective baking and confectionery manufacturing will cause the sector to concentrate on producing high-quality goods.

In their research, the authors identified 9 main *categories of causes* for the food waste (FW) during processing in baking and confectionery industry, but also other causes generated by unavoidable losses, technical inefficiencies, and malfunctions.

In the production section two possible causes of FW were identified, while the unavoidable losses, technical inefficiencies and malfunctions related to these causes were found to be as following (figure 4.1):

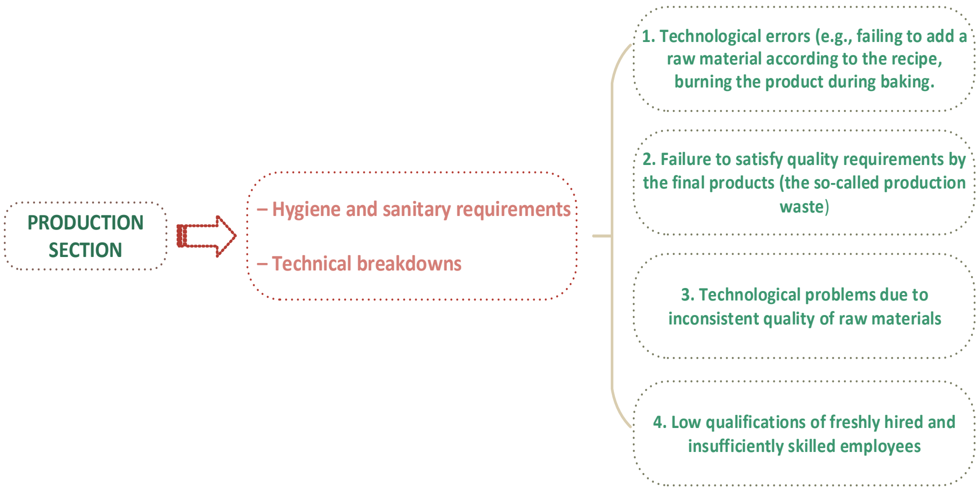

Figure 4.1. *Possible causes of and losses in the production section (adapted after Gorynska-Goldmann et al., 2021)*

For this study, the authors collected quantitative data using an internet survey method. The survey was conducted between 2 January and 20 February 2020 on a sample of 48 Polish bakeries, and the qualitative information was obtained through five individual, in-depth interviews with professionals in the examined industry. According to the findings, the weight of produced goods lost overall in the baking and confectionery business in 2017 and 2018 was 2.39% and 2.63%, respectively. The loss analysis it was made within the sections of the production units: storage of raw materials, production section, storage of final product, transport of the finished product. The highest loss level was reported for production section—1.56% (2017), 1.85% (2018).

In the study done by Gorynska-Goldmann et al. (2021), the studied firms reported that the symptoms of spoilage, mold, and contaminants, all brought on by inappropriate storage and handling or low quality of raw materials, are the most frequent causes of losses at storage of raw materials. The second source of the losses was mechanical damage, which resulted in 13% and 15% of the mass of losses and accounted for 43% and 37% of the overall mass of losses in the storage. A third of the mass of production losses (62–65%) were caused by the production section's two recognized probable sources of FW, namely the inability to meet sanitary and hygienic standards and technological malfunctions. The difference of 35–38% was accounted for by the unavoidable losses, technical inefficiencies, and malfunctions.

Table 4.4. *Causes identified in the processing stage of flour products*

Causes identified	Consequences
Improper organization of the environment in which flour products are made. secondary impurities. Human factor	Ambient impurities – physical hazard Impurities caused by pests Contamination caused by employees that do not respect hygiene procedures. **Production losses and customer complaints**
Lack of supervision over machinery and equipment	Improper quality of semi-finished products ready for baking **Production losses**
Improper conditions of production of flour products. Secondary impurities. Human factor	Ambient impurities – physical hazard Impurities caused by pests Impurities caused by employees failing to observe good hygiene practices. **Production losses and customer complaints**
Improper handling of the production process	Products failing to satisfy the specified quality criteria

	Improper net weight of the weighted dough portions **Production losses**
Improper operation of the oven, with no supervision of the equipment	Failure to observe the process parameters; oven malfunction **Production losses**
Lack of supervision over equipment and machinery	Improper supervision of maintenance of slicing equipment Dull knives may deform or damage the sliced products thus affecting the product aspect **Slicing losses**
Employers' errors and neglect during bulk packing	Damage and deformation of goods that leads to disposal to waste **Losses identified during storage of the final goods or in retail**
Overestimation of orders	Too many final products with short shelf life stored **Production losses in the final Product Magazine**
Improper means of transportation, unfit for transporting foodstuffs, no sanitary approval. Improper sanitary and hygiene condition of the means of transportation.	Reduced quality of the transported goods. Permanent damage of the final goods making them unmarketable **Losses in transport**

One of the main reasons of wastage of flour products in the supply chain is the fact that they lose their freshness very fast and are no longer accepted by the consumers. Improper management of the production process may lead to quality problems and thus to food waste because the products will not be accepted.

For example, failing to maintain the controlled temperature may to microbial growth causing problems related to food safety, product failures and costumer complaints.

Overproduction is also one of the main causes of food waste in the bakery industry. Overproduction is often caused by the improper organization of production activities and distribution of goods.

Many problems in the production process of the flour products appear due to the human factor. This is because due to lack of training, unverified skills, and high rotation of employees many problems could appear that could cause food waste.

Also, non-compliance with the food processing hygiene may lead to obtaining goods that fail to satisfy requirements and will be removed and possibly wasted.

Other common cause of food waste in the flour products is interruption of the cold chain due to a defect of the means of transportation, the refrigerated storage or negligence in controlling storage conditions, or inefficiency of supervision over maintaining the cold chain.

4.3. Causes of FW identified in the packaging stage of flour products

Most losses from the three pre-defined sources during final product storage and transport-roughly 27–29% of the stated, section-specific losses—came from broken packing. For those two years, the effects of breakdowns ranged widely from 4% to 16%. Other causes generated by unavoidable losses amounted 48% and 57% of losses of this technological phase, these being represented by returns of unsold bread (table 4.5). In 85-87% of the cases, mistakes made when making orders led to food waste during self-transport. This indicates that these losses are caused by human mistake or by systemic flaws in order placement and handling. Damaged final product packing accounted for almost 10% of losses, followed by errors (Gorynska-Goldmann et al., 2021).

Table 4.5. *Causes for losses in the packaging stage (adapted after Gorynska-Goldmann et al., 2021)*

Process stage	Cause	Losses foods waste (%)
Final product-storeroom	Damaged packaging	27–29
	Hygiene and sanitary requirements	9 – 10
	Unavoidable losses and returns of unsold bread	48 – 57
	Breakdowns	3 – 16

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Final product transport	Placement and handling systems (*errors made by employees or errors attributed to order placement and handling systems*)	85 – 87
	Damaged packaging	9 – 12
	Breakdowns	3 – 4
	Incomplete packaging	< 1

Sucipto et al. (2020) point out three main processes in the wheat flour milling industry, namely cleaning, milling, and **packing**, and the last step produces many defective products due to a broken pack leak. The authors used a factor analysis system and performed Failure Mode and Effect Analysis (FMEA) which showed the main causes of the pack leak and ranked the failures (table 4.6).

Table 4.6. *FMEA flour packaging process failures, failure modes and effects (according to Sucipto et al. 2020)*

No	Failure	Failure Mode	Failure Effect	Rank
1	Packaged substitution in the production	Stock flour is used up	Need re-filling & packing machine adjustment	-
2	Lack of workers in secondary packaging	The allocation of workers is less precise	Products accumulate in the conveyor belt cause bottlenecks	4
3	Inaccurate filling machine	lack of skilled workers	Many perfect non-sticky packaging causes broken packs, and clipped packaging is not precise	3
4	Inaccurate speed of conveyor belt resulting in bottlenecks	Fewer experts in an adjustment of discharge packing	Broken pack	-
5	Delay in shutdown the filling & packing during machine failure	Operator responsiveness	There is a bottleneck that causes a broken pack	1
6	Blunt sealer blades	The hot plastic seal attached to the packaging machine	The package is not cut perfectly	-

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7	Heater sealer disconnects	Packed old sealers	The packaging is not well full	-
8	Poor packaging quality	The control lack of consumer pack suppliers	The packaging is too thin and easy to tear	2

Many processing units aim to reduce losses by extending the life of the bread. The *best example is the packaging*, which protects the product from drying out as well as from microbial contamination and other degrading factors. Svanes et al. (2018) claim that consumers also employ strategies to preserve the freshness of the bread such as: frozen storage, toasting or changing the packaging. In their research, the authors showed that almost 100% of consumers use an extra bag, whereas only 43% use freeze storage and 31% toast the bread.

So, food packaging must continue to be maintaining the safety, wholesomeness, and quality of food. The impact of packaging waste on the environment can be minimized by prudently selecting materials, following Environment Protection Authority (EPA) guidelines, and reviewing expectations of packaging in terms of environmental impact (Marsh, 2007).

In this regard some examples are:

Intelligent packaging

To reduce food waste, it is possible to use intelligent packaging. For about five decades, plastic packages have been widely used by the food industry due to their advantageous characteristics. Since this field is developing in the last years smart packaging was developed.

Smart packaging describes new packaging concepts, most of which can be classified in of two main categories: active or intelligent packaging (figure 4.2).

Figure 4.2. *Classification of innovative food packaging systems. (TTIs: time-temperature indicators; RFID: radiofrequency identification)*
(Taken from Jinsong Z., J. Feng, 2022)
(https://www.sciencedirect.com/science/article/pii/S2666833522000855)

The characteristics and the roles of intelligent packaging are presented in figure 4.3:

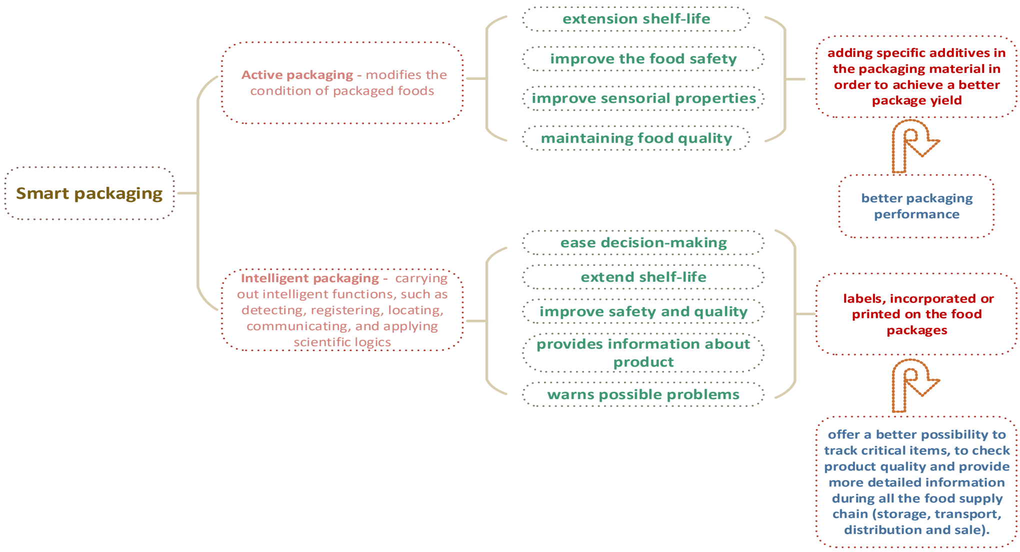

Figure 4.3. *The characteristics and the roles of smart packaging*

Active packaging

This are one of the most dynamic technologies used to preserve foods. They are based on the specific properties of the polymers used and the additives added in the packaging system. The active agents could be incorporated into the packaging material, coated on its surface but also included in materials associated with the packages such as bags, labels, pads. This way is a better choice because they don't interfere with the product's organoleptic properties.

Currently there is a trend for using natural additives in the food products because the synthetic ones are sometimes associated with different health risks.

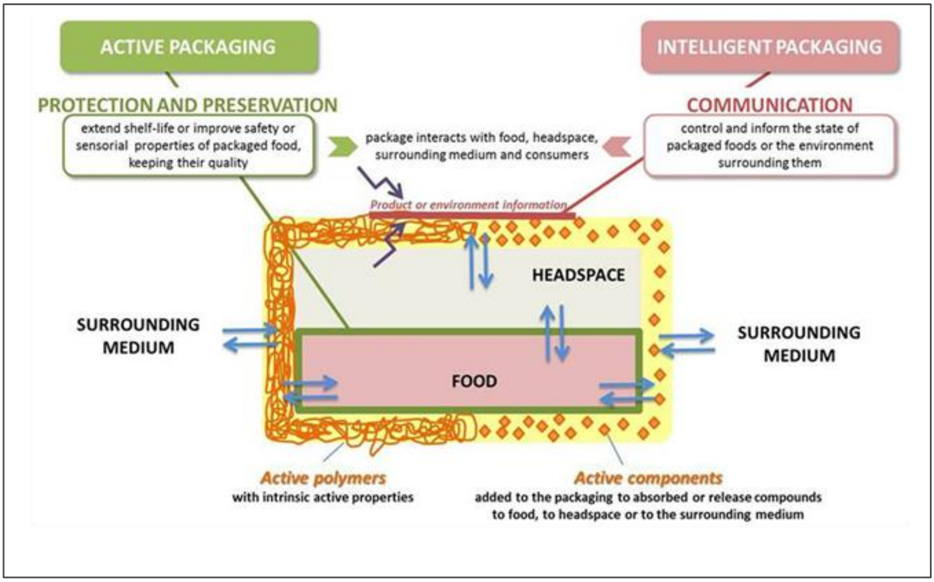

Figure 4.4 *Schematic diagram of active and intelligent packaging concepts (Salgado, P., Di Giorgio, L., 2021) https://www.researchgate.net/publication/351212726_Recent_Developments_in_Smart_Food_Packaging_Focused_on_Biobased_and_Biodegradable_Polymers*

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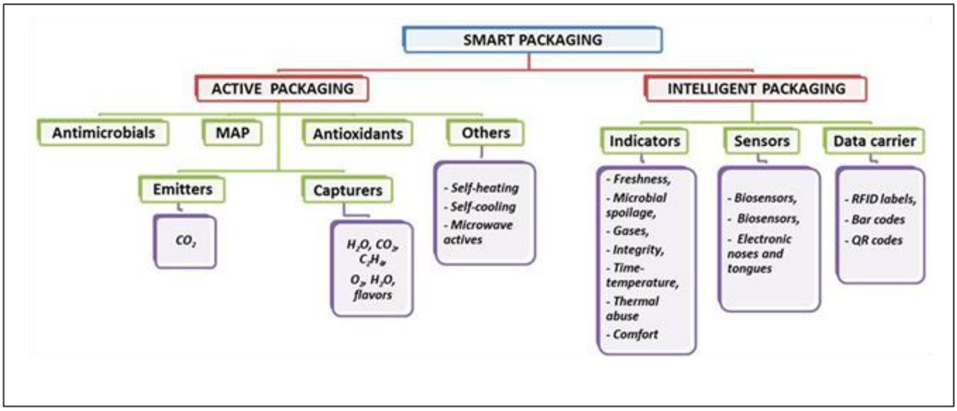

Figure 4.5 *Classification of smart food packaging described (Beshai, H., Sarabha, G., 2020). https://www.researchgate.net/publication/345681867_Freshness_Monitoring_of_Packaged_Vegetables/citation/download*

The effects of intelligent active packaging on food are presented below:

Antimicrobials

One of the problems that appears after the packaging is microbial growth that leads to food-borne disease risks and accelerates smell, color and texture changes of foods and can lead to a shorter shelf-life.

There are two types of antimicrobials used. The first type are the antimicrobial agents which act by migrating to food surface. The second type are effective against surface microbes without requiring the migration of the active agent to food.

Antioxidants

The second cause of food spoilage is lipid oxidation. It causes the appearance of rancid smells and thus making the product unacceptable for human consumption. For the antioxidant package there are two methods that can be applied:

- Addition of antioxidant compounds
- Elimination of undesired

The direct addition of antioxidants to food surface can face the limitation that once the active compounds are consumed in the reaction, protection ceases, and food quality degrades at a higher speed. It can also have other effects like changing the food parameters (color, taste, etc.).

Thus, a good alternative has become the addition of antioxidant agents in the packaging formulation.

Moisture absorbers

These are devices that try to control water activity inside the package for reducing the microbial growth. They have been used to eliminate defrosting water from frozen products and different fluids in meat products – blood for example.

They can be classified as:

- Relative humidity regulators that absorb moisture and control humidity in the package
- Desiccants (liquid removers) that can absorb and hold exuded liquids from food products

Modified Atmosphere Packaging (MAP)

This technology involves the alteration of gas atmosphere inside a food package in order to preserve the food quality for extending the shelf-life.

Oxygen scavengers

Oxygen accelerates the oxidative spoilage of foods and the growth of aerobic microorganisms that leads to the appearance of nasty smells, unwanted color change and loss of aroma.

They act in the following way: they react with the water from food and produce a hydrated metal reducing agent that absorbs oxygen and converts it into a stable oxide. These types of systems can be incorporated as part of the multilayer films or physically absorbed or coated on the surface of the packaging materials or the food surface.

Carbon dioxide (CO_2)

For inhibiting a wide range of aerobic bacteria CO_2 can also be added to the packages.

Flavor/smell capturers

These systems absorb unwanted gas molecules such as volatile ingredients of the package, food chemical metabolites, products of microbial and deterioration products, being used as smell capturers.

The roles of the active packaging and the agents used to achieve its purpose are presented in the table 4.7:

able 4. 7. *The roles, effects and agents used in the case of active packaging (after Salgado et al. 2021 and Huai et al., 2021)*

Active packaging	Effects of active packaging	Agents used	Roles of active packaging
Active packaging	Antimicrobials	✓ Organic acids (*sorbic acid, benzoic acid, acetic acid, propionic acid, ascorbic acid*). ✓ Nanocomposite films such as *chitosan, gelatin* and corn starch.	✓ antimicrobial action.
		✓ Bacteriocins (*nisin*, produced by *Lactococcus lactis*).	✓ action against gram-positive bacteria.
		✓ Enzymes: *Lysozyme.*	✓ can inhibit bacterial infections caused by gram-positive bacteria.
		✓ Inorganic and metal oxide based-nanoparticles (*ZnO, MgO, CuO and* TiO_2).	✓ antimicrobial agents
		✓ Macromolecules (*the chitosan polymer*).	✓ antimicrobial agents.
		✓ Ethanol	✓ antimicrobial agent due to its efficiency on fungi, but it can also inhibit the growth of yeast and bacteria.
	Antioxidants	✓ Synthetic antioxidants (*butylated hydroxyanisole* (BHA)).	✓ prevents lipid oxidation and sensory changes.

		✓ Natural antioxidants *(tea polyphenols and phytic acid*).	
	Moisture absorbers	✓ Desiccants as silica gel, CaO, $CaSO_4$, $CaCl_2$, KCl, K_2CO_3, natural clays, fructose, xylitol and sorbitol.	✓ control water activity. ✓ eliminate defrosting water from frozen products and different fluids in meat products.
	Modified atmosphere packaging (MOA)	✓ O2 ✓ N2 ✓ CO2.	✓ preserve the food quality for extending the shelf-life.
	Flavor/smell capturers	✓ zeolites, clays and activated charcoal, maltodextrin and cyclodextrin	✓ prevents lipid oxidation and sensory changes

Intelligent packages

The technology is based on the use of indicators, sensors, and data carriers.

Indicators supply immediate information regarding food, like color change, temperature change, etc. Sensors can detect molecules of pathogens, pollutants and allergens in the food matrix. Data carriers are new devices that provide information or control the flow of products.

Freshness and microbial spoilage indicators

These indicators can provide information on food product quality from biochemical change or contaminating microorganisms' growth.

The concentrations of the substances used are monitored through indicators and are generally observed as change in color response correlated with the product freshness.

Biosensors

They can be used for product freshness control, reducing food waste and food-borne illnesses risks. Biosensors function in the following way: they contain bio-receptors that recognize the desired analyte and transducers to turn the biochemicals signals into a quantifiable electronic reply. By the new developments, nanotechnology, can being use in this. Gluten is one of the components that can be detected, and because some persons are intolerant to this ingredient it is very important. It can be detected by the conventional enzyme-linked immunosorbent assay based on an electronic sensor based on antibodies used as selective receptors to bind the gluten.

The roles of the intelligent packaging and the agents used to achieve its purpose are presented in the table 4.8:

Table 4.8. *The roles, effects and agents used in the case of intelligent packaging (after Salgado et al. 2021)*

Intelligent packaging	Effects of intelligent packaging	Agents used	Roles of intelligent packaging
Intelligent packaging	**Freshness and microbial spoilage indicators**	✓ Glucose, organic acids, volatile nitrogen compounds, biogenic amines, ethanol.	maintaining food quality (from biochemical change or contaminating microorganisms' growth).
	Biosensors	✓ Optical, calorimetric, electrochemical devices. ✓ Nanobiosensors	✓ product freshness control biological eactions). ✓ detects pathogens, chemical polluters, poilage, and product handling.

The demand for fresh and quality packaged food and concern for longer shelf-life of the food products are driving the market for global active and intelligent packaging technology for food and beverage market.

