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CURRICULUM

Means and methods to reduce food waste in flour products

Material edited in the project
"Methods to reduce food waste in flour products by developing the specific competence of specialists in the sector'' **(Stop Waste to VET)**

Project Reference: ***2021-1-RO01-KA220-VET-000028008***

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CURRICULA DESCRIPTION

Means and methods to reduce food waste in flour products

Name of project: "*Methods to reduce food waste in flour products by developing the specific competence of specialists in the sector*" (Stop Waste to VET)
Project Reference: *2021-1-RO01-KA220-VET-000028008*
Curricula addressed to the specialist in the flour industry - manufacturing, distribution and marketing
Professors responsible with theoretical parts:
Lead Partner (ROMPAN): Voica Daniela, Avram Dana, Pavel Virgil
Partner 1 (LP-BUAS) (P1): Alexa Ersilia, Negrea Monica, Poiana Mariana, Cocan Ileana
Partner 2 (UCA): Filomena Conforti, Fedora Grande, Mariangela Marrelli, Giancarlo Statti
Partner 3 USAMVC (P3): Paucean Adriana, Simona Man, Simona Chis, Anamaria Pop, Anca Farcaş
Partner 4 (EESTI MAAULIKOOL): Kadri Karp, Reelika Rätsep, Ulvi Moor, Priit Põldma, Hedi Kaldmäe, Kersti Aro

Objectives	The curricula establish the cognitive skills and abilities necessary to reduce food waste on flour products. Curricula set the technical and scientific knowledge which will be presented to the trainers in term of acquisition of new knowledge and abilities adaptation of production methods in order to reduce food waste in the bakery and flour industry.
Cognitive skills	**Cognitive skills** refer to ability necessary to use the scientific concepts to develop the capacity of trainers to select the technical and scientific knowledge regarding methods, tools and processes needed to provide the information and message to the specialists in order to obtain the expected learning results.
Professional skills	The **professional skills** that will be developed refer to: - the knowledge of means and methods to reduce food waste on flour products in the current conditions of sustainable development and the circular economy in partner countries with effects on all actors involved in the chain of producers-distributors–merchants; - the Improvement of the procedures and means to reduce food waste in institutions from the partner countries; - the capability to decrease food waste on flour products in the production sector of flour products. - ability to empower specialists in distribution and marketing of flour products to save natural resources and protect the environment.
Competence units	**The relevant competence units** that will be evaluated refer to: knowledge of means and methods to reduce food waste in flour products.
Elements of innovation	**The innovative character** is given by the fact that it responds to the training needs of specialists in the bakery and flour products industry and at present, no such training program has been developed in any of the partner countries in the project.

The impact	The impact of this curricula refers to multiples and interdisciplinary abilities gained by specialists and the ability to apply the knowledge regarding the adaptation of production/packaging/storage methods in order to reduce food waste in the bakery and flour products industry. **The short-term impact** generated by the implementation of this intellectual output relates to increasing the degree of knowledge and professional skills of specialists. **The long-term impact** consists in potential of transferability to the he bakery and flour products industries in order to reduce the negative effects of food waste on the economy and the environment.

Activities hours

Total hours	Theoretical	Individual study
32	**22**	**10**

Curricula

Theoretical part	No of hours	Obs
Chapter 1. Definitions of Food Loss and Waste.	1	The theoretical part consists in 4 hours x 4 days In total 16 hours
Chapter 2. Legislation at national and European level regarding the food waste (FW)along the Food Supply chain (FSC) and in the flour product industry	2	
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.	2	
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	2	
Chapter 5. Causes of FW in the bakery industry. Causes of FW along the production chain. Reception of raw materials. Dough preparation. Dough modelling. Measures to reduce FW in the bakery industry	2	
Chapter 6. Causes of FW in the pasta industry. Causes of FW along the production chain. Reception of raw materials. Dough preparation. Dough modelling. Measures to reduce FW in the pasta industry	2	
Chapter 7. Causes of FW in the biscuits industry. Causes of FW along the production chain. Reception of raw materials. Dough preparation. Dough modelling. Measures to reduce FW in the biscuits industry	2	

Chapter 8. Causes of FW in the pastry industry. Causes of FW along the production chain. Reception of raw materials. Dough preparation. Dough modelling. Measures to reduce FW in the pastry industry	2	
Chapter 9. Possible strategies to prevent FW	1	
Evaluation	2	
Evaluation methods: The evaluation of the specialists is based on objective, semi-objective and subjective items. Objective items refer to the evaluation based on the dual, pair or multiple choice principles of a number of solutions offered to learners. Semi-objective items can be with short answer, complementary, or structured questions in which the student intervenes with solutions expressed in the partially rendered formulation. The subjective items refer to the free or structured essay, in which the learner freely expresses solutions to the requested problem or based on a required scheme. In the category of subjective items, is included also the solving of some problems on the topic taught. The assessment of the certification of competences shall be carried out by means of instruments developed in accordance with the provisions on cognitive and professional competences, taking into account the performance criteria and the conditions of their applicability. Some assessment tools will be able to take into account the integrated assessment of multiple competencies or several performance criteria from the same or different competences. The evaluation highlights the extent to which key competences, general technical competences and specialized technical competences are outlined. The relevant competence units that will be evaluated refer to: knowledge of adaptation of production/packaging/storage methods in order to reduce food waste in the bakery and flour products industry.		
List of teaching and research materials: In order to stimulate the participation of young to the lifelong learning, efficient learning, and teaching methods will be used during the project. Thus, the curricula will have a clear structure, will be elaborated in English. The theoretical parts will be exemplified by texts, pictures and videos, and the final teaching method will take into account the level of the target group to whom it addresses.		