4.4. Methods to prevent FW at the processing of flour products

Considering the survey made by (Gorynska-Goldmann et al., 2021), it could be identified **6 technological operations**, as ***recovery points for FW***, indicated in figure 4.6:

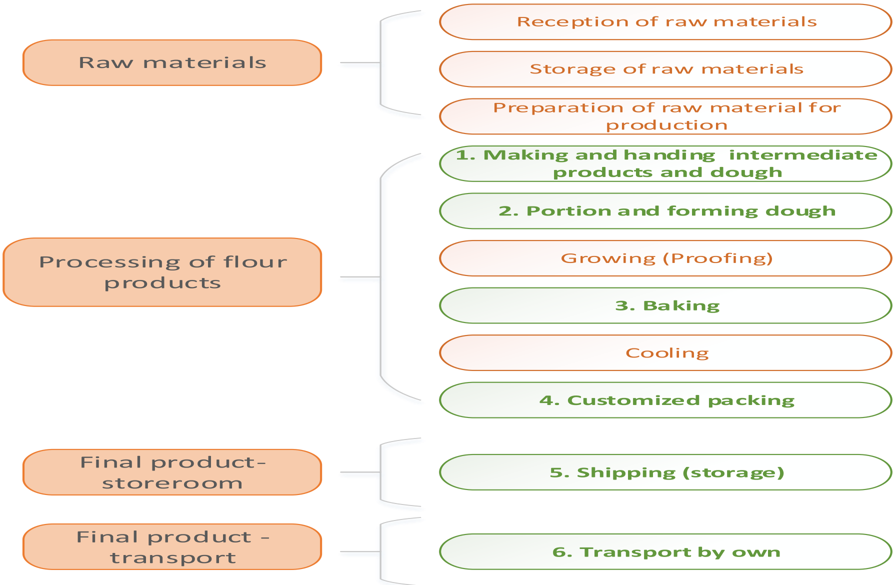

Figure 4.6. *Potential retrieve points highlighted in the processing of flour products (adapted after Gorynska-Goldmann et al., 2021)*

Moreover, Gorynska-Goldmann et al., 2021 identified the following 12 categories of losses concerns (food waste) associated with the production of wheat products:

1. raw materials that don't meet acceptable quality standards;
2. unsuitable raw material storage conditions;

3. mistakes made when preparing raw material mixes for certain recipes and when weighing them;

4. physical contaminants;

5. incorrect circumstances for carrying out certain production process phases;

6. unskilled and inexperienced workers;

7. secondary contaminants;

8. poor cutting and packaging circumstances;

9. incorrect labelling or damage to the finished items;

10. microbiological risks;

11. overproduction;

12. deterioration when finished items are being transported

This critical analysis leads to several **causes** and **methods of preventing FW** during processing, packaging and transport of the flour products. These was identified for the **6 technological operations as recovery points** for FW, are indicated in figures 4.7 - 4.12:

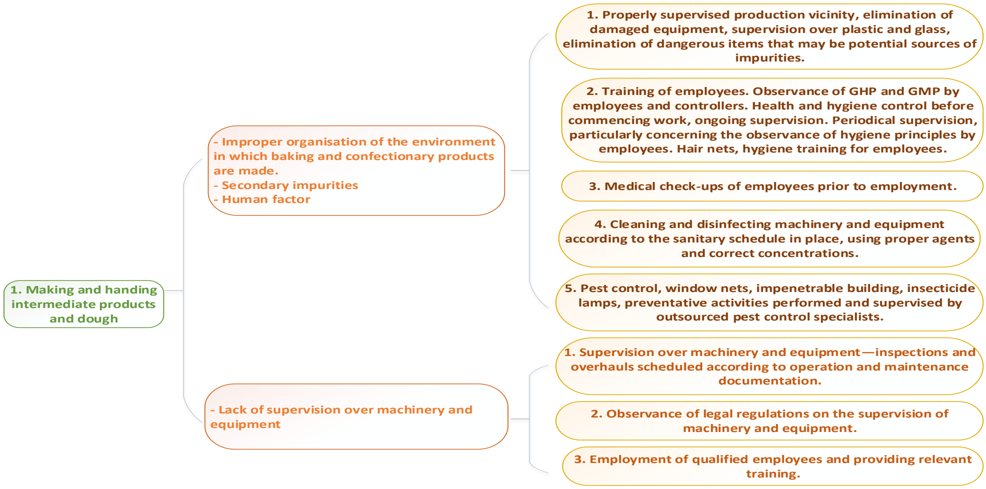

Figure 4.7. *Possible causes and methods of preventing FW during making and handling intermediate products and dough*

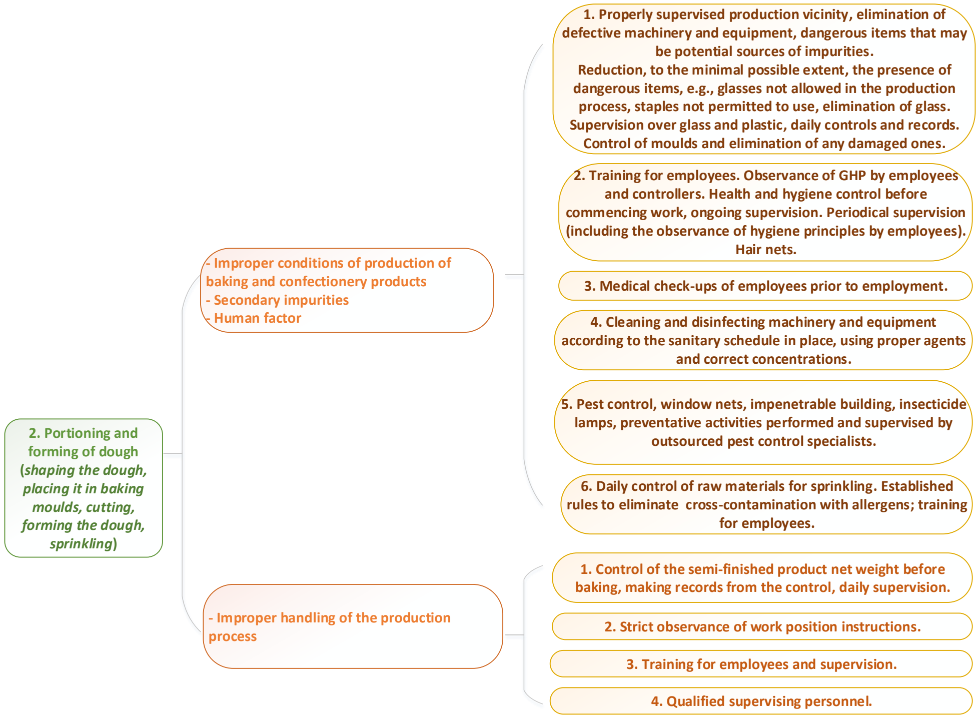

Figure 4.8. *Possible causes and methods of preventing FW during portioning and forming of dough*

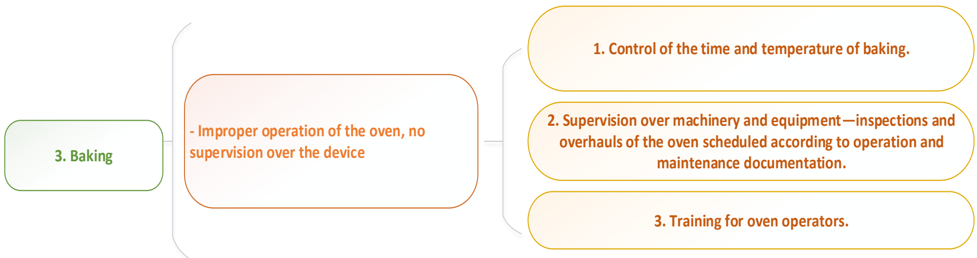

Figure 4.9. *Possible causes and methods of preventing FW during baking*

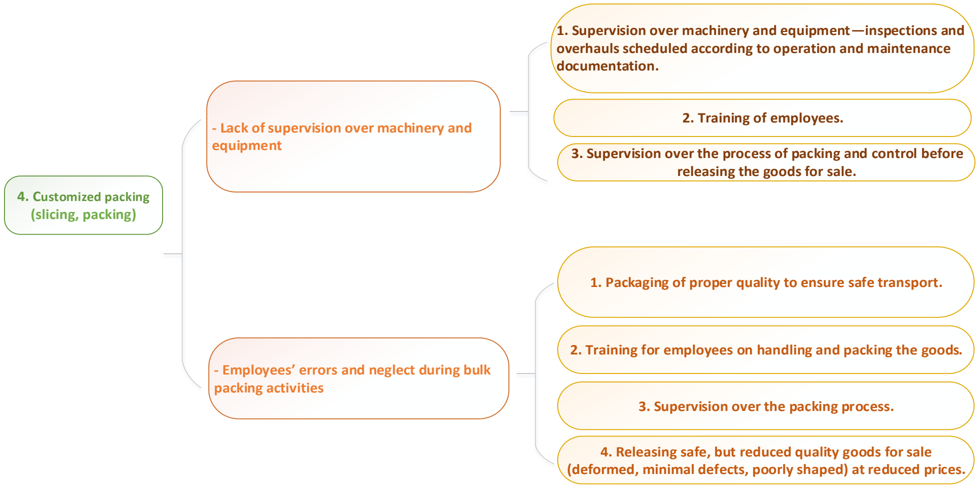

Figure 4.10 *Possible causes and methods of preventing FW during customized packing*

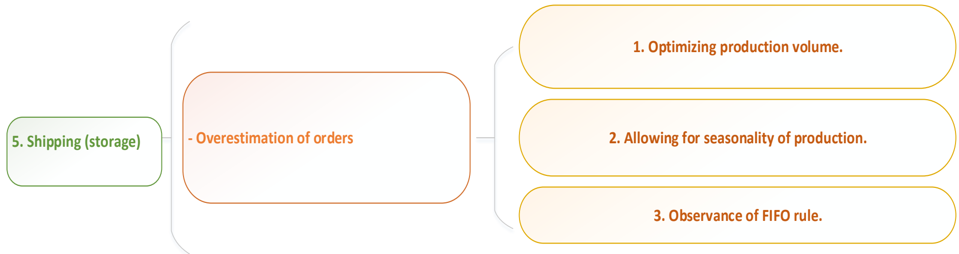

Figure 4.11 *Possible causes and methods of preventing FW during shipping (storage)*

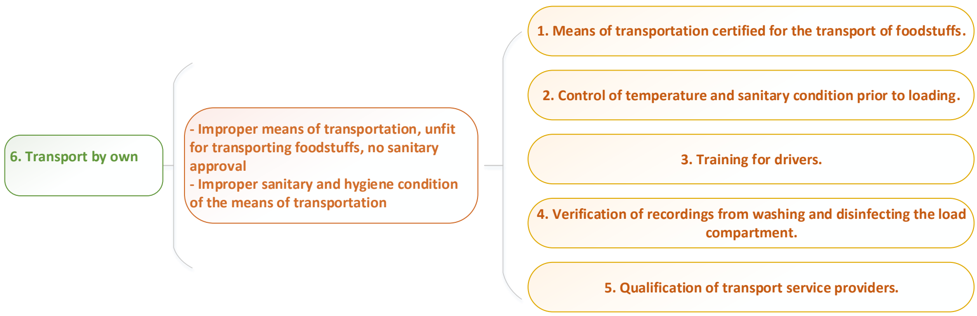

Figure 4.12 *Possible causes and methods of preventing FW during transport by own*

4.5. Consequences of FW and recommended actions to prevent FW in flour products processing

Considering the causes and methods of preventing FW related to the 6 technological operations as recovery points for FW (shown at section 4.4), it was identified the **consequences of losses** and **recommended actions** to reduce losses at flour products processing and packaging (table 4.9):

Table 4.9. *Consequences of losses and recommended actions in the processing and packagind stage of flour products (adapted after Gorynska-Goldmann et al., 2021)*

Technological operations (recovery points for FW)	**Causes**	**Consequences of losses**	**Recommended Actions**
1. Making and handling intermediate products and dough	✓ improper organization of the environment in which baking and confectionary products are made. ✓ secondary impurities. ✓ human factor.	✓ ambient impurities -physical hazard. ✓ impurities caused by pests. ✓ contamination caused by employees due to not respect hygiene procedures. ✓ ***production losses or customer complaints.***	✓ correction of the production process, the reuse clean dough. ✓ baking and the used as fodder. ✓ baking and retailing as reduced quality goods. ✓ application as biomass.
	✓ lack of supervision over machinery and equipment	✓ improper quality of semi-finished products ready for baking. ✓ ***production losses.***	✓ correction of the production process, corrective actions aiming to reuse clean dough. ✓ baking and application as fodder.

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			✓ application as biomass.
2. Portioning and forming of dough	✓ improper conditions of production of baking and confectionery products. ✓ secondary impurities. ✓ human factor.	✓ ambient impurities -physical hazard. ✓ impurities caused by pests. ✓ impurities caused by employees failing to observe good hygiene practices. ✓ ***production losses and customer complaints.***	✓ correction of the production process, corrective actions aiming to reuse clean dough. ✓ baking and application as fodder. ✓ baking and retailing as reduced quality goods. ✓ use for social needs.
	✓ improper handling of the production process.	✓ products failing to satisfy the specified quality criteria. ✓ improper net weight of the weighed dough portions. ✓ ***production losses.***	✓ corrective actions (e.g., adding more dough before baking). ✓ sale at reduced price—lower quality, lower net weight. ✓ use for social needs.
3. Baking	✓ improper operation of the oven, no supervision over the device.	✓ failure to observe the process parameters, oven defect. ✓ ***production losses***	✓ sale at reduced price – lower quality. ✓ use for social needs
4. Customized packing	✓ lack of supervision over machinery and equipment.	✓ improper supervision of maintenance of slicing equipment. ✓ dull knives may deform or damage the sliced products and reduce the	✓ sale at reduced price-lower quality. ✓ use for social needs. ✓ internal sales.

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	✓ employees' errors and neglect during bulk packing activities.	aesthetics of the goods. *slicing losses.* ✓ damage and deformation of the goods (sometimes forcing the disposal of the final goods to waste). ✓ ***losses identified during storage of the final goods or in retail.***	✓ sale at reduced price -lower ✓ quality. ✓ Use for social needs. ✓ internal sales
5. Shipping (storage)	✓ overestimation of orders.	✓ too many final products with short shelf live stored in the magazine. ✓ shelf-life expiration. ✓ ***production losses in the Final Product Magazine***.	✓ use for social needs.
6. Transport by own	✓ improper means of transportation, unfit for transporting foodstuffs, no sanitary approval. ✓ improper sanitary and hygiene condition of the means of transportation.	✓ reduced quality of the transported goods. ✓ permanent damage of the final goods making them unmarketable. ✓ ***losses in transport.***	✓ sale at reduced price-lower quality. ✓ use for social needs. ✓ internal sales

The results of the present studies indicate the need to raise awareness and qualifications of employees as a method of limiting food losses. More studies followed by information dissemination to the economic environment and education may help reduce the phenomenon of "**food waste**" not only for food processing enterprises, but also for other participants of the supply chain.

4.6. Causes and methods to prevent losses along the grain chain processing

Mesterházy et al., 2020 reported that along the grain value chain in addition to pre-harvest losses, the losses occurring during transport, pre-processing, storage, processing, packaging, marketing, and plate waste are also substantial. The authors summarized for the main technological phases the causes and methods of preventing losses along the grain chain, these being presented in the table 4.10:

Table 4.10. *Causes and methods of preventing losses along the grain chain (adapted after Mesterházy et al., 2020)*

Technological phase (Recovery points for FW)	**Causes**	**Methods of preventing**	**Losses (%)**
Field (pre-harvest)	✓biotic factors (pests, pathogens, and weeds etc.). ✓abiotic factors (temperature, humidity, rain, floods, etc.).	✓ fertilizer use ✓ pesticide use ✓ fungicide use	✓ soybean and wheat 26 -30% ✓ maize 35% ✓ rice 40%
Storage	✓ biotic factors insect, pests, rodents, fungi). ✓ abiotic factors temperature, humidity, rain).	✓ Before storage the grain must be cleaned and contaminants (dust, insects, straw, chaff, weed seeds, etc.) removed ✓ test for toxins ✓ humidity temperature and CO_2 control	✓ direct storage losses (physical loss of grains) 10 - 20% ✓ indirect storage losses (loss quality and nutrition) ✓ 1–2% in developed countries using metal silos ✓ 20–50% in developing countries where

			grains are generally stored by in traditional storage structures
Mycotoxin contamination	✓ high susceptibility of the grain crops (large toxin epidemics in the field) ✓ bad storage	✓ toxin regulations ✓ monitoring the formation of fungi during storage	✓ 25–40% of global cereal grains are contaminated produced by fungi ✓ 25% of the world grain crop is significantly contaminated ✓ 10% yearly loss.
Consumer waste	✓ Applied technology ✓ consumer behavior	✓ consumer awareness by disseminating information from the economic environment	✓ 5-20% ✓ ↑ in developing countries ✓ ↓ in developed countries

Regarding the reducing losses during storage of grain crops, Kumar and Kalita, 2017 have declared that the storage losses account the largest share of all post-harvest losses for cereals in developing countries, and negatively affect the farmers' livelihoods. The authors argue that the most used warehouses are traditional storage structures, which are inadequate to avoid the insect infestation and mold growth during storage and lead to a high amount of losses. Utilization of modern storage and improving technology can play a critical role in reducing postharvest losses and increasing farmers' revenues. They show that the properly sealed hermetic storage structures has resulted in up to a 98% reduction in storage losses, maintained seed viability, and its quality for long storage times. So, using better agricultural practices and adequate storage technologies can significantly reduce the losses and help in strengthening food security, and poverty alleviation, increasing returns of smallholder farmers.

Figure 4.13. by Kumar and Kalita (2017) provides a summary of various cereal crop supply chain losses and the main causes of such losses in developing countries.

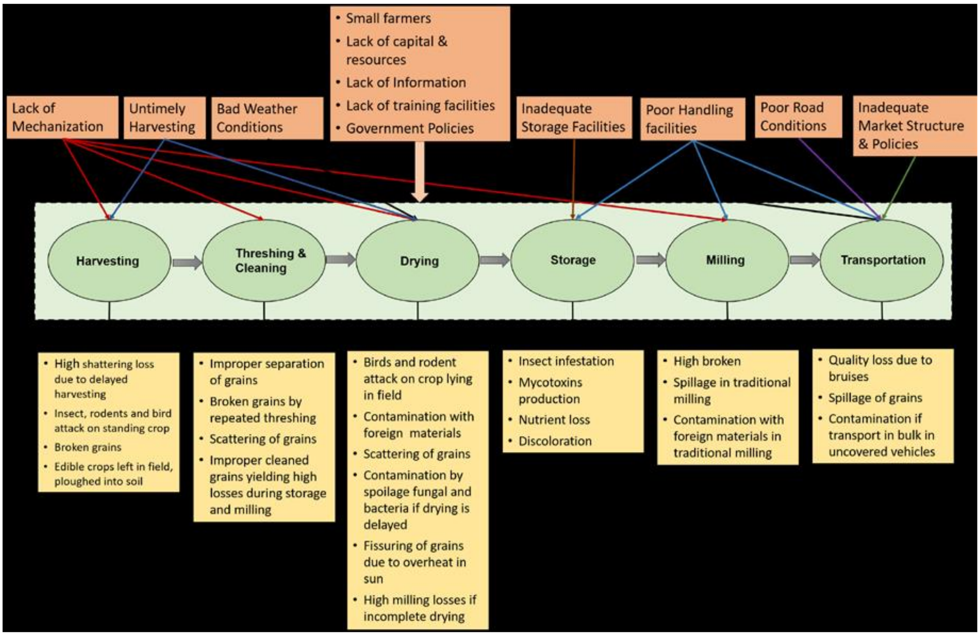

Figure 4.13. *The factors and types of losses during the supply chain of cereal crops in developing countries. Taken from Kumar and Kalita, 2017 (https://www.mdpi.com/2304-8158/6/1/8) Copyright 2020 Creative Common Attribution License*

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Chapter 5

Causes of food waste in the bakery industry. Measures to reduce food waste in the bakery industry

5.1. Studies carried out on the causes of food waste along the production chain of the bakery products.

Bread is one of the basic human foods, being indispensable in the daily diet, due to both its nutritional properties and the content of heat energy-producing substances. This important food was and is a permanent concern of people since ancient times. Although bread is a relatively simple food product, obtained from wheat, water and a few other auxiliary ingredients, the results can be very varied.

Bread has undergone numerous transformations, becoming more and more extensive and complex over time, its history being very old.

Bread is a bakery product prepared from a dough obtained from different types of flour, used in a mixture or alone, with or without other ingredients, kneaded with water, loosened by yeast fermentation and pre-baked/baked, including in a frozen state.

As in other food industries, the production of bread involves losses and waste at each stage of processing, but not only, human error being the most frequent.

Kulak et al. (2015) studied the technological chain of bread to the consumers and found that the potential for global warming (GHG emissions) was 0.8–2.3 kg CO_2-eq/kg of bread.

Notarnicola et al. (2017) conducted a study on food waste in the bakery fiels in 21 European nations and discovered even more diversity, with GHG emissions from production to retail ranging from 0.5 to 6.6 kg CO_2-eq/kg of bread. Another study (Espinoza-Oriaz et al., 2011) examined bread made and consumed in the UK using different types of flour, packaging, and wheat from various suppliers. According to the study, bread's GHG emissions ranged from 0.98 to 1.24 kilogram CO_2-eq/loaf, or 1.2 to 1.6 kg CO_2-eq/kg of bread. Only fruits, vegetables, and leftovers from cooked major meals account for greater waste than bread in Europe, where the rate of edible bread waste is estimated to be 22 kilograms per capita annually (Stensgaard and Hanssen, 2016).

Summarized, the losses from the baking process in Europe countries can vary from 1.2-10%, and a centralization of these data, type of losses and the authors who reported these data are presented in table 5.1. Gorynska-Goldmann (2020).

Table 5.1. *Losses in the form of Food Waste at the processing in the baking and confectionery industry (Gorynska-Goldmann et al. (2020)*

Losses	Country	Type of losses	Reference
Losses exceeding 5% and less than 10%	Finland	losses in bread processing amounted to 6.5–8.5% and the volume was 21–25 thousand tons	Katajajuuri et al., 2014
	Sweden	losses in bread processing amounted to 6.9%	Polarbröd, 2020
	Sweden	losses in bread processing amounted to 5.2	Brancoli et al. 2019
	Switzerland	bakeries losses were 5.1%, and the authors found that almost half of the identified losses could be avoidable	Beretta et al. 2013
Losses of less than 5%	Belgium	losses in bread processing amounted to 3.93%	Dora et al. 2020
	Norway	losses in bread processing amounted to 1.2%, but the losses were calculated as a percentage of fresh bakery products	Stensgård and Hanssen 2015

Research performed over a period of two years (2017-2018) by Gorynska-Goldmann et al. (2020) focused on reduction of food waste and on identifying more sustainable actions for the management of resources in the baking and confectionery industry, highlighted that a more efficient baking and confectionary production, combined with the growing expectation of consumers, will bring the baking and confectionery industry to focus on high-quality products. In their research, the authors identified 9 main categories of causes for the food waste (FW) during processing in baking and confectionery industry, but also other causes generated by unavoidable losses, technical inefficiencies, and malfunctions presented in table 5.2.

Table 5.2. *Possible causes of food waste (FW) for processing of flour products. Unavoidable losses, technical inefficiencies, and malfunctions*

Sections of the production units	Possible causes of FW	Unavoidable losses, technical inefficiencies, and malfunctions
Storage of raw materials	Mechanical damage Magazine pests Signs of spoiling, molds and impurities	- expiration date - human errors - improper specification
Production Section	Hygiene and sanitary requirements	- technological errors (e.g., failing to add a raw material according to the recipe, burning the product during baking)
	Technical breakdowns	- failure to satisfy quality requirements by the final products (the so-called production waste)
	-	- technological problems due to inconsistent quality of raw materials
	-	- low qualifications of freshly hired and insufficiently skilled employees
Storage of final product	Damaged packaging Hygiene and sanitary requirements	- breakdowns - returns of unsold bread
Transport of the finished product	Errors in placed orders Damaged packaging Incomplete packaging	- breakdowns

For this study, the authors collected quantitative data using an internet survey method. The survey was performed during the period from 2 January to 20 February 2020, on a sample of 48 bakeries from Poland, and the qualitative data was provided by five individual in-depth interviews with experts from the surveyed industry. The results showed that the total scale of losses in the baking and confectionery industry reached 2.39% (in 2017) and 2.63% (in 2018) of the weight of manufactured products. The loss analysis it was made within the sections of the production units: storage of raw materials, production section, storage of final product, transport of the finished product. The highest loss level was reported for production section—1.56% (2017), 1.85% (2018).

The losses in the bakery are due to the inadequacy of the raw materials, the wrong management of the technological process that causes defects in the bread and bakery products and their withdrawal from consumption.

Defects and losses in the bakery sector can also be due to contamination with fungi and molds, either from raw material contamination or non-compliance with technological conditions.

"Spoiled food may be defined as a food that has been damaged or injured so as to make it undesirable for human consumption`` P. Saranraj and M. Geetha, 2012. Microbiological spoilage produced by bacteria, yeast and molds is the concern in high moisture products. *Penicillium* species occurs in bakery products, the dominant spoilage flora varied with the type of bread and the storage temperature (Legan, 1993).

The storage conditions of bakery products represent a factor that leads to the high loss rate of bread and contribute to the alarmingly high numbers in worldwide food waste (Arpes,). Correct storage conditions are unable to reduce and to prevent food waste.

Therefore, by reducing loss or recycling waste into valuable products, understanding the process of waste formation and holistic approaches to treat these wastes at various points in the supply chain may help to boost the economy.

By closely adhering to the instructions, regulating the baking settings, and assessing the quality of the goods at each stage of manufacturing, human errors can be reduced. Before putting the goods on the market, production facilities should oversee the packaging procedure and guarantee quality control.

It was discovered that goods that didn't match the company's quality requirements (such the wrong net weight) were either sold to staff at a discount or to retailers as inferior goods.

Control and educating workers on the repercussions of production errors, according to interview participants, are key factors in minimizing losses (Narisetty et al., 2021).

Losses can also be kept to a minimum by hiring professionals to introduce creative methods of work organization, planning inspections of machinery and equipment, and implementing these methods to avoid flaws.

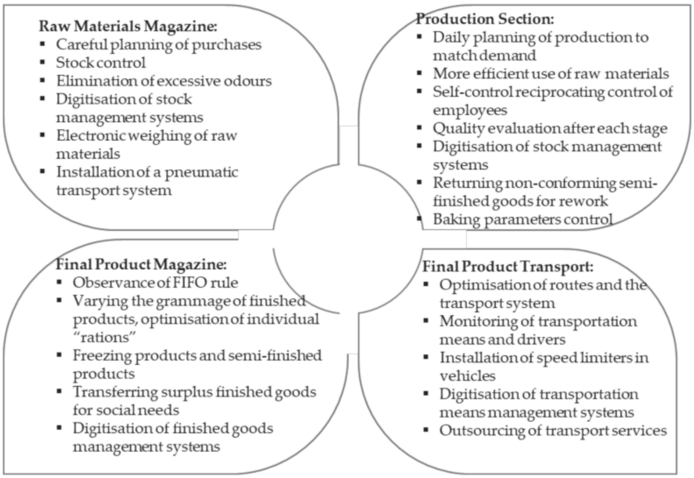

Figure 5.1. *Tools for preventing and reducing food losses in bakeries (Gorynska-Goldmann et al., 2021)*

5.2. Causes of FW generated by the physical-chemical characteristics of raw materials and by the technological process. Measures to reduce the losses identified along the production chain.

The technological process of baking is as follows: preparation and dosing of raw and auxiliary materials, dough preparation, dough processing, dividing, modeling, fermentation, baking, and cooling of bread (Figure 5.2).

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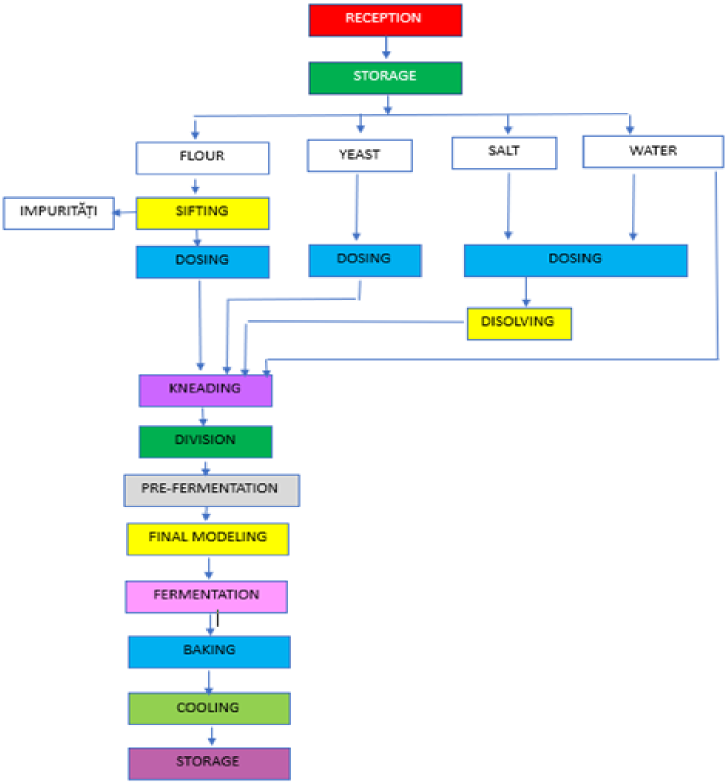

Figure 5.2. *Technological flow of bakery process*

Reception of raw materials

Controlling the storage conditions for raw materials is crucial to reduce losses (e.g., warehouse temperature and humidity control, cooling system control). It goes without saying that accurate weighing is the key to producing quality bakery products day after day. Customers expect to buy a bakery product that tastes the same as the last time they were in the store. Without a standardized measurement system, that won't happen.

Suppliers of bakery raw materials have equipment like scales for dry goods and measuring spoons and cups for liquid components that helps the bakery quality system. Bakery businesses should cooperate with reputable suppliers who provide raw materials of sufficient, dependable quality to reduce losses.

Raw material suppliers must be monitored and evaluated very strictly (for example, suppliers must provide quality and compliance certificates and be auditated), qualified employees must check each delivery (and inform the supplier in case of irregularities). Also, employees responsible for purchasing and receiving raw materials must be well trained.

Bakery units place a high priority on the need to regulate raw material conditions and set guidelines to prevent allergen cross-contamination. It was found that the automatic logistics of raw materials through electronically controlled pneumatic transport allows the dosing and weighing of raw materials directly in the production area, thus significantly reducing the loss of raw materials. The integrated silo tank system also allows raw materials to be stored in food safe environments. It was estimated that 1-2% of raw materials were lost annually as a result of material losses (including flour and other raw materials spills).

Regarding the quality of raw materials, when a problem is discovered during the delivery of raw materials, defective sections of deliveries are discarded. The market provides unrestricted access to raw materials, allowing for quality-based selection. Bakery units constantly check to make sure the packing is sealed, to ensure that the ingredients are kept in their original state and the materials are kept in proper storage conditions. Due to individual actions within the technological process, human mistake is another source of waste in the bakery units. It's possible for an employee to pick or distribute the raw material wrongly; mistakes can also happen when mixing raw materials. When raw materials are stored, weighed, distributed for manufacture, or dosed, human error may result in material loss (Gorynska-Goldmann et al., 2021).

Dough preparation and modeling

Gorynska-Goldmann et al. (2021) identified possible methods for the recovery of bread waste in the bakery sector, from the stage of manufacturing and handling intermediate products and dough; from portioning and forming the dough.

A more efficient control of the technological parameters (regarding the handling of the dough and the evaluation of its temperature and acidity, among other things) can significantly reduce production losses during the stage of forming and modeling the dough to obtain bakery products. The researchers pointed out that employee training on proper organization and physical control of the production environment plays an important role in waste management.

The most one-tier reasons were found in the machines category, including lack of supervision of the machinery, the use of antiquated equipment, poor developed infrastructure, malfunctions of equipment, unqualified workers, and subpar technical and hygienic conditions of equipments.

During the processes of pre-fermentation, shaping, and fermentation of product, differences between the dough mass are visible immediately after mixing and before placing in the oven. Losses of this nature are caused, among other things, by unreliable forming machinery and devices, defects in the functioning of the dough growth chambers and the slicing equipment, as also showed researchers Joardder and Masud in 2019. Defects and losses of raw materials, semi-finished goods, dough and final products may result from disregard for the technical state of gadgets and machinery, particularly transportation equipment (Caldeira et al., 2019).

The oven and the bread-baking process, among other technological processes, are subject to errors. Baking losses happen, and items that don't satisfy factory standards are discarded. Up to 0.5% of production losses occur in the form of deformations or damage, burned, or inadequately baked items, and they typically occur in the oven, etc.

The causes that lead to bread defects, for each technological stage, the main defects generated in the product, as well as the measures that can be taken to avoid them, are presented in table 5.3.

Table 5.3. *Causes of bread defects and measures to avoid the defects*

Causes of bread defects	Main defects	Measures to be taken to avoid defects
The use of inappropriate raw materials in the dough preparation stage		
Poor quality flour or wheat flour with a high percentage of sprouted grains.	The bread has a small volume, it is flattened, the crust is darker in color, moist and sticky, separating from the crust.	Airing the flour in order to oxygenate it, mixing it with healthy flours, increasing the acidity by increasing the amount of freshness using sourdough or food acids (ascorbic, lactic, acetic acid acids), preparing colder doughs (23 - 25^{0}C), dividing into pieces of small weight and baking them at higher temperatures, making semi-finished products with high consistency, reducing the leavening time, leavening at max. 33^{0}C, increasing the dose of salt from 1.5% to 1.7-1.8%, the addition of oxidizing substances.
Unripened flours or from new wheat.	The bread has a too light colored crust (pale), the crust has cracks; the core is crumbly	Same as the previous point + addition of gluten 1-2%, addition of sugar 2%.
F**lours with low content of enzymes** and especially of amylase.	"Hard" flours with low amylase activity, starch resistant to enzymatic attack: the bread has low volume and porosity, weakly colored crust, weak aroma, rough core that ages faster.	Addition of α-amylase in the form of malt preparations or fungal α-amylase (from moulds), improvers containing α-amylase, a 5% part of the processed flour, adding sugar or glucose to kneading the dough, in proportion of 4-5% of the flour.
Burnt wheat flour with denatured gluten proteins (Deformation index ID< 4mm and stability of 15-17 min).	The bread is dense and undeveloped.	The addition of malt preparations or improvers that bring a considerable supply of amylases and proteases, proteolytic preparations or reducing substances, the preparation of low consistency doughs, extending the duration of the technological process depending on the amount of gluten

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		in the flour, relaxation of the dough, intermediate leavening of the pieces.
Poor quality gluten flours. Flours with strong gluten ID<6mm	The bread is dense undeveloped, with small pores, round in section, with a shape close to the shape printed by modeling.	Mixing with hyperenzymatic flours, using improvers with protease intake, adding proteolytic preparations or reducing substances (glutathione), preparing semi-finished products with a small consistency, extending the duration of the kneading time, relaxing the dough, intermediate fermentation of the pieces.
Poor quality gluten flours. Flours with weak gluten ID>20mm	The bread is flattened, with reduced volume and coarse porosity (similar to unripened flours)	Preparation of doughs with low temperatures (23-25^{0}C) and high consistencies; increasing the acidity of semi-finished products; preparation of small yeasts (in the yeast phase, a smaller amount of flour is added than usual); reducing the duration of the technological process; increasing the proportion of salt to 1.7-1.8%, dividing the dough into smaller pieces and baking of it at higher temperatures, for the faster fixing of the volume of the bread, the addition of oxidizing substances.
Using poor quality yeast	The bread has a small volume, it is flattened, the core is compact.	Adding a quantity of about 0.2% yeast when kneading the dough, activating the yeasts by adding a certain amount of sugar (2%) to the suspension.
Wrong management of the technological process		
Using too little **yeast** when preparing the dough.	The bread is undeveloped; the crust is cracked and with burnt blisters; the core is compact and inelastic.	Adding a quantity of about 0.2% yeast when kneading the dough and re-kneading it. Respecting the proportions prescribed in the recipe for the formation of leaven and dough
Using too much **yeast** when preparing the dough	The bread is flattened, the crust is too light in color; the core is crumbly and has	Idem as previous and shortening the fermentation time of the dough.

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	cracks; it has small and uneven pores.	
Preparation of dough that is too hard (dough that is too "bound")	The bread has a small volume, it is convex; the crust is too light in color; the core is too crumbly and has cracks; it has small and uneven pores.	Dosage of flour and water according to the recipe of the respective quality of the flour used in manufacturing. Extending the duration of fermentation and final leavening of the dough
Dough fermentation was carried out in too short time or at too low a temperature, obtaining an insufficiently fermented dough (young dough).	The bread has a small volume and is bulging; the crust has burnt blisters and separates from the core; the core is compact, moist and sticky, with layers and cracks; sweet taste and yeasty smell.	Extending the duration of the final fermentation until full maturity; raising the pieces before putting them in the leaven or after 35 min of leavening; baking will be done at a low temperature (in a "soft" oven)
Dough fermentation was carried out for too long or at too high a temperature, obtaining over-fermented dough ("old" dough)	The bread is flattened, the crust is pale and with cracks on the surface and on the side; the core is darker in color and has horizontally elongated voids, the taste is sour.	Shortening the final leavening time; the pieces of dough will rise before putting them in the oven at higher temperatures ("fast" oven); in the case when the acidity is too high and the resistance of the gluten is destroyed, the yeast, respectively the dough, will be divided during the formation other semi-finished products.
Using too much flour when **shaping** the pieces of dough	The bread has a floury appearance and cracks in the crust; the core is crumbly and cracked.	The dough of normal consistency will be prepared; the amount of flour prescribed for modeling will be respected; the pieces will be raised very carefully before putting them in the oven.
Baking bread at too high a temperature (in a "fast" oven)	The bread has a small volume, it is bulging; the crust is dark, without gloss, showing burnt grains and cracks; the core is moist and sticky, sometimes showing darker stripes.	Setting the temperature of the oven by repeatedly wiping the hearth with a wet cloth, by introducing steam that escapes or by keeping the smoke channels open; the final leavening of the dough will be done until it is fully matured; the oven hearth will be fully loaded, to keep within the

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		limits prescribed by the manufacturing recipe.
Baking the bread at too low a temperature (in a soft oven)	The bread is flattened; the crust is too thick and hard, pale and with cracks on the surface, directed in several directions, and the crust on the hearth is soft; the core of the bread is dark.	Adjusting the temperature of the oven by interrupting the baking for a short time (returning); shortening the final leavening time; the amount of steam in the baking chamber will be reduced, and the pieces of bread will be placed further apart on the hearth.
Baking bread in an environment with too much steam	The bread is flattened and has a small volume; the crust is too thin, having a "cooked" appearance; the core is moist.	Opening the registers in time to release excess steam; the dough will no longer rise; baking will not be done with the oven door open. The correct handling of the devices for forming steam and those for its evacuation from the baking chamber.
Baking bread in an environment with too low steam	The bread has a pale crust, it is rough without gloss, showing cracks on the surface or side.	The introduction of steam on time and the correct handling of the respective devices; in case they are defective, a bowl of water with a large surface is inserted into the oven, for faster evaporation of the water; the dough will wash or spray intensely when it is placed in the oven. The correct handling of steam-forming devices; the removal of defects that occur in these devices and in those that exhaust steam.
	Storage and handling of bread after baking	
Storage of bread in too close or overlapping rows	The bread is flattened, deformed; the crust is cracked, soft, crushed; the core is compact.	Regular placement of bread in boxes, on racks or on shelves.
Transporting warm bread or placing it in close or overlapping rows	The bread is flattened, deformed; the crust is cracked, soft, crushed; the core is compact.	Transporting bread only in crates or racks; care will be taken that the bread is cooled first.

Crust defects

Core defects

Figure 5.3. *Bread defects*

5.3. Causes of food waste generated by microbiological contamination of raw materials and the technological process

5.3.1. Types of microbiological spoilage of raw materials and of bakery products

One of the major factors that cause food waste is microbial spoilage of bakery products. Microbiological spoilage is one of the factors that limits the shelf-life of the bakery products. Spoilage due to microbial growth causes economic loss both for manufacturers and consumers. There are three types of bacterial spoilage that can appear: **bacterial spoilage, yeast spoilage and mold spoilage.**

Bacterial spoilage

Bacteria have the potential to contaminate the bakery products although their growth is more restricted by low water activity and low pH.

The spores of *Bacillus subtilis* for example are heat resistant.

This microorganism is present mainly in raw ingredients – flour, sugar and yeast and causes rope in bread. One of the characteristics of the ropey bread is that discoloration from brown to black appears, also a smell of rotten fruits and a very stringy bread crumb.

This problem usually appears in the summer when the weather is warm and humid.

One of the main source of bacterial contamination is the ingredients so it would be highly recommended to use only ingredients with low level of contamination. The most common species that cause bacterial spoilage are *Bacillus subtilis, Bacillus licheniformis, Bacillus megaterium* and *Bacillus cereus*.

Spoilage of bread is first detected by an odour similar to the pineapple one. After that, he crumb will become discoloured, soft and sticky, which will make impossible for the bread to be consumed.

The deterioration of bread is due to the effect of amylolytic and proteolytic enzymes produce by the *Bacillus* strain.

In order to reduce the incidence of this problem it is necessary to have in force strict sanitary and manufacturing practices. Also, the use of preservatives like propionate can be used to eliminate this problem.

Yeast spoilage

In bakery may also occur yeast problems due to the wild yeast including *Trichosporon variable, Saccharomyces, Pichia and Zygosaccharomyces.* They produce white spots in bread and they can be divided in two types:

- visible yeast that grow on the bread surface and produce white or pinkish patches – mainly *Pichia burtonii*

- fermentative spoilage that cause appearance of alcoholic odors - osmophilic yeasts. This mainly results from unclean equipment and ustensils.

Thus, maintaining good manufacturing process will minimize the contamination by osmophilic yeasts.

Mold spoilage

One of the most costly and serious problem for bakeries is mold spoilage. In general, mold spores are killed during the technological process in fresh bread and other baked products. Thus, if any mold contamination appears it's from the air, bakery surfaces, equipment, food handlers or raw ingredients after baking during the cooling, slicing or wrapping operations. The mold count is usually higher during summer due to airborne contamination in warm weather and humid storage conditions. Also, moisture condensation on a product's surface can lead to mold growth. The most common molds in bakery products are: *Rhizopus sp., Aspergillus sp., Monilia sp., Mucor sp. and Eurotium sp.*

Mycotoxins

In addition to the economic losses associated with bread spoilage and food waste, a further concern is the possibility that mycotoxins produced by molds in the spoiled bread that may lead to public health problems.

5.3.2. Measures to reduce the microbiological losses identified along the production chain

In order to reduce food waste in the bakery industry due to **microbial spoilage** the main action that can be applied is the control of microbial growth.

In order to reduce the incidence of bacterial spoilage it is necessary to have in force strict sanitary and manufacturing practices. Maintaining good manufacturing process will minimize the contamination by osmophilic yeasts.

Molds are tolerant to acid conditions, therefore foods with pH value < 4,5 are not usually spoiled by bacteria but are more susceptible to mold spoilage

Temperature plays a dominant role in mold growth and in the spores germination. Thus, reduction of storage temperature from 27 °C to 21 °C doubled the mold free shelf life of cakes (Chamberlain, N. 1993.).

Mould growth can be reduced by a range of techniques including the following: i) attention to hygiene within the bakery to reduce the opportunities for mould spores to gain access to the product; ii) pasteurization of bread once packed, iii) use of preservatives, iv) use of novel ingredients with mould-inhibiting properties. This can be achieved by using several methods presented below.

Reformulation involves a reduction of available water (a_w) in bakery products in order to obtain a longer shelf life. This reduction can be achieved by dehydration, evaporation, freeze-drying or by high osmotically active additives, sugar and salts, incorporated directly into the products.

Control of mold growth in the bakery relies mainly in maintaining a sufficiently low water activity. For exemple, an a_w of 0,75 can offer a 6 month extension of shelf life.

Because low a_w can adversely affect the quality of products, each reduction must be done very carefully.

Freezing has been used for long term preservation of bakery products in particularly. It is important that the freezing process to be quick so that the forming of ice crystals can be controlled. Large ice crystals can disrupt membranes and internal cellular structures. Commonly frozen are products like cakes, pancakes and short cakes. Bread has been kept fresh for many months by storage at -22 °C.

Desroisier (2006) reported that bread frozen quickly after baking and held for one year at - 18°C was equivalent in softness to fresh bread held for two days at 20°C.

Preservatives. For controlling mold growth in baked goods preservatives are most commonly used.There are two types of preservatives: chemical and natural permitted mold inhibitors in bread. The chemical inhibitors include: acetic, sorbic and propionic acids and their salts. **Sorbic acid** has been reported to have a good effect on the growth of *Aspergillus niger* and *Penicillium species.* (Ray, L. and Bullerman, L.B. 2001).

in a study carried out by Doores, S. 1993, it was highlighted that propionic acid and its salts have an effect of inhibiting the mold growth. Propionate concentrations between 8 and 12% have been reported to be effective in controlling mold growth on the surface of bakery products.

Bio-preservatives are microorganisms and their metabolites used to prevent spoilage and extend the shelf life of foods). The ones that are of a particular interest are lactic acid bacteria (LAB). They were used for centuries as starter cultures in the food industry and are able to produce different kind of bioactive molecules such as organic acids, fatty acids, hydrogen peroxide and bacteriocins.

Modified atmosphere packaging

Carbon dioxide - it is proven to be an effective way of retarding the development of mould and other highwater activity baked goods. In general terms, the higher the concentration of CO_2 used the greater is the extension of mould-free life.

The high cost of gas packaging (high investment in equipment, expensive packaging films and gas) lowers the use of CO_2 packaging of bread to high-value products intended to have a long storage life such as some part-baked ling life-products, special dietary products such as gluten-free breads, ethnic products such as naan and some internationally traded breads.

Oxygen absorbers - another approach to modified atmosphere packaging is to reduce the pack O_2 concentration using an oxygen-absorbing material such as " Ageless" (Mitsubishi, Gas Chemical Company Inc., Tokyo, Japan) or the ATCO oxygen absorber (ATCO S.A., Caen. France).

Even in a simple system of packaging, bread with a mould-free life in air of only 5-6 days can be kept mould-free for over 60 days when packed with an oxygen-absorbing sachet. (J.D. Legan.)

Other measures for reducing microbiological contamination are:

- Prevention of debris accumulations on machinery such as trays, racks, travelling belts ad slicing machines
- Launder prover pockets frequently
- Keep walls, floors, ceilings and other surfaces clean, particularly any surfaces coming into contact with product
- Separate flour handling areas from product cooling and wrapping areas
- Keep returned product out of the bakery, especially if it is mouldy.

Chapter 5

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Chapter 6

Causes of food waste in the pasta industry. Measures to reduce food waste in the pasta industry

6.1. Researches and studies carried out regarding possible causes of food waste in the pasta industry

Worldwide, pasta is known as a convenient and popular staple food. Consumers' choice regarding pasta is related to its sensory and nutritional value but also to its versatility for different dishes.

A recent study of (Bresciani et al., 2022) reports that worldwide, 14.3 million tons of pasta are produced annually. Globally, the major pasta producer is Italy, followed by the United States, Brazil, Turkey, and Russia. The main raw materials for pasta are different milling products obtained from durum wheat (*Triticum durum* Desf.) such as semolina, coarse semolina, or whole meal semolina. The use of durum semolina in pasta production highly influences the quality of the product, especially in terms of dough rheological properties, cooking quality and consumer acceptance. In Italy producing pasta from durum semolina is a mandatory aspect. However, in other countries, the common wheat (*Triticum aestivum* L.) is used also, mainly due to its high availability and low cost.

Pasta belongs to Cereals and cereal products group 6.4 of Appendix D of Regulation (EC) No. 1333/2008 of the European Parliament and of the Council, entitled Food groups. The main processing steps during pasta production are raw materials reception, dosing, mixing, and kneading, shaping (pressing, extrusion or rolling), cutting, drying and packaging (figure 6.1). The pasta may or may not be dried. Pasta is basically divided into two groups: fresh pasta (moisture about 25%) and dried pasta (moisture 12%).

Reception and storage of raw materials

↓

Dosing (flour, water and/or other ingredients)

↓

Mixing

↓

Pressing/ extrusion / rolling

↓

Cutting

↓

Drying

↓

Cooling and stabilization

↓

Packing and packaging

Figure 6.1. *General technological diagram of pasta production (after Klinger 2010)*

During the last decades, research studies are reporting on several strategies for producing functional pasta. The growing market trend to achieve certain nutritional advantages resulting from the alternative raw materials used in the manufacturing of pasta is reflected in the consumer interest in various varieties of pasta, as it could be seen in Figure 6.2.

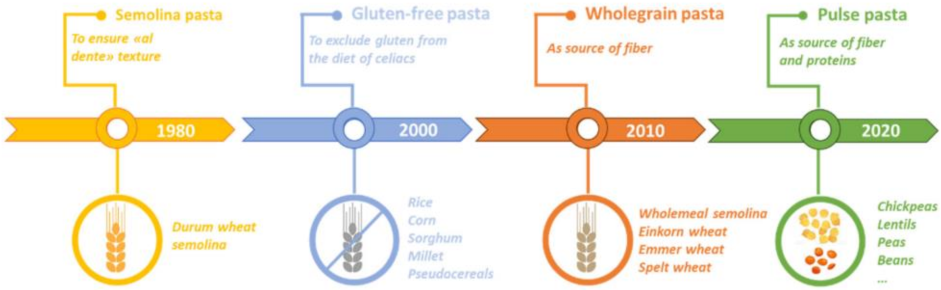

Figure 6.2. *Type of pasta and raw materials evolution during last decades (Bresciani et al.,2022)*

Production loss in the production process is related to production quality. One possibility is to examine the quality of the pasta according to the Pasta quality model (Figure 6.3).

A single element, such the kind of raw material (refined vs. wholegrain semolina), can have a significant impact on the entire process and the final product's quality. It is crucial to identify the present elements in this situation (i.e., which process variables are impacted by alternative raw materials) in order to effectively modify the process and produce a high-quality pasta.

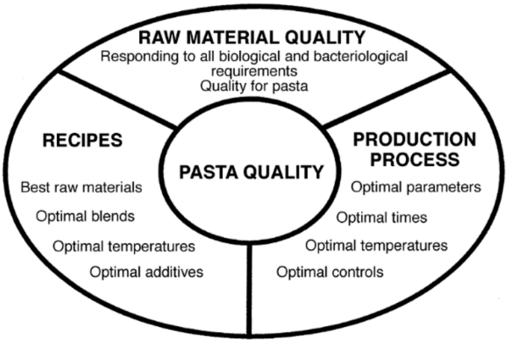

Figure 6.3. *Pasta quality determinants model (Sissons 2008).*

6.1.1. Raw materials quality

The main raw material of the pasta is durum wheat flour, either from the middle layer of the grain (so-called semolina) or from the whole grain (whole wheat flour) and water. Durum wheat flour is obtained by grinding durum wheat (*Triticum durum*). The protein content of the flour as well as the quality of the protein is an important *indicator of the quality* of the pasta flour. In general, the higher the protein content, the stronger the pasta. In this case, the pasta has a better texture during cooking and less starch is released during cooking.

Another important *indicator of flour quality* is flour coarseness. The flour should be of uniform thickness so that all flour particles absorb an equal amount of water. Otherwise, smaller particles absorb more than large particles. The result is white spots on the pasta.

It is also known that semolina starch properties, namely level of damage starch and swelling power, are highly influencing pasta quality characteristics. The damaged

Chapter 6

starch contains both amylose and amylopectin which takes up high levels of water and can form a temporary network based on entanglement (Bruneel et al., 2010).

Moreover, the relationship that is established between protein and starch during pasta cooking is overwhelming for their quality. If a strong protein network forms during cooking and starch particles are confined in this network, the final cooked pasta will be firm and elastic. If a weak protein network does not develop during cooking, the pasta will be sticky and squishy (in the opposite case of significant starch swelling). (Delcour et al., 2000). When cooking, this already formed network remains continuous in high-quality pasta. The coherence of this network could be destroyed by the starch swelling. Waxy starches from various sources were used in place of semolina starch, and the results included greater starch swelling properties and a soft textured product.

However, besides this quality indicators, a complete picture of the semolina quality parameters and its influence on pasta quality and safety are summarized in Figure 6.4.

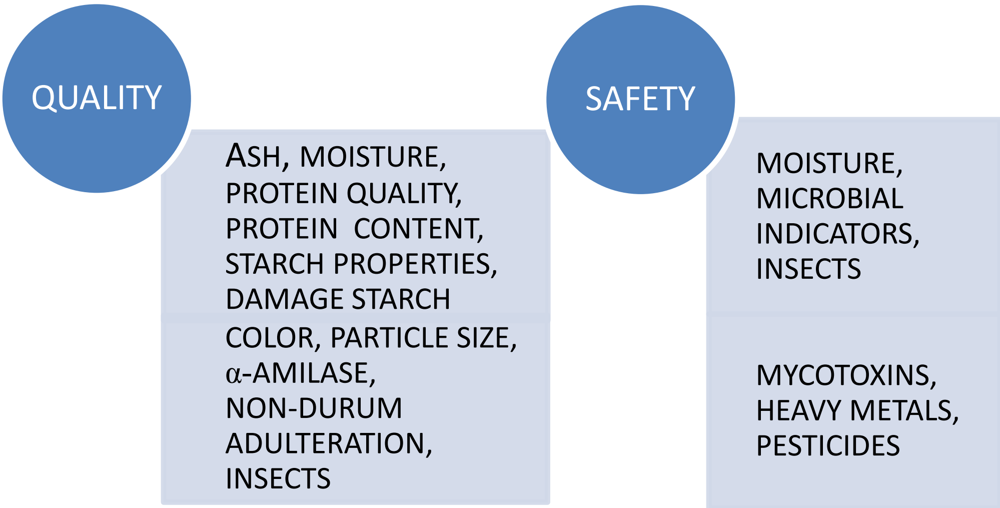

Figure 6.4. *Semolina quality parameters and their influence on pasta quality and safety (after Turnbull, 2001)*

Typically, durum semolina with an *ash content* of about 0.88-0.9 % dwb (dry weight basis) is used to make high-quality pasta. Semolina with an ash percentage between 0.9% and 1.1% dwb will produce pasta with a darker color and a more "wheaty" flavor. Because they contain such a high percentage of ash, pasta made with semolina with above 1.1% ash will be too dark, have a strong flavor, and have a worse texture. Different durum wheat cultivars and agronomic practices can result in wheats with varying ash contents. This might result in semolina with varying ash concentrations but identical extraction and other quality attributes. Sometimes, debranning milling techniques could produce semolina of good color at high ash levels. Although the mineral content itself cannot be observed in the finished product, the measurement of ash is a helpful indication of the milling process and of potential effects on the finished pasta product.

Particle size, shape, flour quantity, as well as β-carotene amount and bran content, all have a role in how colored a sample of semolina seems to be.

It is conceivable that the durum wheat used to make semolina will have started to sprout before it is milled if it has been exposed to unfavorable environmental conditions (such as high humidity or heavy rain). When seeds are sprouted, the enzyme α-amylase is released from the germ into the endosperm, where it breaks down the starch into sugar for quick absorption as the plant grows. If the semolina has excessive levels of this sugar, issues might arise during processing, but the end-product in particular could become sticky. Extremely high amounts will also result in extrusion issues.

6.1.2. Formulation and production process

When preparing the dough, it is important that the raw materials are dosed in a certain ratio, so that the raw materials are completely mixed, and the flour particles bind the same amount of water. When calculating the amount of water, the moisture content of the raw materials added to the dough and their behavior in the mass of the dough should be considered. Semolina and water are carefully dosed and blended to form a hydrated mixture with a total moisture content of about 30–32%. Semolina hydration guarantees the proper solvation of proteins, while gluten is still in the early stages of development. Only proper protein hydration will ensure that a continuous gluten network can be formed in the processes that follow, controlling and avoiding excessive starch swelling during cooking.

De la Pena and Manthey , 2017 examined the effects of various hydration levels (between 30 and 34%) on the extrusion characteristics of refined or wholemeal semolina (alone or combined with flaxseed flour) and on the cooking behavior of the corresponding pasta samples. Specific mechanical energy (SME) and extrusion pressure decreased as the amount of hydration rose, according to the study's findings. *The formulation of pasta* appears to have a major impact on the extrusion pressure in particular: the semolina dough records a drop in pressure that is lower than that seen for wholemeal semolina. Moreover, related to the pasta' s color, high hydration levels (32-34%) are linked to a decrease in brightness/luminosity and an increase in the degree of red (a*), but they have no effect on the degree of yellow (b*) (De la Peña et al., 2014).

When components or grains other than durum wheat are used in the formulation, the hydration procedure becomes even more crucial. Studying and maximizing the amount of moisture is crucial for re-forming pasta since it influences both the end product's quality and the properties of the dough (in particular, how it is processed during the extrusion step). Due to fiber's strong hydrophilicity, which puts it in competition with proteins for water absorption, it may decrease the amount of water available for their solvation, which might put in risk the construction of a uniform network. Additionally, the dilution effect of gluten (caused by the lower amount of semolina in the formulation) and a discontinuity in the protein network brought on by the interference of the non-starch polysaccharides are both contributing factors to the worsening of pasta quality in the presence of fiber. Similar results were observed when flaxseed flour, buckwheat bran, or durum wheat bran were included in pasta formulation or when wholemeal semolina was used (Bresciani et al, 2022). According to La Gatta et al., 2017 one way to reduce the competition for water between fiber and proteins is to hydrate the two components separately (for instance, semolina and bran) before extrusion.

When mixing the dough, there is a risk of the dough heating up. As the temperature rises, the adhesive protein becomes tougher and stiffer, the elasticity and viscosity of the dough disappears at 55°C. But if the sticky protein were to coagulate, the coagulated protein pieces in the dough prevent the pasta from forming a smooth surface. Mixing air into the dough should also be avoided, because mixed air makes the quality worse because the air in the pores expands during drying. In this case, the structure of the finished pasta deteriorates.

When pressing and shaping short pasta, it is important that the strands of pasta do not dry out more than is necessary to reduce the stickiness of the dough. In this process, as the top layer must not dry towards the middle, otherwise stresses will develop, resulting in cracks in the finished product. As the surface dries, the moisture decreases by about 1-2% of the mass.

The long pasta must be rolled in stages. Stepped rolling gives the pasta dough a uniform but less compacted consistency. Such rolling improves the dough's cooking properties, swelling ability and bite strength.

The pressure and specific mechanical energy as extrusion factors are helpful for assessing the whole process. They are connected to and impacted by the same factors, such as the extrusion temperature, screw speed, and moisture content. The link between hydration level and specific mechanical energy is the main area of emphasis. Being less compact, an overly wet dough would need a lower specific energy and not provide enough resistance inside the extrusion cylinder to encourage protein aggregation and, as a result, a satisfactory production of gluten. A low specific mechanical energy reduces the pasta density. The water that isn't attached to proteins or other hydrophilic (macro)molecules evaporates during the later drying phase and as a result a lower density of pasta is obtained.

Regarding the dough formulation, it was reported that lipids (from oil seeds for example) could reduce the extrusion specific mechanical energy by lubricating the dough and in consequence less resistance to extrusion will lead to pasta with smaller diameter (Bresciani et al., 2022). The amount of material released into the cooking water is inversely correlated with the width of the spaghetti, according to De la Peña, E. and Manthey, 2017.

The fresh pasta is sent to the boiling bath, its purpose is the gelatinization of the starch, the denaturation of the egg white (if an egg is added to the dough), the formation of the texture of the dough, the inactivation of enzymes, the destruction of microbes, the formation of aroma.

For the technological process of pasta, the main intrinsic and extrinsic factors that influence the dough and pasta quality and consequently could lead to losses and wastes are summarized in Table 6.1.

Table 6.1. *Intrinsic and extrinsic parameters influence on dough/pasta quality (after Bresciani et al., 2022)*

Operation	Intrinsic parameters	Extrinsic parameters
Dosing, mixing and kneading	• Semolina particle size • Semolina protein, ash, fiber, damaged starch content • Enzyme activities • Water temperature and residue	• Presence of a pre-mixer • Vacuum degree
Kneading and shaping by extrusion	• Gluten tenacity • Dough humidity • Dough temperature • Dough viscosity	• Mixture feeding into the extruder • Geometrical characteristics of the screw (length, design, etc.) • Extrusion conditions (specific mechanical energy, screw speed, heat regulation system, etc.) • Shape of the extruded product • Die material • Open surface of the die (number and position of the inserts)
Drying	• Gluten tenacity • Starch pasting properties	• Air temperature • Air relative humidity • Drying time

The most difficult process in pasta production is drying. If the pasta dries out too quickly, the pasta may break during cooking. If the drying time is too long, the flavor characteristics may decrease. Since the pasta products must dry both inside and out, the pasta products are passed through different warm and dry zones until the desired moisture, smooth and elastic surface is achieved. In the last stage of drying, cooler chambers are used to adapt the pasta to normal room conditions. In general, the pasta is dried to a moisture content of about 12%.

Drying reduces water content and water activity. When drying, it has to be assured that the surface of the pasta does not harden before the content (middle part). Otherwise, cracks will appear, and the pasta will break. When pasta is properly dried and cooled, it is a relatively inert material, but it still needs to be handled carefully and the right quality of packaging chosen. Long pasta is usually stored in a stack in a room with the right regime (temperature, humidity) that keeps the product in the right condition necessary for cutting and packaging. Short pasta is stored in towers.

Towers must be cleaned regularly. Spirals can get stuck to the inner wall of the towers and products from a different batch can mix as a result. Conveyor belts, between which pasta can get stuck, must also be checked.

Cracks and broken pieces (crumbles) are among the most common dry pasta flaws because they impact consumers' quality impression (Figure 6.5). They arise during drying because of non-uniform moisture and/or temperature distributions, but also after drying as a result of collisions between pasta pieces and different surfaces. The initial exposure of extruded pasta to high drying temperatures is one of the primary causes of fractures and breakages in pasta owing to quick and uneven water loss.

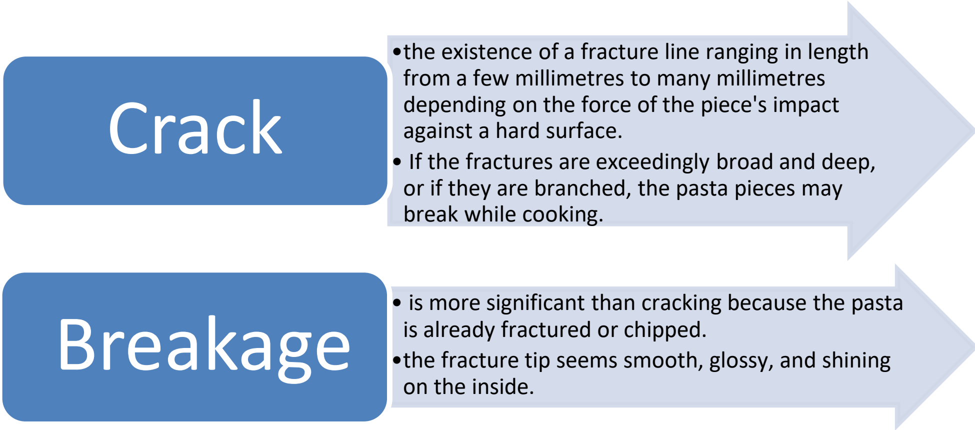

Figure 6.5. *Main pasta defects and their description (after (A. Baiano et al., 2019)*

Crack development might be slowed when high temperatures are paired with extremely humid air. After drying, crack and breakage faults might emerge as a result of the amplification of prior pressures or the production of new stressors to a higher level (A. Baiano et al., 2019). The acceptable degree of cracking is determined by the standards of each plant, but the usual level of breaking permitted in most specifications is less than 2%. (Turnbull, 2001).

After drying the main critical points at which the cracks and breakages are found to be higher are (A. Baiano et al., 2019):

- conveyor belt that transfers the dried pasta from the silos to the vibrating sieve;
- vibrating sieve;
- loading hopper of multi-head scales;
- package after control by metal detector;
- package withdrawn from the carton box

The study's findings show that large increases in defects occurred along the path of pasta between the loading hopper of multi-head scales and pasta packing, as well as during the handling of packaged pasta and the production of the cardboard box. It was also reported that this behavior is due to the longer length of some pasta (ex. rigatoni), which makes them more fragile than other forms of pasta. Moreover, the pasta thickness was found to be inversely corelated to the increasing defectiveness.

6.2. Causes of food waste identified along the production chain in the processing of pasta

Regarding cereal waste, it is important to note that wheat is the main raw material used in the production of pasta, and is the main crop grown in middle- and high-income countries. In Europe, North America and industrialized countries from Asia, cereal food losses and waste account 35% of the total production, most of them occurring at the processing and consumption stages (FAO, 2011, Gustavsson et al., 2011; Faggini et al., 2021). According to the reported data, in Europe, about 10–12% of the total food production is lost during pre-consumption stages, meaning until distribution (Gustavsson et al., 2011).

With respect to the pasta industry, according to a study performed by Barilla Group during March –December 2016, it was reported that for the entire life cycle - *from field to table* - of the pasta produces in Italy, food loss in the field is less than 2%, while the straw obtained during the harvest is usually used as animal feed and for litter. Loss generated during the grinding of the grain and the pasta production corresponds to around 2%. The same study has shown that the largest amount of waste is concentrated in the consumption phase, especially in households and hospitality. It was determined that this value of losses reached between 10-40% and the sector of school catering was identified as generating the largest waste of pasta, around 25%, respectively.

The causes of food losses and waste during the pasta life cycle are due to a number of conditions that varies from one stage to another.

The *wheat pre-cleaning* removes the impurities before the wheat is stocked in the silos. This technological step generates around 0.01% food losses on the whole. These losses are partially used for animal feed, while their non-edible parts are considered waste.

The stage of *wheat milling* produces an average value of 17% losses on the whole, from lifecycle perspective (Principato et al., 2019). Regarding this losses, if only the durum wheat milling stage is considered, the milling waste is 0.02%, while semolina flours represent 75% and wheat co-products 24.98% (Principato et al., 2019 citing the Barilla Group study). In this regard, semolina production is followed by obtaining wheat bran. Nowadays, wheat bran is considered an important by-product that could be alternatively valorized by bioprocessing or by other approaches.

During *dough modeling*, the main losses are the pasta production scraps. The food losses and waste in this stage of production are mainly the consequence of the production lines' cleaning as well as the changing of pasta shapes. 1.03% on the whole is the value of the losses which are not usable for human consumption, while 0.07%, on the whole, is the loss caused by the pasta shape equipment cleaning which could be edible.

During the *transport and packaging* of pasta, a value of 0.09% was found as being waste. The main causes are filling of mobile silos, emptying of mobile silos, packaging and transporting unpackaged pasta.

In retail situations, the main cause of waste (0.10%) is the damaged packaging, which makes the pasta unable to be sold. Dry pasta (before cooking) is the least wasted product, due to the fact is shelf stable having a low water activity.

As it was reported by Principato et al. (2019) citing the Barilla Group study, each kilogram of pasta produces 1978.73 g of loss and waste throughout its entire lifecycle. From this value, 83.4% are inedible parts and only 16.6% are edible food losses and waste. The main reason for this high percentage of losses and inedible waste is the fact that in the pasta production process only the wheat grain (caryopsis) from the entire inflorescence called ear is used.

Table 6.2. *Causes of food losses and waste (FLW) generated during pasta production (after Principato et al., 2019)*

Stage	**FLW type**	**% FLW**	**Cause**
Cultivation	Field losses	2.76	Combine harvester failure
Milling	Wheat co-products	17.21	Milling
Milling	Waste	0.01	Wheat pre-cleaning
Pasta production	Production scraps	2	Equipment cleaning
Pasta production	Pasta waste	0.09	Transport, packaging
Retail	Unsold pasta	0.1	Damage pasta
Consumption	Waste	12.61	Cooked, too large servings, disliked

6.3. Measures to reduce food waste in the pasta industry

In order to reduce the food losses and waste from the pasta industry and its supply chain, the Food Loss and Waste Accounting and Reporting Standard (FLW Standard) provided "requirements and guidance for quantifying and reporting on the weight of food and/or associated inedible parts removed from the food supply chain". Following these requirements, some correction actions could be developed by producers in order to reduce or eliminate FLW, also for choosing possible future destinations and/or use for loss and waste (Principato et al., 2019). At the pre-milling stage, dedicated to wheat cleaning or to the progressive removal of external layers, the scrap fraction can be used for producing animal feed (Cimini et al., 2019), while wheat fractions and bran can be converted into wheat feed pellets (UNAFPA, 2015). During pasta production, the waste could be given to people in need (through food banks), to animals, or composted. At the retail level, the unsold product could be given to food banks and for animal feeding (Fagini et al., 2020). It must be considered that part of these food wastes can be used as renewable energy sources contributing to reducing our current dependence on fossil fuels (Volpe et al., 2016). As can be seen in table 4, 93.6% of the food losses and waste during pasta production are valorized as raw materials in other sectors.

Table 6.3. *Utilization of food losses and waste generated during pasta production (after Principato et al., 2019)*

Utilization	%
Human consumption	0.07
Animal feed	40.28
Composting/aerobic processes	6.40
Not harvested (left in field)/plowed-in	24.80
Energy recovery	22.05
Landfill	6.40
Total	100

The enactment of Circular Economy (CE) strategies as a holistic approach in order to make the pasta supply chain more sustainable is pointing to merging efficiency, effectiveness and sustainability. These strategies could boost efficiency (loss reduction) and effectiveness (waste reduction by activation of recycling, reuse, regeneration and remanufacturing processes). As a result, the overall sustainability of the system could be improved significantly. Waste and loss minimization or even their complete elimination could be obtained by using innovative technologies and eco-friendly strategies or changing consumers' behavior. In this view, recently several innovative and smart technologies have been introduced for having high quality durum wheat (Barrett et al., 2012). Specific cultivation monitoring systems and advanced harvesting methods using drones or intelligent systems to provide information about possible parasites attacks, time of maturation, gas measurement or fertilizers dosage.

Related to the production chain, the implemented technologies are targeted to remove impurities or to monitor storage parameters (temperature, time, cleanness, insects and parasites presence) in order to enhance efficiency.

Also, some modern technological approaches were proposed with the specific aim to obtain pasta with improved quality and thus reducing pasta waste.

It was previously showed that hydration level is one of the critical points for pasta quality and in consequence for the waste amount. Generally, the new technologies allow for more equal dispersion of water throughout the flour than conventional mixing but in a much shorter period; hence, a well-developed protein matrix may not be generated.

To provide a more uniform hydration of the raw materials, several hydration systems have been developed in addition to precise devices for the dosage phase. Indeed, dough emerges as "lumps" of various sizes at the conclusion of the mixing process in the typical extrusion press. In the innovative devices, the premixing and mixing steps are usually combined in a single operating unit, which mixes and develops pasta dough in 20 s. Excellent pasta color is guaranteed since the system is completely vacuumed (Bresciani et al., 2022). Modern equipment that are promoting a rapid and uniform hydration during 1-2 seconds of the surface of each individual semolina particle, followed by 10 minutes rest period before extrusion were proposed. In another modern device, hydration occurs in two stages: 2 seconds in the mixing system and 18 seconds in a low-pressure extruder at 10^6 Pa. All these mixing techniques yield products of acceptable quality and with appropriate cooking behavior, with cooking loss values less than 3 g/100 g pasta.

Regarding drying, which is also an operation involved in pasta waste, the majority of drying-stage advances have tried to reduce drying periods while maintaining pasta quality. Microwave drying pasta has shown to be highly efficient, not only in terms of reducing drying time, but also in terms of producing a finished product with fewer fissures, more firmness, and less gelatinization than hot air-drying pasta. This drying technique increase pasta's cooking resistance as well as its cooking time. Vacuum drying where the removal of moisture from food products is obtained under low pressure, appears very effective too. When compared to traditional drying, vacuum drying has a lower drying temperature and a higher drying rate (i.e., water evaporates more rapidly). The improved moisture transfer may reduce the creation of surface barriers, which creates internal tension within the product. Consequently, vacuum-drying may minimize internal stress and avoid structural deterioration, resulting in improved cooking quality (high water absorption and hardness, reduced cooking loss, and adhesiveness). Furthermore, because moisture is eliminated in the absence of oxygen, oxidative degradations such as browning or fat oxidation are avoided, resulting in a bright yellow pasta.

Moreover, specific logistics management systems (e.g., the first-expired-first-out transportation model) have minimized the most frequent pasta losses due to package damages (Jedermann et al., 2014). Regarding the packaging of pasta, specific technology-based packaging solutions were developed to extend packed pasta's self-life (Kirtil et al., 2017).

With regard to the packaging of flour pasta, specific packaging solutions have been developed based on technologies to extend the shelf life (lifetime) of the packaged pasta. In addition, mobile applications were developed and implemented to preserve the quality of the pasta and optimize its consumption before the expiration date.

Another important aspect of these CE strategies is related to the output effectiveness of targeting pasta safety and security. In this context, pasta should be protected from the physical, chemical, and biological contamination that can occur during the supply chain. Modern solutions by using nano-technologies are implemented in several phases to achieve this goal. For instance, for pasta packaging, which is a critical point for pasta safety, nano-biocomposites were developed as gas barriers and biodegradable polymers reinforced with nano-fillers (Faggini et al., 2021).

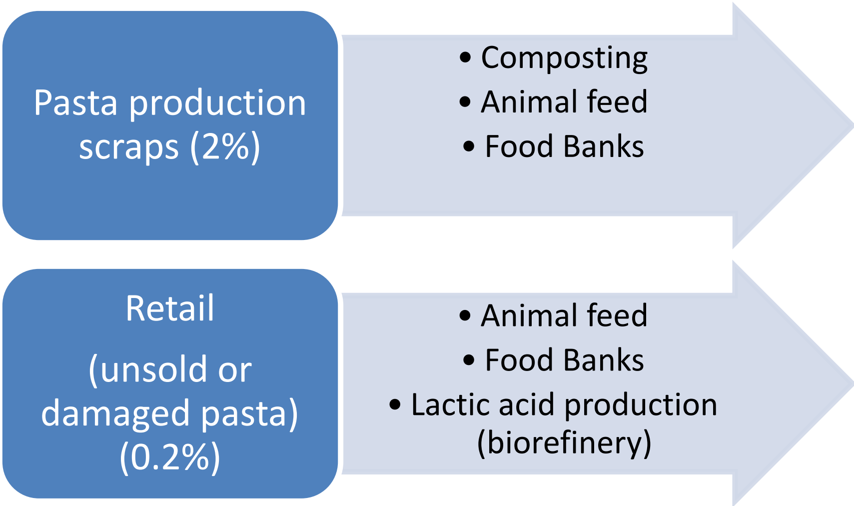

Figure 6.7. *Possible destinations for FLW from pasta chain*

Given its consistent availability and low price, using industrial pasta waste as animal feed is an excellent option. Pasta waste contain 119 g kg^{-1} of crude protein and 3494 kcal kg^{-1} of nitrogen-corrected apparent metabolizable energy, with essential and non-essential amino acid digestibility coefficients between 0.929 and 0.914 g/ g. Thus, Santos et al., 2018 proposed the introduction of pasta waste in broilers diets. They found that in terms of efficiency, carcass features, and profitability this strategy is viable for chicks in the pre-starter phase.

It was also reported that pasta waste was used for lactic acid production following a biorefinery approach. The major goal of the study performed by Marzo-Gago et al. 2022, was to increase the economic feasibility by substituting the commercial enzymes required for starch hydrolysis in pasta waste with microbial enzymes that were also produced from waste (wheat bran).

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Chapter 7

The causes of food waste in the biscuit manufacturing industry

7.1. Research and studies carried out regarding the possible causes of food waste in the processing and packaging stage of biscuits.

The medieval Latin word “biscoctus”, which means twice cooked, is where the name "biscuit" originates. Biscuits were once a staple of military stockpiles because of their extended shelf life and ability to be double cooked to reduce humidity of the final product.

Biscuits are a versatile food products and can be found in several varieties characterized by different crispy, open textures, and savory flavors. They can be classified into: glutenous biscuits, sugary, powdered or not powdered with sugar, digestive biscuits or crackers, biscuits glazed with chocolate, vanilla or lemon, etc.

The methods used in the manufacturing of biscuits have significantly advanced in recent years, particularly in terms of automation and safety: today, human intervention is minimal, while hygiene regulations and the choice of raw materials are receiving more attention in order to increase the safety of the products offered to consumers (Arepally et al., 2020).

Along with sugar, sugar syrup, butter or other vegetable oil, salt, skimmed milk powder, flavorings, and raising agents, flour is the main component of biscuits. Various ingredients, such as cocoa, hazelnuts, and other flours or flavorings, might be added depending on the type of biscuit.

When making dry biscuits, the dough is well mixed before being rolled through smooth rollers to the desired thickness. The biscuit is then given the desired shape by rolling out the dough and placing it in molds.

The dough for shortbread is molded with a "rotary" that presses it into molds to give the biscuits the correct shape before leveling the top with a scraping knife.

There are also more fluid doughs, for example those of spritz crackers or amaretti, which are extruded by passing through dies that give the product its shape and then be cut flush and transported directly to the oven. The waffle dough is liquid and is dried quickly on heated plates to form large flat sheets. In the case of wafers, the sheets are subsequently sandwiched with cream and cut with saws or wires (Arepally et al., 2020).

Due to their taste and nutritional benefits, biscuits are a form of food that are widely consumed worldwide. In fact, because they come in a variety of shapes, fillings, and decorations, they are loved by customers of all ages.

Both the main and secondary ingredients play an important role in the nutritional value of the biscuits, therefore the combination of all the components must be standardized avoiding batch quality variations. Fortunately, today the production of biscuits is fully automated or semi-automatic, therefore, it is easy to guarantee the quality of the products. Packaging also plays an important role in guaranteeing the quality and safety of the product by preventing any contamination. The packaging also has the function of attracting consumers, but above all of providing them with all the necessary information on the composition and nutritional properties of the biscuits (Chavan et al., 2016).

7.2. Causes of food waste identified in the biscuits processing stage

A 2021 review, conducted by Pasqualone A. et al., looked at the current state of the scientific literature on biscuit contaminants (physical, chemical and biological hazards) and critically assessed ways to mitigate these contaminations.

According to this study, raw materials are the primary contributors to a wide range of contaminants. Technological parameters steps and machinery must also be monitored, because if they cannot improve the initial safety status.

The employment of different baking technologies to reduce the thermal load is one of the most effective mitigating strategies for reducing contaminants.

Reformulation and low oxygen permeable packaging materials are essential for preventing the spread of contamination during biscuit storage (avoid direct contact with recycled packages).

Therefore, it is very important to continuously monitor the quality of raw materials, intermediates products, finished products, and processing conditions in order to comply with existing regulatory requirements as well as to fulfill the goal of outlawing dietary contaminants and treating related ailments (Pasqualone A, et al., 2021).

In an effort to reduce production losses, the manufacturing method for biscuits was evaluated by Bandara, S.M.U.A., and Dissanayake, K.D.D.N, in 2010. Start-up waste cannot be prevented. For the situation to be improved, skilled workforce is crucial. The results demonstrate that greater levels of automation are also to blame for increasing levels of technological losses.

Other study conducted Wohner, B.; et al., 2019 highlighted that packaging is typically constructed of plastic, a contentious packaging system; they are used only once, and are not being recycled.

Packaging can be one of the factors of waste in the food industry due to inadequate sizes.

In the aforementioned study, the drivers, issues and implications of food loss and waste (FLW) related to packaging are highlighted, as well as implications for implementation in life cycle assessments.

Variability in a manufacturing process results in defects in finished products, which in turn decrease product quality, productivity, profitability, and ultimately consumers satisfaction. To minimize the defect rate and variability of the final product, biscuits can be packaged using statistical process control (SPC) tools in a biscuit manufacturing facility, thereby increasing productivity, profitability and competitive advantage in the market (Jaiswal, Y., & Khanzode, V.R., 2020).

Despite increasing improvements in biscuits production processes, there is still a waste of resources and technological waste accumulation. The quantity of waste produced, and consequently its disposal, affects the production cost. The best way to maximize profit is obviously to reduce technological waste and plan its proper disposal (Manley and Clark, 2011).

Contamination is one of the primary reasons technological waste occurs during the making of biscuits.

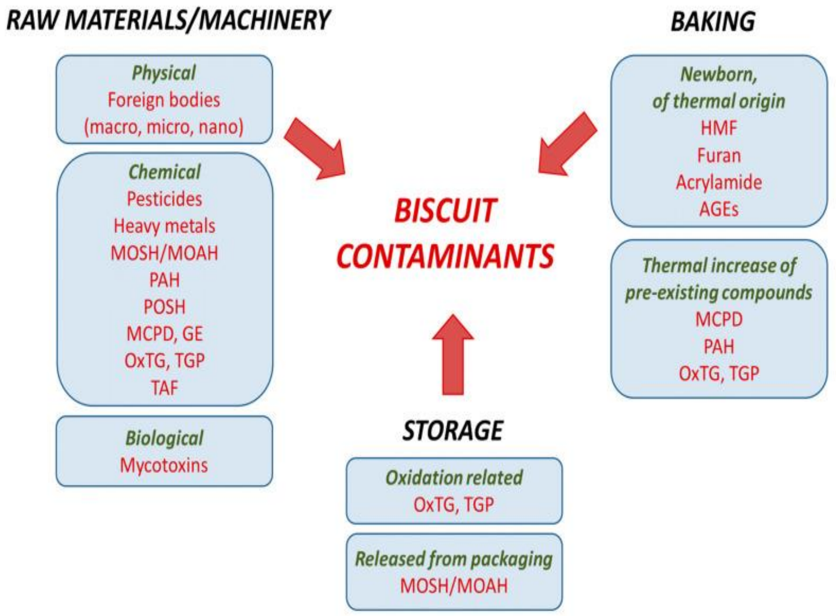

Fig 7.1. *Possible contaminants in biscuits derived from raw materials / machinery, baking process and storage (Pasqualone A, et al., 2021)*

7.2.1. Contaminants resulted from raw materials or equipments

Physical contaminants

Glass, plastic, textile threads, wood, paper, and metal are a few of the most typical foreign objects that might contaminate biscuits.

Chemical contaminants

Chemicals can pollute the soil, water, and crops since they are present in the environment. Since chemical contamination in raw materials is an issue on a worldwide scale, current legislation governs them.

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It is possible for the grains used to make flour to contain pesticides. Because of this, pesticide use is strictly regulated in the majority of nations today.

Heavy metals are another type of chemical contamination that can occur. Heavy metals from irrigation water, fertilizers, and metal-based plant protectants can contaminate the cereal crops that are used to obtain flour.

Cadmium and nickel are two examples of heavy metals that may be present in biscuits (Pasqualone A, et al., 2021).

Biological contaminants

Mycotoxins are regarded as biological dangers since their existence results from fungal pre- or post-harvest contamination of raw materials with a vegetable origin.

100 nations, or over 85% of the world's population, had explicit laws or regulations regarding mycotoxins in food in 2003.

7.2.2. Contaminants deriving from the baking process

Typically, biscuits are baked for a brief period of time at a high temperature (200 °C) (around 20 minutes).

The dough experiences changes in volume, water evaporation, and starch gelatinization, among other physical, chemical, and biological processes. The Maillard process and sugar caramelization are the two most important chemical reactions that take place during baking.

As a result of the Maillard reaction, baking may also result in the creation of other contaminants, such as acrylamide. Following its production, acrylamide is absorbed through eating, inhalation, and skin contact before being broken down into the mutagenic and genotoxic compound glycidamide.

The maximum acrylamide contents established for bakery product is 350 µg/kg, according to 2158/ 2017 Regulation. To solve this issue, products may be reformulated to have a lower pH, less antioxidant activity, or both.

It was discovered that ammonium bicarbonate should be replaced with other baking agents since it’s use favorized the production of acrylamide.

7.2.3. Contaminants from the storing stage

During the storage degradative processes can appear within the food matrix and chemical migration from packaging are both possible during biscuit preservation.

Chemical deterioration, such as lipid oxidation, is one of the reactions that manifests during storage.

Therefore, biscuit packaging must protect the product from water vapor, oxygen to prevent moisture absorbtion and oxidation of lipids.

Another problem that can occur is the growth of microorganisms. Bacterial growth was observed in the biscuits packed in cellophane bags because it was an insufficient barrier.

Oriented polypropylene (OPP) is one of the packaging materials most frequently used for biscuits. A greater barrier to oxygen will be provided by OPP in conjunction with PVC/PVDC. Metalized plastic films can also help to prevent photooxidation.

In order to protect the biscuits, other innovative materials were used - materials containing poly-lactic acid (PLA) and OPP with ethylene vinyl acetate (EVA). EVA was found to be more effective in reducing lipid oxidation (Pasqualone A., et al., 2021).

In particular, waste can result from mistakes made during the cooking or leavening phase, trial waste or scrapes (especially when biscuits do not have regular shapes or break during the production phases), or machinery malfunction, especially in the packaging phase (leading to unpacked biscuits or a defective packaging).

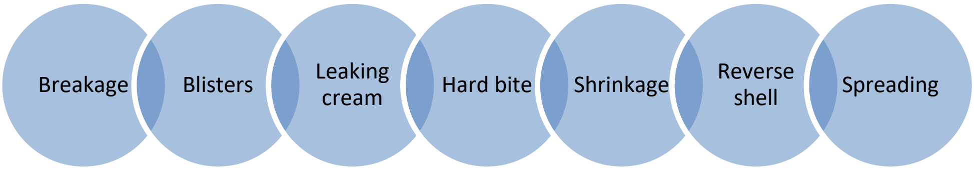
A large food industry would actually suffer significant image damage from poor packaging. Repackaging is also not a cost-effective option.

Losses can occasionally be linked to a product's removal from the market. In 2% of situations, this happens because the expiration date was passed.

The best way to minimize financial losses is to plan an effective trash recycling process. In this situation, the cookies ought to be gathered and stored in appropriate containers that ensure safety and hygienic conditions by preventing contamination. Then, using specialized grinders, they could be reduced to a flour that could be quickly recycled in new batches of biscuits.

This type of flour from the grinding of biscuits can be used up to 2% of the batch weight without changing the qualities of the dough. Biscuits flour must be appropriately labeled on the box and can only be used for a corresponding kind of biscuits (Konstantas et al., 2019).

Defects that occur in the processing stage of biscuits (Konstantas et al., 2019):



The causes of biscuits breakage are (Garcia-Armenta E., et al., 2017):

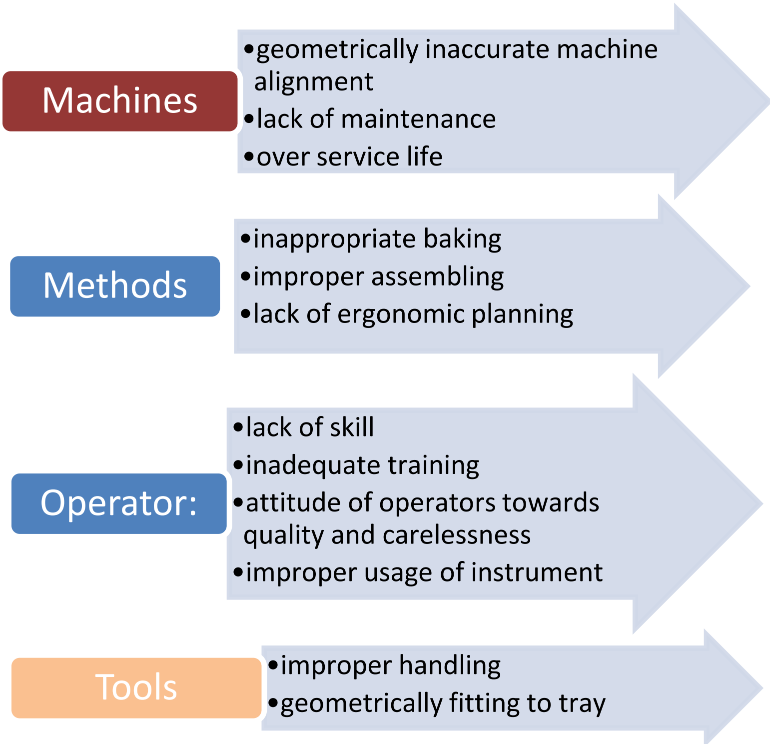


Fig. 7.2. *Breakage in biscuits (Garcia-Armenta E., et al., 2017)*

The causes of blistering in biscuits:

Tools
- Slower roller drive speed
- Geometrically inaccurate moulder

Operator
- fatigue
- lack of skill
- carelessness
- lack of training

Material - method
- Too high temperature
- Lack of ergonomic consideration
- Long baking process

Machine
- Overuse of capabilities and limitations
- Lack of preventive maintenance
- Over service life
- Improper machine setup

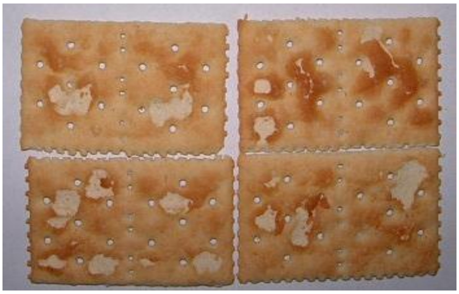


Fig. 7.3 *Blistering of biscuits*
(https://www.biscuitpeople.com/magazine/post/the-lamination-process-in-fermented-crackers)

Table 7.1. *Defects, causes and solutions to avoid waste in the technological process* (https://biscuit-maker.com/common-problems-of-biscuit-making-cookies-and-their-solutions/)

Defects	Causes	Solutions
Foaming	Temperature in front of the oven is too high	The oven temperature should be controlled not to be very high at first
	The dough is too elastic.	If the gluten blocks the gas channel and does not easily spread out, foam will appear at the surface. This can be solved by reducing the dough elasticity and using a mold with more needles.
Biscuits without color	The recipe contains a smaller quantity of sugar.	The sugar content must be increased.
Rough texture	Insufficient or excessive flour mixing time	the maturity of flour mixing should be judged correctly and in time
	the amount of leavening agent in the recipe is too small or too much	adjust the amount the quantity of leavening agent
	the amount of sugar and oil in the recipe is small	increase the amount of sugar and phospholipid should be added.
Cracking of biscuits:	The biscuits is over swollen and too loose	the amount of leavening agent should be reduced
	The amount of starch is too high	reduce the amount to be appropriate

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7.3. Causes of food waste identified in the packaging stage

Overproduction, improperly shaped food, and damaged packing are the primary sources of losses at the processing step.

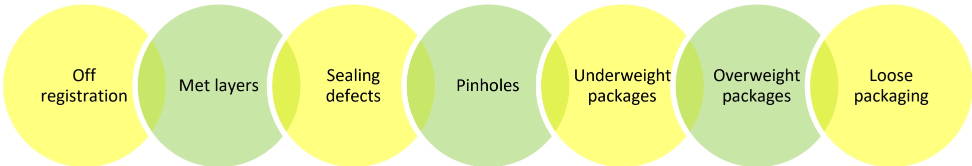
Due to improper handling, technological waste can appear during a manual filling operation. When packaging and filling machines are not properly matched or if there is a mechanical issue with the equipment, losses can happen during an automatic filling operation.

Packaging may leak after filling if the closure fails (ex: heat seal). The modifications made to the products for marketing purposes provide another problem at this point.

The package could be harmed later, the expiration dates could have been passed, or there could have been poor stock management.

Losses can now be reduced significantly by packaging and probable future advancements in material technology.

The packaging stage is susceptible to the following flaws (Jaiswal, Y., & Khanzode, V.R.,2020):



7.4. Prevention techniques for food losses in biscuit manufacturing industry

Reception of raw materials is one of the production stages where biscuit contamination might occur.

Cereals can be treated with UV, ozone, or pulsed light to prevent contamination and lower mycotoxins in raw materials.

The adoption of alternate baking technologies (vacuum baking, radio frequency heating), along with product reformulation, is another effective technique for reducing the thermal load that leads to the production of contaminants like acrylamide.

The best methods for reducing the rise in oxidation-related contaminations during biscuit storage involve the use of low oxygen permeable packaging materials and product reformulation using antioxidants (Pasqualone A, et al., 2021).

Active and intelligent packaging is another type of packaging technology that includes elements designed to release or absorb substances into or from the packaged food or from the environment around the food with the goal of extending the shelf life of the food (Wohner, B., et al., 2019).

Using biscuits technological waste as animal feed offers a potentially more sustainable strategy for improving resource efficiency.

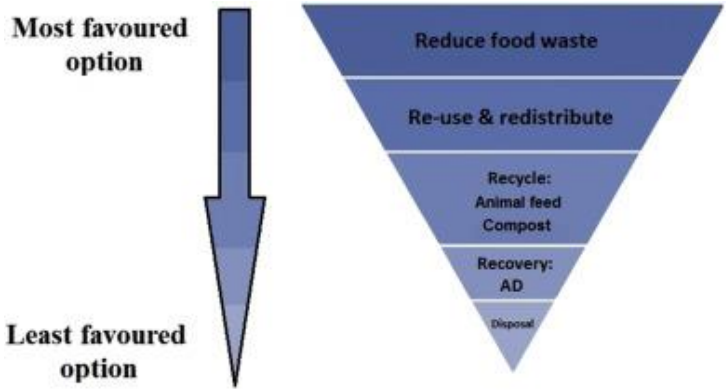


Fig. 7.4. *Stategies to prevent food waste in biscuits manufacturing industry* (https://ars.els-cdn.com/content/image/1-s2.0-S0959652616305042-gr1.jpg)

Utilizing food loss and waste in animal diets tackles issues with resource management, waste management, and food security. Since livestock can turn inedible food into high-quality protein non the form of meat, eggs, and milk, they are essential to the answer to reduce food loss and waste.

Any effort to divert food that does not meet criteria for human consumption or that is retrieved before being disposed of in landfills must guarantee that the health of animals, people, and the environment is not jeopardized.

More specifically, the rumen and, to a lesser extent, the large intestine contain a variety of microorganisms that can efficiently break down fiber found in by-products of plants that are inedible to humans, allowing the ruminant host to produce high-quality protein, including essential amino acids and fatty acids (Ominski K., et al., 2021).

Table 7.2. *Sensorial properties and the admissibility criteria of biscuits according to Romanian Standard STR 1406-88*

No.	Assort-ment	Appearance		Color	Taste	Aroma/ Smell	Consis-tency
		Exterior	Section				
			A. GLUTEN BISCUITS				
1	Regular biscuits	Whole flat pieces with semi-glossy surface, smooth, without blisters, with stings specific to the variety	Well baked, uniform layers, without gaps	Yellow brown	Pleasant - sweet	Characteristic of the flavors used	Hard
2	Graham biscuits	Whole flat pieces with semi-glossy surface, smooth, without blisters, with stings specific to the variety	Well baked, uniform layers, without gaps	Yellow to brown with darker points, whitish or burnt coloring is not allowed	Pleasant, characteristically graham	Characteristic of the flavors used	Hard
3	Honey biscuits	Whole flat pieces with semi-glossy surface, smooth, without blisters, with stings and drawing specific to the variety	Well baked, uniform layers, without gaps	Yellow to light brown, whitish or burnt color is not allowed	Pleasant sweet	Characteristic of the flavors used	Crunchy but not crumbly
4	Petit-beure biscuits	Whole flat pieces with semi-gloss surface, smooth, unburnt, blister-free, with stings	Well baked, uniform layers, without gaps	Yellow to light brown, whitish or burnt color is not allowed	Pleasant sweet	Characteristic of the flavors used	Crunchy but not crumbly
5	Spritzgebäck (spurt biscuits)	Regular shape with a matte upper surface,	Well baked, uniform layers, without gaps	Yellow to light brown, whitish or	Pleasant sweet	Characteristic of the flavors used	Crunchy but not crumbly

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		without cracks with well-embossed striations		burnt color is not allowed			
			B. SUGAR BISCUITS				
6	Sugar biscuits	Whole flat pieces of regular shape, with matte top surface, well-embossed design, unburnt, no blisters	Well baked with fine pores, without gaps	From golden yellow to uniform brown, whitish or burnt coloring is not allowed	Pleasant sweet	Characteristic of the flavors used	Crunchy, slightly crumbly
7	Dietary biscuits	Geometric figures, with a matte surface, not burned, without blisters	Well baked, fine porosity, no gaps	Light brown to dark brown on surface and golden in section	Pleasant sweet	Characteristic of the flavors used	Crunchy
			C. BISCUITS WITH ICING				
8	Biscuits with icing	Flat pieces, matte surface, slightly embossed design covered with a layer of cocoa or chocolate glaze	Well baked, fine porosity, no gaps	Brown specific to cocoa or chocolate glaze, yellow in section with brown border	Pleasant sweet	Characteristic of the flavors used	Crunchy but not crumbly
			D. CREAM BISCUITS				
9	Cream biscuits	Pieces with regular shapes, semi-glossy surface, smooth, not burnt, no blisters, no fat on the surface; Cream appearance: homogeneous, matte, greasy, evenly distributed without going beyond the edges of the biscuits	Well baked with uniform layers without gaps, with an evenly distributed layer of cream	Yellow to reddish brown for biscuits, no whitish or burnt colouring; Cream: uniform brown, light or yellow white	Pleasant sweet	Characteristic of the flavors used	Crunchy but not crumbly
			E. SNACK BISCUITS				
10	Snack biscuits	Flat, whole, regularly shaped pieces with matte semi-glossy surface, blister free, with stings, can be pigmented with cumin	Well baked with even layers without gaps	Yellow brown with darker dots; whitish, brown coloring or burning is not allowed	Pleasant, slightly salty taste of cheese and cumin	Characteristic, specific to the cheeses used	Crunchy but not crumbly

The biscuits must fulfill the condition from table 7.2.

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Chapter 8

Causes of food waste in the pastry industry. Measures to reduce food waste in the pastry shop

8.1. Studies on the causes of food waste along the production chain in pastry

Pastry products are foods made by baking a dough from flour, water and shortening/fat; they can be salty or sweetened. Sweetened pastries are often described as bakers' sweets.

Pastries are products based on dough shaped as such or in combination with other components (fillings, creams, different toppings), which increase their nutritional value.

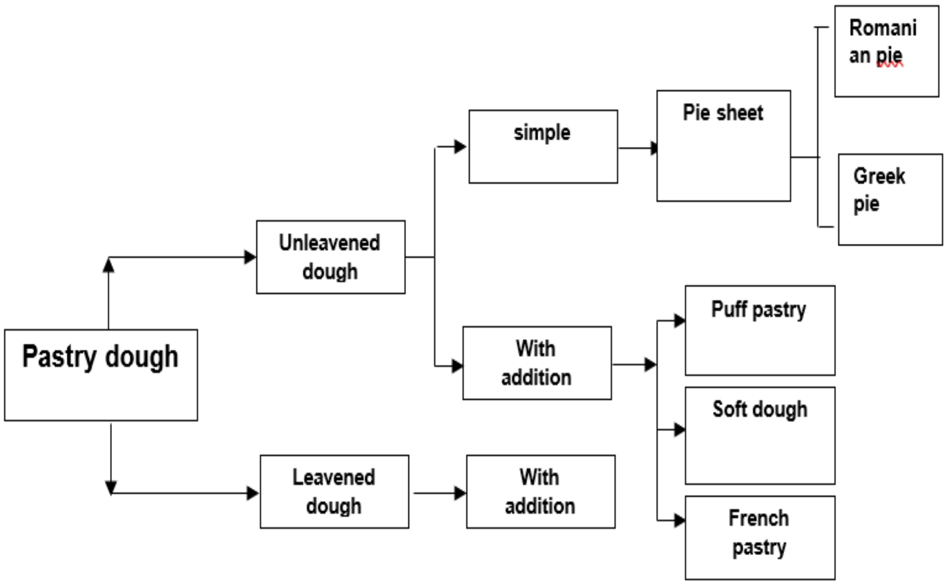

Figure 8.1. *Clasification of pastry dough (Alexa, 2008)*

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The leavened dough is the dough in the composition of which, in addition to flour, liquids, etc. baker's yeast is also added, which through the fermentation process creates a high porosity, increased volume, characteristic taste. The technology for obtaining leavened pastry dough is the same as the technology for obtaining bread and bakery products and can be achieved by two methods: direct and indirect.

The puff dough is an unleavened dough obtained by scalding the flour in a mixture of liquid, fat, salt in which eggs are incorporated at the end. By baking, preparations are obtained that are much increased in volume with high porosity in the shape of a honeycomb.

Soft dough is an unleavened dough consisting of a compact, dense mass, which after baking becomes soft and crumbly.

Puff pastry (French) is the dough that contains only flour and fat (butter, lard, margarine).

The characteristics of this type of dough are:

- represents an unleavened dough, which after baking separates into several overlapping sheets;

- the flour used must have an extraction degree of 30% and a wet gluten content of 24-32%;

- fat is used in the same proportion as flour,

- vinegar in small quantities has the role of increasing the viscosity of the dough;

- water has the role of hydrating the flour and the role of favoring the process of loosening and separating into sheets. The amount of water added depends on the quality of the flour. If the quality of the flour is high, the amount of water required is greater.

Handmade Romanian pie sheet is based on simple dough (flour, water, salt and lard) which, after resting, is partially spread on the table greased with lard, then by rotating overhead based on centrifugal force (Alexa, 2008).

Since pastry industry is considered as part of bakery industry it is difficult to find food waste information separately for pastry industry.

In a study conducted in Estonia by Piirsalu and others (2021), the production of the pastry industry was not considered separately, but pastry products were considered together as bakery products. Survey were sent to companies that produced bread and pastry products, including products like cakes, pies, tarts, biscuits, cookies, gingerbread, toasted bread and to producers of sweet and salty snacks (e.g. crackers, salt sticks, waffles, etc.). According to Piirsalu et al., 2021 the bakery and pastry industry in Estonia food waste makes up approximately 1-5% of the finished product.

8.2. Causes of food waste identified in the processing stage of pastry products

According to the research of Gorynska-Goldmann et al. (2021) the most common causes of losses in raw materials are signs of spoiling, moulding and impurities, all possibly caused by improper storage and handling or poor quality of raw materials. Also, bad hygiene and poor pest control are reasons for spoilage of ingredients during the storage.

For example, in Estonia, according to Piirsalu et al. (2022), in wheat production, 1.2% of product was discarded as food waste, mainly during pre-cleaning wheat caused by poor grain quality, and during drying process caused by power or equipment failures.

Loss of freshness and costumer preference are the main reason of wastage of baking and confectionary products in the supply chain. Short shelf life of non-permanent pastry products must be the central point of attention of whole production and retail chain. Improper management of activities within the production may lead to quality problems. For example, failing to maintain the controlled temperature within supply chain of pastries with perishable ingredients (cream, fresh fruit, meat, etc.) may lead to the fast growth of microorganisms, in turn leading to problems related to food safety, product failures and customer complaints. Gorynska-Goldmann et al. (2021).

Within production human errors are most common bakery waste generator (Iakovlieva, 2021) for example not correct measuring of the ingredients or aberrance from technological scheme can lead to spoilage/waste in production. Also, technical breakdown of machinery causes losses during production. Dough modelling can be very different depending on the product and the way of production (manual or mechanized) and same goes with occurrence of leftovers from dough modelling. Aberrance from technological scheme and technical problems with proofers/ovens can lead to waste in production (over proofed dough, under or overbaked/burned products).

In the production of bakery products, a lot of yeast dough is used, which is a so-called "living" product due to the presence of yeast and is not always controllable as a process, i.e. the dough can rise too much or, on the contrary, rise too little. In such cases, the dough is not usable in production and must be disposed. After baking, the visual quality of the finished product may be insufficient, making the product unfit for sale. Some waste (flour, dough, etc.) are also generated during the cleaning of equipment and premises. Normally, such bio-waste is handed over to waste handlers. (Piirsalu et al., 2021).

On retail level causes of waste are errors in placed orders, spillages, abrasion, bruising, excessive or insufficient heat, inadequate storage, technical malfunction, damaged packaging. Out-grading of blemished, misshapen, or wrong-sized food in an attempt to meet consumer demand.

Loss of freshness and costumer preference are the main reason of wastage of baking and confectionary products in the supply chain. Short shelf life of non-permanent pastry products must be the central point of attention of whole production and retail chain. Improper management of activities within the production may lead to quality problems. For example, failing to maintain the controlled temperature within supply chain of pastries with perishable ingredients (cream, fresh fruit, meat, etc.) may lead to the fast growth of microorganisms, in turn leading to problems related to food safety, product failures and customer complaints. Gorynska-Goldmann et al. (2021).

Since bakery products do not have a long shelf life, some products may remain ununsold (including returns by trading companies). Unsold bread and pastry have a significant share in the food waste and loss. Where possible, such bakery products are sold with discount, donated to charities or fed to livestock farmers. If this is not possible, the products are thrown away as waste (Piirsalu et al., 2021).

8.3. Measures to reduce food waste in the pastry industry

Reducing changeovers on the line and proper maintenance of the equipment prevents food wastage.

Proper sanitation standards for operating procedures have to be provided to enable preventative maintenance. Maintenance of the mixers, dividers, proof box and ovens have to be done once a week.

When the critical equipment fails to work at peak, it costs time and creates high levels of waste. For example, ovens not properly calculated can mean undercooked or burnt food. Mixers that don't function effectively fail to properly combine the ingredients, so products lack consistency in texture and taste. A poorly serviced machine might endanger employees and customers.

Maintenance steps provided by the equipment manufacturer for cleaning, storage, and preparations must be followed. All machines in the bakery have to be observed regularly to keep them working efficiently and to ensure all bakery goods meet high standards.

Innovations of packaging can be also one way to extend shelf life and protect products during transport and can't be underestimated.

Food loss in the production process can be reduced by knowing and analyzing the factors that cause it. Ways to reduce waste in bakery and pastry industry are described in table 8.1.

Table 8.1. *Manners of limiting food waste in bakery and pastry industry based on Gorynska-Goldmann et al. 2021*

Causes	Prevention
Improper organization of the environment in which baking and confectionary products are made. Secondary impurities.	Properly supervised production vicinity, elimination of damaged equipment, supervision over plastic and glass, elimination of dangerous items that may be potential sources of impurities.
	Cleaning and disinfecting machinery and equipment according to the sanitary schedule in place, using proper agents and correct concentrations.
	Pest control, e.g., window nets, impenetrable building, insecticide lamps, preventative activities performed and supervised by outsourced pest control specialists.
Human factor	Training for employees. Observance of GHP and GMP by employees and controllers. Health and hygiene control before commencing work, ongoing supervision. Periodical supervision, particularly concerning the observance of hygiene principles by employees. Hair nets, hygiene training for employees.
	Medical check-ups of employees prior to employment.
Lack of supervision over machinery and equipment.	Supervision over machinery and equipment—inspections and overhauls scheduled according to operation and maintenance documentation.
	Observance of legal regulations on the supervision of machinery and equipment.
	Employment of qualified employees and providing relevant training.
Improper handling of the production process.	Control of the semi-finished product net weight before baking, making records from the control, daily supervision. Strict observance of work position instructions. Training for employees and supervision. Qualified supervising personnel.
Improper operation of the oven, no supervision over the device.	Control of the time and temperature of baking. Supervision over machinery and equipment—inspections and overhauls of the oven scheduled according to operation and maintenance documentation. Training for oven operators
Employees' errors and neglect during bulk packing activities.	Packaging of proper quality to ensure safe transport. Training for employees on handling and

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	packing the goods. Supervision over the packing process. Releasing safe, but reduced quality goods for sale (deformed, minimal defects, poorly shaped) at reduced prices.
Overestimation of orders.	Optimizing production volume. Allowing for seasonality of production. Observance of First in First out rule.
Improper means of transportation, unfit for transporting foodstuffs, no sanitary approval. Improper sanitary and hygiene condition of the means of transportation.	Means of transportation certified for the transport of foodstuffs. Control of temperature and sanitary condition prior to loading. Training for drivers. Verification of recordings from washing and disinfecting the load compartment. Qualification of transport service providers.

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Both Iakovlieva (2021) and Gorynska-Goldmann et al. (2021) claim that human factor is most common bakery waste generator, for example low qualifications of freshly hired and insufficiently skilled employees can be one reason of the losses of production, so good training of the staff is very important part of prevention of food loss in industry.

Lebersorger and Schneider (2014) have indicated to some points for the future prevention approaches to be focused on returns of bread and pastry products that will shift responsibility from bakeries/producers to retail companies, additional internal optimization (benchmarking among retail outlets within a company and application of best practices), staff training, information and education of employees, raising customers awareness and increasing cooperation with social services e.g. food donations.

Also tracking leftovers in production and retail level helps to adjust production and errors in placed orders and providing opportunities for the research, development and production departments to improve efficiencies helps to reduce food loss. Implementation of a food loss prevention programs would be great importance in the pastry industry to reduce waste. Some examples of defects, causes and remedies for different pastry products are presented in tables 8.2; 8.3; 8.4; 8.5 and 8.6.

Tabel 8.2. *Defects, causes and remedies at Romanian/Greek pie (Alexa, 2008)*

Defects	Causes	Remedies
Unevenly spread sheets	Flour with weakly kneaded gluten and insufficient dough rest	After the first sheet, the rest is extended
Torn sheet	Flour with weak gluten, overstretched	Irreparable
Dry or stuck sheets	Insufficient use of grease Irremediable	Irremediable
Salted sheets	Incorrect dosing	Addition of filling

Tabel 8.3. *Defects, causes and remedies at shell of puff pastry (Alexa, 2008)*

Defects	Causes	Remedies
Clumps of flour	Flour was added gradually, not mixed immediately and quickly	Beat the dough with the mixer
The dough has a cut appearance with oil on the surface	Improper water (oil)/flour ratio or incomplete boiling of the liquid	Preparation of another quantity with more flour that is mixed with the cut dough.
Dough consistency too soft	Insufficient boiling, incorrect water/flour ratio or increased egg content	Combining with more consistent dough to which no eggs have been added
Insufficiently raised shells	Bake at temp. < 180 degrees or the oven was opened in the first 10 min	They cannot be fixed
Incorrect size shells Proper return	Incorrect casting or use of incorrect size sprit	Proper return

Tabel 8.4. *Defects, causes and remedies at products obtained from puff pastry (Alexa, 2008)*

Defects	Causes	Remedies
Inadequate weight	Incomplete dosing of the components or small space to fill the shells	Completing the preparations with decorative elements
Inadequate height	Due to filling and decoration, it was not raised properly	-
Incomplete and uneven glazing	Inadequate fondant fluidity	Covering with additional fondant
Matte appearance	Too high fondant temperature	Cover with additional fondant
Sticky icing	Fondant temperature too low	Covering with extra fondant
Whipped cream	Beating point exceeded	Replace with another cream

Tabel 8.5. *Defects, causes and remedies at soft pastry (Alexa, 2008)*

Defects	Causes	Remedies
Separating the fat from the rest of the components.	The fat contains too much water or too many eggs.	Heat the composition slightly and homogenize it internally.
Raw dough is too hard or too soft.	The recipe was not followed	
After baking, the dough shows white spots or voids on the surface	The cast sugar was not completely dissolved, and the baking was done on too low a heat	Mask the surface by covering it with icing or powdered sugar
Hard consistency after baking	- The recipe was not followed, - the flour was added by kneading	They can only be prevented
The product leaves traces of fat	- The flour/water ratio was not respected, - the baking was done on too low a heat.	They can only be prevented
Too crumbly dough, which does not keep its shape when cut	- The flour/fat ratio was not respected, - the amount of liquid was too little.	They can only be prevented
Reddish color, unpleasant taste and smell	- The fat was rancid, rancid -it has not been quenched with an acid before use.	They can only be prevented
Insufficiently baked product in the middle	- Dough too thick, or the oven too cold. -In the first phase of baking, the product is insufficiently loosened.	An empty tray is inserted under the tray with dough, and its surface is covered with a paper.

Tabel 8.6. Defects, causes and remedies at product obtained from french pastry (Alexa, 2008)

Defects	Causes	Remedies
After combining with the fat, the dough changes its consistency	- The flour was not of appropriate quality -excess water was not removed, - the temperature of the room where you work is higher than 20^0C	They can only be prevented
At the first turn, the dough breaks	- The fat has a different consistency from the dough,	They can only be prevented
After baking, it looks flattened and insufficiently raised	- The recipe was not followed	

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Undercooked in the middle	- The baking time was not respected; - the baking temperature was too high in the first phase; -Adequate cooling was not ensured.	If the defect is noticed before complete cooling, put it back into the oven.
It leaves traces of fat on the hand	- The flour had weak gluten; -baking was done at a temperature lower than 200-250^{0}C; - the pan was greased the sheets placed on paper to absorb the excess fat	the sheets are placed on paper to absorb the excess fat

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Chapter 9

Possible strategies to prevent FW in flour-based product industry

9.1. Studies regarding possible strategies to prevent FW

Over time, many researchers and companies in food industry have tried to find better alternatives to reduce and prevent waste (Iakovleva 2021) and since the Eurpean Green Deal the European Union has decided to focus sharply on reducing food waste (EU Parliament, 2020). Life cycle assessments have clearly indicated that food waste prevention is an important strategy when looking for ways to reduce the environmental impact of bread (Svanes et al., 2019).

Food waste prevention is an important issue to improve food security and resource management at the planning and implementation level (Zorpas & Lasaridi, 2013).

Work plans, schemes and strategies are among the most important tools for planning and optimizing bakery technological processes for companies in this industry (Goryńska-Goldmann et al., 2010).

In order to prevent the losses and waste in food and flour industry, the technological schemes need to be revised and supplemented. Implementation of a food loss prevention program would be of great importance in the large industries where the generation of waste and losses are evident and may seem at first un-avoidable.

Goryńska-Goldmann et al. (2021) suggest that the monitoring of volumes and causes of losses should be maintained across all individual technological operations. Faggini et al. (2021) have proposed the ways towards food sustainability and effectiveness, an example is presented on figure 1.

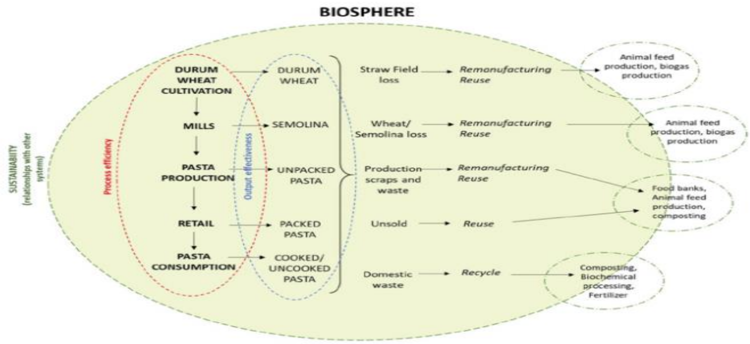

Figure 1. *How to make pasta supply chain sustainable, a focus on loss and waste.* (In Faggini et al., 2021; Source: Adapted from the Ellen MacArthur Foundation, 2014)

In a study by Aschemann-Witzel et al. (2017) the authors indicate there are 3 main pillars concerning the tackling consumer food waste, as follows:

- consumer awareness regarding its ability to avoid food waste,
- foodbanks or consumer-led actions and
- thirdly, different strategies of the supply chain such as retailers' actions.

Moreover, timing, collaboration and competencies are the main key success factors able to sustain the three aforementioned pillars. The idea of food banks is also supported by Ramírez et al. (2021) who mentioned that one strategy to avoid fruits and vegetable waste could be the donation of it to food banks. . As well as products based on purchased flour that are removed from sale and overproduced could also be donated to a food bank.

Recently, De Laurentiis et al. (2020) mentioned that European Commission Joint Research Centre has built up a framework evaluation regarding the actions aimed to prevent food waste.

EU platform on Food Losses and Food Waste is supported by the framework which has the mail goal to identify best practices and to further share knowledge focused on food waste prevention initiatives.

Moreover, authors developed their own framework which is based on two quantitative criteria such as efficiency and effectiveness and on four qualitative ones such as sustainability of the action over time, action design quality, scalability, transferability and intersectoral cooperation.

Moreover, authors mentioned the need to have a calculator based on the principle of life cycle thinking which can be considered a way to prevent food waste in the early stages.

Katt and Meixner (2020) outlined that shopping-related behavioral aspects at the consumer level could also influence food waste prevention. Aspects regarding the environmental and health concerns together with price awareness proved a positive influence on food waste prevention, meantime, a negative effect of hedonic shopping value was mentioned.

Vidal-Mones et al. (2022) tested the potential to prevent food waste in school canteens and showed that a prevention of 59% was mainly identified for dessert such as fruits, whilst the daily meal waste was reduced to 41%. The study concluded that for a higher successful rate in preventing food waste all canteen staff should be equally involved, increasing their awareness with respect to food waste health and environmental implications.

Considering the food waste prevention pyramid, the best way to reduce food waste is to prevent the extra production of food together with the disposal of avoidable food waste and, when it is possible, the reuse of the surplus food, which is still edible (Giordano et al. 2020). In this direction, in Italy and France some specific laws considering food waste have been approved and Directive 2008/98/EC (EU, 2008) mentioned that prevention, reuse preparing, recycling, other recovery and disposal represents the main priorities in waste management.

Other strategies to prevent food waste could be related to the retail company through redistribution of food still edible to charities, monitoring the food waste as a key performance indicator in the retail company, or promotion price strategies such as the discount of a product which has a short shelf life, (Poças Ribeiro et al., 2019). On the other side, Goryńska-Goldmann et al. (2021) outlined that employee's qualification, the information transfer, education, and the development of guidelines for each enterprise based on its scale production and specificity could lead to a positive influence on food waste.

Talking about possible strategies to prevent food waste, it should be considered also the technological ones, including the storage of the final products. For instance, Alpers et al. (2021) showed that bread products must be protected against moisture that could promote the spoilage development, through the use of specific packaging materials. Moreover, the use of sourdough is a tool that decrease spoilage and staling process, leading to a prolonged shelf life together with sanitary conditions during storage (Alpers et al. 2021). The use of sourdough fermented with yeast and/or yeast and lactic acid bacteria in bread manufacturing led to the development of organic acid such as lactic, of exopolysaccharides, different enzymes and to the formation of antimicrobial compounds and bactericidal substances that enhanced the shelf life of the final baked goods Taglieri et al. (2021).

It is worthy to mention also the novel advanced packaging technologies, that are claimed to prolong the shelf life of different products. For instance, the combination between modified atmosphere packaging and active packaging could be successfully used for prolonging the bakery products shelf life. Moreover, the incorporation of an iron-based oxygen scavenger could act as an antimicrobial agent, in a similar way as CO_2, enhancing bakery products shelf life (Upasen et al., 2018).

The development of antifungal sachets based on essential oils in microcapsules showed positive results in inhibiting the development of moulds and yeasts thanks to eugenol and citral compounds (Ju et al., 2020). Furthermore, the use of different types of packaging such as low-density polyethylene, high density polyethylene and polypropylene could increase the shelf like of the bread, compared to the control. For instance, bread packed in high density polyethylene reached a shelf life of 15 days, while the bread control has only 5 days of shelf-life (Ju et al., 2020).

The use of enzymes such as maltogenic amylase, α – amylase lipase enzyme formulation could also enhance the extension of bread shelf life through their anti-stalling effect and through a slow decrease of hardness and chewiness parameters over time (Taglieri et al., 2021).

Beretta et al., (2013) have suggested more complex approach for assessing the food loss and wastes. For example, if the cereals are sorted out in mills and the waste are used for feeding then this tends to be less relevant than the same amount of baked bread going to waste in a restaurant. Therefore, food losses should be evaluated by life cycle assessment, but not only be quantified. This would allow more precise quantification of the environmental benefits of reducing food waste and lead the way to define priority fields.

Piirsalu et al. (2022) did point out some recommendations for policymakers as well:

creating strategies and setting political targets for food waste prevention and reduction at the state level;	contribution to the further development of monitoring and measuring methodologies, especially accounting of different by-products;	promoting food donation and supporting other organisations dealing with donations;	increasing motivation to donate food beyond the retail sector, particularly in the food industry, catering sector, and primary production.	promoting the prevention and reduction of food waste and support valorisation opportunities in food processing industries and the primary production sector;	promoting and supporting the recycling of food waste (e.g., composting); and	supporting awareness-raising activities.

9.2. Possible strategies to prevent FLW at the handling and storage stage of flour products

9.2.1. Strategies to prevent flour degradation in the storages

- warehouses should be clean, dry, well ventilated, air temperature of 10-12°C.
- flour sacks must be stored on wooden grates to ensure ventilation of the stacks and on the lower part and not to draw moisture from the floor.
- between the bag stacks and the walls or between two stacks, a minimum 0.5 m for inspection and ventilation space must be left.

- installation of traps for insect control and disinfection with insecticidal substances.

- separating the flour from insects by sifting using a suitable sieve, thus removing the larvae, chrysalises and even the adult insects.

- the remains of infested flour, together with the broom, are destroyed by burning.

- keeping warehouses in a state of permanent cleanliness, ventilation and their dry state are the most effective measures to prevent the formation of outbreaks of infestation.

9.2.2. Methods for reducing fungal and mycotoxins contamination in different flour during storage:

- Flour contamination with total bacteria by Dry heating at 80-180^{0}C for an interval of 5sec-15 min.

- Wheat flour with *Staphylococcus aureus*, *E.coli*, can be decontaminated by dry heating at 290^{0}C for 5 min.

- Wheat flour with aerobic mesophilic bacteria and *Enterobacteriaceae*, decontaminated chemical treatment with 5.0% lactic acid–NaCl.

- Flour contaminated with *Saccharomyces cerevisiae* and with *Salmonella*, can be treated by pulse for 10 ms, with 395 nm wavelength.

- Wheat flour contaminated with aerobic mesophiles, thermophiles, and molds, decontaminated by cold atmospheric pressure plasma with following conditions: power supply frequency 9 kHz, voltage at 15–20 kV, for 60 or 120 s.

- Soft winter wheat organic flour contaminated with *Enterococcus faecium*, *Salmonella*, decontaminated by pasteurization with conditions: 6kW, 27.12 MHz RF heating unit. Electrode gap 35 mm. Aluminum test cells and 85°C, 33 min.

- Wheat infested with insects during storage can be treated by irradiation (treatment with 1, 10 and 25 kGy of radiation from a 60Co source).

- Flour with microbial load can be decontaminated with ultraviolet radiation combined with ozone (20 mg/kg of flour).

- Soft winter wheat organic flour contaminated with *Enterococcus faecium, Salmonella* can be treated by vacuum steam treatment at 65°C for 8 min.

- Wheat flour infected with microorganisms by radio frequency irradiation up to temperature of 75-100°C, followed by cooling and cold air.

- Wheat flour with Ochratoxin A (OTA) can be decontaminated using cooking in electric oven with ultraviolet radiation combined with ozone.

Food losses can be avoided to a minimum by planning inspections, hiring professionals to use effective methods of work organization, of machinery and equipment.

9.3. Possible strategies to prevent FLW at the processing and packaging stage of flour products

Measures that can be taken to avoid defects in the processing of the bakery flour products, are described in table 9.1:

Table 9.1. *Measures taken to avoid defects in the processing of the bakery flour products*

The use of inappropriate raw materials in the dough preparation stage	Airing the flour in order to oxygenate it, mixing it with healthy flours, increasing the acidity by increasing the food acids (ascorbic, lactic, acetic acid)
	Addition of gluten 1-2%, addition of sugar 2%.
	Addition of α-amylase in the form of malt preparations or fungal α-amylase (from moulds).
	The addition of malt preparations or improvers to bring supply of amylases and proteases, proteolytic preparations or reducing substances
Wrong management of the technological process	Adding a quantity of about 0.2% yeast when kneading the dough and re-kneading it.
	Shortening the fermentation time of the dough.
	Dosage of flour and water according to the recipe of the respective quality of the flour used in manufacturing.
	Extending the duration of the final fermentation until full maturity.
	Adjusting the oven temperature by interrupting the baking for a short time.

	The correct handling of the devices for forming steam and those for its evacuation from the baking chamber.
Storage and handling of bread after baking	Regular placement of bread in boxes, on racks or on shelves.
	Transporting bread only in crates or racks; care will be taken that the bread is cooled first.

9.4. Possible strategies to prevent FLW in the bakery industry

- **Ensure proper conditions for raw materials storage**

Controlling the storage conditions for raw materials is crucial to reduce losses (e.g., warehouse temperature and humidity control, cooling system control).

- **Reducing bacterial contamination of raw materials by using preservatives and modified atmosphere packaging.**

In order to reduce the incidence of this problem it is necessary to have in force strict sanitary and manufacturing practices. Also, the use of preservatives like propionate can be used to eliminate this problem.

- **Control of technological parameters in order to reduce loss in the stage of forming, modeling and baking the dough**

A more efficient control of the technological parameters (regarding the handling of the dough and the evaluation of its temperature and acidity, among other things) can significantly reduce production losses during the stage of forming and modeling the dough to obtain floury bakery products.

It is very importabt that the employees to be proper trained on the proper organization and physical control of the production environment.

- **Maintenance**

One of the most important things in bakery is equipment maintanence. When the equipments are not working properly that creates loss of money, time, etc,.

If the oven does not work properly that means that the products can be undercooked or burnt. In the case the mixers do not function properly it is possible that they do not combine the ingredients as they should and the final product can be affected and considered waste.

- **Proper measuring**

Accurate measuring systems are very important for obtaining products with the same quality. Using verified scales for dry ingredients, measuring containers for liquid ingredients the waste can be reduced.

- **Monitor sales**

Another way to reduce the waste is to monitor the orders. If the sales forecasting are accurate this allows inventory management, an efficient baking schedule can be established and also the marketing strategy can be adapted based on customer trends.

- **Proper Handling**

Handling the products is very important, thus the employees must be trained in order to handle correctly each product during baking, packaging and delivery.

9.5. Possible strategies to prevent FW in the pasta industry

Measures that can be taken to avoid defects in the processing of the pasta are:

- Implementing innovative and smart technologies to remove impurities and to monitor storage parameters (temperature, time, cleanness, insects, and parasites presence) for the raw materials.
- Checking the quality of raw materials (by using quality indicators)
- Providing uniform hydration of raw materials during the mixing.
- Using calibrated devices for the dosage phase.
- Using modern equipments for mixing and dough development which work under vacuum and promote a rapid and uniform hydration; this technology requires a resting period before pasta extrusion.
-Using drying equipments (vacuum dryer, microwave drying systems) which reduce drying periods in order to obtain finished product with fewer fissures, more firmness, and less gelatinization than hot air-drying pasta.

-Implementing smart technologies to monitor production parameters (temperature, pressure, time, moisture content).

- Adoption of specific technology-based packaging solutions to extend packed pasta's self-life (intelligent packaging, nano- biocomposites, biodegradable polymers reinforced with nano-fillers for packing matherials etc).

- Implementing innovative and smart technologies to monitor the presence of foreign objects (metal detectors, plastic detectors).

-Using specific logistics management systems (e.g., the first-expired-first-out transportation model) to minimize the most frequent pasta losses due to package damages.

- Implementing mobile apps for preserving pasta quality and optimizing its use before the expiring date

9.6. Possible strategies to prevent food waste in the biscuits industry

9.6.1 Prevention techniques for food waste in the biscuit sector

- Choosing raw materials (cereal or flours) already treated with UV, ozone, or pulsed light in order to prevent contamination and lower mycotoxins in raw materials.

- The adoption of alternate baking technologies (vacuum baking, radio frequency heating), along with product reformulation, is another effective technique for reducing the thermal load that leads to the production of contaminants like acrylamide.

- Using packaging materials with low oxygen permeability and improving the product recipe using antioxidants to reduce the increase in oxidation-related contamination during biscuit storage.

- Using active and intelligent packaging that includes special elements designed to release or absorb substances into or from the packaged food or from the environment around the food with the goal of extending the shelf life of the food.

9.6.2. Strategies to avoid food waste in the technological process of biscuits

- In order to avoid foaming due to too elastic dough or improper temperature, the oven temperature should be controlled not to be very high at first, and the surface temperature should increase gradually;
- If biscuits have no color**,** must be due to low quantity of sugar and the sugar content must be increased;
- Rough texture of biscuits come from insufficient or excessive flour mixing time, low sugar and oil content and the main measures refers to correctly mixing time and increase the amount of sugar and phospholipid;
- Cracking of biscuits due to high starch content can be prevented by reducing the amount of starch;
- Cracking of biscuits due to over swollen or too loose can be prevented by reducing the amount of leavening agent.

9.7. Possible strategies to prevent food waste in the pastry industry

Many pastries experience food waste on a regular basis but fail to identify it, especially when it involves dry nonperishable ingredients.

The other type of food waste with the potential to significantly affect this industry is overestimating the amount of finished product needed to meet daily market demands.

Ways to prevent food waste in pastries:

- **Monitor technological waste**

Carefully monitoring technological waste provides an convenient way to fine-tune production outputs so that losses are minimum.

Keeping an itemized record of any profits or losses involved in second-day sales of your baked goods so you'll know which products to give your primary focus to when it comes to tweaking production schedules.

- **Donate unsold products**

Donating unsold products that are still in the validity term to a local charity, centers for homeless persons and food banks, veterans' organization, elderly organization, nursing homes can use a few pastry products on a regular basis.

- **Staff training**

Untrained pastry staff is one of the primary drivers when it comes to food waste in production units.

- **Equipment maintenance**

Improperly maintained equipment is responsible when it comes to food waste in a production unit.

9.8. Good practices in FLW prevention. FLW standards and guide.

Good practices in FLW prevention. FLW standards and guides

Each entity from production or commercial sectors must develop inventories for waste and loss. By completing an inventory, companies employing a FLW standard (or guide) should document the factors or causes that contribute to their FLW production. Record-keeping causes may assist entities in identifying the best FLW prevention and reduction strategies.

Prior to the implementation of an action, it is essential to identify its aim(s), objectives, and key performance indicators (KPIs), as well as to be aware of the baseline against which the action's success will be assessed. This will make it possible to track progress and successes as well as spot areas for development.

The success of a preventative intervention, or how well it achieved its goals or produced the expected outcome, is measured by its efficacy.

For this reason, some procedures for FLW accounting and reporting, as well as some requirements that must be followed for a FLW inventory are necessary.

To establish good practices in FLW prevention some steps are mandatory. These steps are summarized in Figure 9.3.

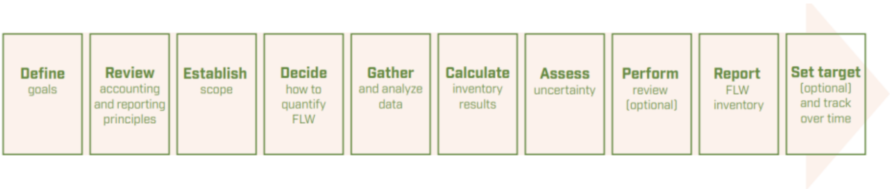

Fig. 9.3. *The main of Steps in FLW Accounting and Reporting*
(Food Loss and Waste Protocol (flwprotocol.org)

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To account and report FLW, five principles must be taken into consideration to implement the good practices: relevance, completeness, consistency, transparency, and accuracy. Their descriptions are shown in Table 9.2.

Table 9.2 *Principles of FLW Accounting and Reporting*

Food Loss and Waste Protocol (flwprotocol.org)

Principle	Guidance
Relevance	Food waste report must contains the information that is necessary for an entity’s internal and external stakeholders to make their decisions. Food waste inventory relevance is due to selecting relevant methods for quantification and data sources as well as collecting data of sufficient quality
Completeness	Any components that would affect the accuracy of the reported inventory should not be left out of the food waste inventory.
Consistency	To consistently provide food waste data throughout time, it is crucial to apply the same inventory scope, quantification methods, and assumptions.
Transparency	The degree to which information about the food waste inventory's methods, procedures, assumptions, and limits is accurately recorded and communicated in an impartial, intelligible manner is referred to as transparency.
Accuracy	Data must be accurate enough to provide intended users a fair level of assurance that the data in the inventory is reliable before they make a choice.

It is also very important to establish the timeframe, material type, destination that will be covered by FLW inventory and what type of quantification method will be used. Gathering, calculating, and analyzing data obtained after FLW quantification are also important phases of this process. To convey environmental impacts, nutritional content, or financial implications, companies may use the FLW in terms or units of measurement in addition to weight. The final steps are reporting FLW and setting targets of FLW reduction as well as tracking the progress of FLW reduction, monitoring performance, and adjusting.

Regarding timeframe, material type and destination, their definitions are:

• Timeframe: the period for which the inventory results are being reported, for example a 12-month period

• Material type: the materials that are included in the inventory (edible parts only, inedible parts only, or bot h)

• Destination: where FLW goes when removed from the food supply chain

With respect to the destination, firstly, it is necessary to identify the FW action which is suitable for the company. The actions could be grouped in five classes as follows:

1. Redistribution of food for human consumption
2. Food valorisation
3. Consumers behaviour change
4. Improvement of the supply chain efficiency
5. Food waste prevention governance

For each action, a number of sub-actions could be identified in order to achieve the goal; these are summarized in Table 9.3.

Table 9.3. *Clasification of FW prevention actions (after Caldeira et al., 2019)*

Type of action	Sub-type of action
Redistribution	Surplus food redistribution Digital tools for redistribution
Food valorisation	Value added processing. Animal feed
Consumers behaviour change	Awareness/educational campaign Digital tool for behaviour change School programs Awards
Supply chain efficiency	Process innovation Innovation of products - packaging Innovation of products - date marking Training & guidelines Price discount

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	Imperfect product sale Certification Public procurement Digital tools for supply chain efficiency
Food waste prevention governance	Voluntary agreement Regulatory framework/policy National food waste prevention program Fiscal incentives

The goal of the *Redistribution* actions is to redistribute surplus food fit for human consumption through activities like selling surplus food to businesses for a profit; donating it to charities for the benefit of those in need or using digital tools to manage the redistribution of food (e.g. apps, websites).

The goal of the *Food valorisation* actions is to valorise food by processing into other food products or to produce animal feed.

The goal of the *Consumer behaviour change* actions is to encourage consumer behavior change to reduce the amount of food waste produced by a less wasteful behaviour, educational programs for children and teenagers or developing digital tools to guide consumers towards food waste reduction.

Supply chain efficiency have the goal of increasing the efficiency at any stage of the food supply chain by using actions as: implementing more efficient processes and technologies, providing training, developing guidelines to achieve FW reduction at production/processing/distribution stages, developing digital tools to provide guidance, introducing new packaging systems, optimizing the validity date from the labels etc.

Regarding the *Food waste prevention governance*, these activities include all voluntary and mandated measures impacting actors towards FW reduction by supporting; it can also be referred to as crosscutting actions.

9.8.1. Methods of Quantifying food waste

The main methods of quantification for food waste that could be used are:

Table 9.4. *Food Loss and Waste Protocol*

Food Loss and Waste Protocol (flwprotocol.org)

Method	Description
Direct weighing	Using a measuring tool to determine FLW's weight
Counting	Combining scanner and sensors data as well as counting the number of elements that make up FLW to calculate weight
Volume determination	Determining the weight by evaluating the actual space that FLW occupies.
Waste composition analysis	Removing FLW physically from other materials in order to weigh and analyze it
Records	Using specific data points that have been noted or preserved and are sometimes routinely gathered for purposes other than assessing FLW (e.g., waste transfer receipts or warehouse record books)
Diaries	Keeping a daily record of FLW and other data
Surveys	Using a series of structured questions to collect data on FLW quantities or other information (such attitudes, opinions, or self-reported actions) from a large number of people or entities
Mass balance	Measuring inputs (such as ingredients at a production site, grain entering a silo, and products manufactured, grain sold to market), outputs (such as grain shipped to market), changes in stock levels, and changes in the weight of food throughout processing
Modeling	By employing a mathematical strategy based on the interplay of several variables that affect the production of FLW
Proxy data	Utilizing FLW data from sources other than the FLW inventory of an entity (such as older data or FLW data from another nation or business) to infer FLW amounts that fall within the inventory of the entity

9.8.2. Calculation of food waste across stages of the food supply chain

It is best practice to create a flow diagram that shows the movement of food products (and, if applicable, related inedible elements) inside and between phases when assessing FLW quantities between stages. An example of calculation is given in Table 9.5.

Table 9.5. *Example for FLW calculation during supply chain*

Supply Chain Stage	Recorded FLW at each stage (tone)	% FLW by stage	Cumulative % of FLW
Production	25 t (from 100 t)	2,5%	2,5%
Handling and storage	2 t (from 75 t)	2,66%	[(25+2)/100)] *100=27%
Packaging	0,8 t (from 73 t)	1,09%	[(25+2+0,8)/100]*100=27,8%
Distribution and market	8,2 t(from 72,2t)	11,35%	[(25+2+0,8+8,2)/100]=36%

9.8.3. Principles for reducing food waste in flour product industry

An industry road map for collaborative innovation and reduction of food waste procedures that is ethical and inclusive is of crucial importance. Thus, *10 principles* for reducing food waste in flour products sector could be states:

- **Cooperation along the whole value chain**

1. To improve, we must work together.

To put food waste on the value chain agenda, educate consumers, and exchange best practices, all players must work together.

2. The value chain requires more cooperation from us.

This means developing a relationship of trust and cooperating to get better answers.

3. Encouraging transparency and sharing along the value chain.

Clarifying shared objectives, exchanging data pertaining to food waste, and improving cooperation are examples of this.

4. Holistic thinking is essential.

Not simply the food waste of individual actors, but the overall amount of food waste, must be decreased through cooperation.

- **Internal communication in companies**

1. Instilling ownership and incentives for decreasing food waste across the *business.*

It is of hreater importance to define targets, measure progress, develop culture and competences, and include a food waste viewpoint into all organizational activities. Consumer involvement and education in the battle against food waste.

2. Consumer support is required

This calls for greater consumer behavior testing, educating customers, and cultivating a culture of tolerance for food goods with small aesthetic defects and less abundance.

3. Communicating with consumers more frequently.

This suggests more participatory forms of communication where customers are more engaged in business innovation and product development.

participation of other actors

4. Communicating with the authorities.

This means removing legislative obstacles to crucial food waste efforts and helping authorities set up or support industry-led initiatives.

5. Sharing knowledge.

From a variety of perspectives, industry players should offer their knowledge to food waste efforts aimed at consumers, the education sector, and other players who may help develop competence and positive attitudes within their own workforce and society.

6. Participating in new research collaborations to a larger level.

Contributing to the creation of fresh, pertinent information that is intended to prevent food waste.

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QUESTIONS & ANSWERS

I. Questions

1. What is the definition of Food Waste in the European Union?
2. What are the causes of food waste?
3. What are the food supply chain stages?
4. What are the causes of flour degradation in the storage stage?
5. What can significantly reduce production losses during the stage of forming and modeling to obtain floury bakery products?
6. What are the causes of food losses and waste generated during pasta production?
7. In which phase of pasta production the largest amount of waste is concentrated?
8. What are the causes of food waste in the biscuits industry and what are the most effective mitigating strategies?
9. What are the solutions to avoid waste in the technological process?
10. What are the causes of food waste in the pastry industry?
11. What are the responsible factors for flour quality in order to avoid processing losses in storage stage?
12. What are the intrinsic factors responsible for flour quality in order to avoid processing losses in storage stage?
13. Which are the causes of flour degradation?
14. What are the methods for reducing fungal and mycotoxins contamination in different flour during storage?
15. What are the main stages of the technological process of baking?
16. What are the main causes of bread defects?
17. Which are the microbiological factors that limit the shelf-life of the bakery products?

18. What are the most common species that cause bacterial spoilage in raw ingredients for bakery products?
19. What are bio-preservatives? Please give an example.
20. What are the possible contaminants in biscuits derived from raw materials / machinery, baking process, and storage?
21. List the contaminants of the biscuits that can come from the raw materials / equipment, the baking process and storage.
22. What is the maximum content for acrylamide established for bakery products?
23. What are the defects that occur in the processing stage of biscuits?
24. What are the causes of defects resulted from the technological process of the biscuits?
25. What methods can be used in order to prevent contamination of cereals and lower mycotoxins in raw materials?
26. What are the issues that must appear in order that the biscuits are rejected and considered waste?
27. What are the causes of food waste in the bakery and confectionery production section?
28. Where are the points of food waste recovery highlighted during the processing of flour products?
29. What are the causes of food waste during the preparation and processing of dough to obtain flour products?
30. What are the causes of food waste during baking and packaging of flour products?
31. What are the causes of food waste during the shipping (storage) and transport operations of flour products?
32. What are the characteristics and the roles of active packaging?
33. What are the characteristics and the roles of intelligent packaging?
34. What are the stages and types of food losses and waste generated during pasta production?
35. What are the causes of food losses and waste generated during pasta production?

36. What are the possible destinations for food losses and waste from pasta chain?
37. What are the actions that can be taken when food losses and waste are removed from the food supply chain?
38. What quantification methods can be used for food losses and waste?
39. What are the principles for reducing food waste in flour product industry?
40. What are the two different stages in the process that distinguish food loss and food waste?
41. What is „food waste“?
42. What is the food supply chain?
43. What could be the measures to implement food waste control along the food processing and distribution chain?
44. What could be the most important determinants in pasta quality?
45. What are the main causes for food loss and waste in pastry industry?
46. What could be the measures to prevent and reduce food waste in pastry industry?
47. What are the 5 sectors of the food chain?
48. In which sectors the food waste occur in the industrialized countries?
49. In which sectors the food waste occur in the developing countries?

II. ANSWERS

1. Any food substance, raw or cooked, which is discarded, or intended or required to be discarded.

2. a) they differ depending on the stage of the food supply chain;

b) they differ depending of the type of product and where the food is wasted.

3. Farm production, handling and storage, processing, distribution, consumption

4. a) Improper storage conditions

b) Inadequate humidity and absence of ventilation;

c) Improper placement of flour bags;

d) Infestation degree.

5. A more efficient control of the technological parameters (regarding the handling of the dough and the evaluation of its temperature and acidity.

6. Cultivation, milling, pasta production, retail, consumption.

7. The largest amount of waste is concentrated in the consumption phase, especially in households.

8. a) Raw materials are the primary contributors to a wide range of contaminants;

b) The employment of different baking technologies to reduce the thermal load is one of the most effective mitigating strategies.

9. a) To prevent foaming the oven temperature should be controlled not to be very high at first, and the surface temperature should increase gradually;

b) To prevent obtaining discolored biscuits the sugar content must be increased;

c) To prevent cracking of biscuits the amount of leavening agent should be reduced.

10. The most common causes of losses in raw materials are signs of spoiling, moulding and impurities, all possibly caused by improper storage and handling or poor quality of raw materials. Also, bad hygiene and poor pest control are reasons for spoilage of ingredients during the storage.

11. The factors responsible for maintaining flour quality in order to reduce losses in the processing and storage stage are: implicit factors, intrinsic factors, extrinsic factors, processing factors.
12. The intrinsic factors are: water activity, nature of substrate, mineral nutrition, nutrient composition.
13. The causes of flour degradation are:
    - Inadequate storage conditions, inadequate humidity and lack of ventilation
    - Improper placement of flour bags
    - The degree of flour infestation
    - Contamination with molds and mycotoxins
14. Among the methods of reducing the contamination with molds and mycotoxins of various flours during storage, we can list: hot air, chemical treatment, pulse, cold plasma at atmospheric pressure, radiofrequency (rf) heating, pasteurization, vacuum steam treatment, irradiation . , ultraviolet radiation combined with ozone, radiofrequency irradiation, baking in an electric oven.
15. The technological process of baking is as follows: preparation and dosing of raw and auxiliary materials, dough preparation, dough processing, dividing, modeling, fermentation, baking, and cooling of bread.
16. The main causes of bread defects are:
    - Poor quality flour
    - Unripened flours or from new wheat.
    - Flours with low content of enzymes and especially of amylase.
    - Burnt wheat flour with denatured gluten proteins
    - Poor quality gluten flours. Flours with strong gluten
    - Poor quality gluten flours. Flours with weak gluten
    - Poor quality yeast
    - Baking bread at too high a temperature (in a "fast" oven)
    - Baking the bread at too low a temperature (in a soft oven)
    - Storage of bread in to close or overlapping rows
    - Transporting warm bread or placing it in close or overlapping rows
17. There are three types of bacterial spoilage that can affect the shelf-life of bacterial products: bacterial spoilage, yeast spoilage and mold spoilage.

18. The most common species that cause bacterial spoilage are *Bacillus subtilis*, *Bacillus licheniformis*, *Bacillus megaterium* and *Bacillus cereus*.

19. Bio-preservatives are microorganisms and their metabolites used to prevent spoilage and extend the shelf life of foods). The ones that are of a particular interest are lactic acid bacteria (LAB).

20.

- Physical: foreign bodies
- Chemical: pesticides, heavy metals, etc.
- Biological: mycotoxins
- Others during baking: furan, acrylamide, etc.

21. Glass, plastic, textile threads, wood, paper, and metal are a few of the most typical foreign objects that might contaminate biscuits.

22. The maximum acrylamide contents established for bakery product is 350 µg/kg, according to 2158/ 2017 Regulation.

23. Defects that occur in the processing stage of biscuits are: breakage, blisters, leaking cream, hard bite, shrinkage, reverse shell, spreading.

24. Temperature in front of the oven is too high, especially at the surface

- The dough is too elastic.
- The recipe contains a smaller quantity of sugar.
- Insufficient or excessive flour mixing time
- The amount of leavening agent in the recipe is too small or too much
- The amount of sugar and oil in the recipe is small
- The biscuits are over swollen and too loose
- The amount of starch and biscuit crumbs in the ingredients is too much

25. UV, ozone, or pulsed light

26. Appearance of mold, insects or arachnids in any form of development;

- Appearance of foreign taste and smell (rancid, bitter, moldy, without creaking due to mineral impurities);
- A maximum of 10% crackers with a rough surface, with burns, blisters or voids are allowed;

27. a) hygiene and sanitary requirements;

b) technical breakdowns.

28. Making and handing intermediate products and dough;

- Portion and forming dough;
- Baking;
- Customized packing;
- Shipping (storage);
- Transport by own.

29. a) Inadequate organization of the environment in which baking and confectionary products are made;

b) Secondary impurities;

c) Human factor;

d) Lack of supervision over machinery and equipment;

e) Improper conditions of production of baking and confectionery products

f) Improper handling of the production process.

30. a) Improper operation of the oven, no supervision over the device;

b) Lack of supervision over machinery and equipment of packaging;

c) Employees' errors and neglect during bulk packing activities.

31. a) Overestimation of orders;

b) Improper means of transportation, unfit for transporting foodstuffs, no sanitary approval;

c) Improper sanitary and hygiene condition of the means of transportation.

32. a) Extending shelf-life;

b) Improving the food safety;

c) Improving sensorial properties;

d) Maintaining food quality;

e) Offer better packaging performance by adding specific additives in the packaging material.

33. a) Extend shelf-life;

b) Improve safety and quality;

c) Provides information about product;

d) Warns possible problems;

e) Offer a better possibility to track critical items, to check product quality and provide more detailed information during all the food supply chain (storage, transport, distribution and sale) by labels, incorporated or printed on the food packages.

34. a) Cultivation (field losses);

b) Milling (wheat co-products, waste);

c) Pasta production (production scraps, pasta waste);

d) Retail sale (unsold pasta);

e) Consumption (waste).

35. a) Combine harvester failure;

b) Milling;

c) Wheat pre-cleaning;

d) Equipment cleaning;

e) Transport, packaging;

f) Damaged pasta;

g) Preparation, too large servings, sensorial unpleasant.

36. a) Pasta production scraps for composting, animal feed, food banks;

b) Retail (unsold or damaged pasta) for animal feed, food banks, lactic acid production (biorefinery).

37. a) Redistribution of food for human consumption;

b) Food valorizations;

c) Consumers behavior change;

d) Improvement of the supply chain efficiency;

e) Food waste prevention governance.

38. a) Direct weighing and counting;

b) Volume determination;

c) Waste composition analysis;

d) Records, diaries, surveys;

e) Mass balance;

f) Modeling;

g) Proxy data.

39. What are the principles for reducing food waste in flour product industry?

a) Working together;

b) The value chain requires more cooperation;

c) Encouraging transparency and sharing along the value chain;

d) Holistic thinking is essential;

e) Instilling ownership and incentives for decreasing food waste across the business;

f) Consumer support is required;

g) Communicating with consumers more frequently;

h) Communicating with the authorities;

i) Sharing knowledge;

j) Participating in new research collaborations to a larger level.

40. Food loss occurs along the food supply chain from harvest/slaughter/catch up to, but not including, the sales level. Food waste occurs at the retail and consumption level.

41. Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea).

42. The food supply chain is the connected series of activities used to produce, process, distribute and consume food. The food supply chain starts when the raw materials for food are ready to enter the economic and technical system for food production or home-grown consumption.

43. The measures could be:

a) Use of waste as fertilizer

b) Donations

c) Valorization of byproducts internally or by marketing (e.g., incorporation into other products, animal feed)

d) Marketing of products at a reduced price

e) Selective collection

f) Waste to be taken over by a neutralization company

g) Production optimization through new technologies or supply management

44. The most important determinants are:

a) Raw material quality

b) Production process (optimal parameters, times, temperatures, controls)

c) Recipes (raw material, optimal blends, temperatures, additives)

45. **What are the main causes for food loss and waste in pastry industry?** Here are the main causes of food loss and waste in pastry Industry:

a) Loss of freshness and costumer preference

b) Short shelf life of non-permanent pastry products

c) Perishable ingredients (cream, fresh fruit, meat, etc.)

d) Human errors within production (not correct measuring of the ingredients or aberrance from technological scheme)

46. The measures to prevent and reduce FW in pastry Industry are:

a) Well informed and trained stuff

b) Reducing changeovers on the line

c) Proper maintenance of the equipment

d) Proper sanitation standards

e) Innovations of packaging to extend shelf life

47.

a) Agricultural production

b) Management and storage

c) Processing

d) Distribution

e) Consumption

48. As for industrialized countries, most of the food waste occurs at the final stages, i.e. at the distribution and consumption stages, mainly due to the overabundance of food produced.

49. In developing countries, the waste of food shortage occurs mostly in the early stages, due to the lack of advanced agricultural technologies, efficient transport systems and infrastructure (e.g.: uninterrupted maintenance at a low temperature) and the possibility of safe food storage.