EXTENDED CURRICULA

Introduction

Efforts are underway by the Food and Agriculture Organization (FAO) and the United Nations Environment Program (UNEP) to measure progress towards SDG Target 12.3 through two separate indices: the Food Loss Index (FLI) and the Food Waste Index (FWI).
According to FAO's *The State of Food and Agriculture 2019*, globally, in 2016, around 14 percent of the world's food is lost from production before reaching the retail level. Generally, levels of loss are higher for fruits and vegetables than for cereals and pulses.
Estimates from UN Environment's Food Waste Index suggest that about 931 million tons of food, or 17 percent of total food available to consumers in 2019, went into the waste bins of households, retailers, restaurants and other food services.
In 2011, an FAO publication based on studies carried out by The Swedish Institute for Food and Biotechnology (SIK) found that the total of global amount of food loss and waste was around one third of the edible parts of food produced for human consumption, amounting to about 1.3 billion tons (1.28×10^9 long tons; 1.43×10^9 short tons) per year.
How is food wastage measured? An underpinning feature of any food wastage reduction strategy is to have quantitative data as to how much food wastage is occurring, and specifically where it is occurring so that solutions can be effectively targeted. Measurement of food loss and waste has revealed stark differences in the causes of food wastage between different countries - depending on the individual country's infrastructure, economy and climate. A further key difference is that developing countries' food wastage is primarily due to food loss, whereas in developed countries it is largely due to food waste (FAO, 2013). For example, a 2016 study in the EU found that 53% of food waste arises from households (EU FUSIONS, 2016). These differences call for tailored strategies unique to each country. In the UK, efforts aimed at altering consumer behaviour will be amongst the most effective to reduce food waste.
Food loss and waste are measured at a global scale right down to individual businesses. Global food loss and food waste are being tracked by two indicators, the Food Loss Index (FLI) and the Food Waste Index (FWI), in line with the definitions given by the FAO. Globally, the most recent estimate from FAO was 14% of food is lost pre-retail. Food waste estimates are expected imminently from the United Nations Environment Program. WRAP reports UK food waste statistics in line with their definitions for food waste: in 2018, there was 9.5 million tons of food waste estimated in the UK, equating to a loss of £19 billion and 25 million tons of greenhouse gas (GHG) emissions (WRAP, 2020). Methodology for food waste accounting has been developed by several different bodies.
Best practice and guidance for measuring food wastage are given in the Food Loss and Waste Accounting and Reporting Standard (FLWARS) and can be applied at a range of scales, from an individual company to an entire country. UK specific guidance has been created by WRAP and is tailored to different actors along the food supply chain. In addition, Defra's Waste and Resources Strategy document (Dec 2018) has raised the prospect of mandatory reporting of food waste.
For progress to be made there needs to be transparency of food waste measurement from businesses. WRAP reports that more companies are reporting their food waste, however, many are only doing so privately, and a significant number are reluctant to divulge their internal company information.
The reluctance stems from fears that data sharing may compromise a company's competitive edge or create a negative reputation (Mena, 2011). However, as 'food waste' becomes an increasingly

important issue to consumers, failing to be transparent about the amount of food waste generated may in itself become detrimental to company reputation. Transparency and information sharing would aid more efficient collaboration between different stages in the food supply chain, particularly in supporting more accurate demand forecasting (Mena, 2011).

As the following table shows, industrialized and developing countries differ substantially. In developing countries, it is estimated that 400–500 calories per day per person are wasted, while in developed countries 1,500 calories per day per person are wasted.

In the former, more than 40% of losses occur at the post-harvest and processing stages, while in the latter, more than 40% of losses occur at the retail and consumer levels. The total food waste by consumers in industrialized countries (222 million tons or 218,000,000 long tons or 245,000,000 short tons) is almost equal to the entire food production in sub-Saharan Africa (230 million tons or 226,000,000 long tons or 254,000,000 short tons).

Food loss and waste per person per year	Total	At the production and retail stages	By consumers
Europe	280 kg	190 kg	90 kg
North America and Oceania	295 kg	185 kg	110 kg
Industrialized Asia	240 kg	160 kg	80 kg
sub-Saharan Africa	160 kg	155 kg	5 kg
North Africa, West and Central Asia	215 kg	180 kg	35 kg
South and Southeast Asia	125 kg	110 kg	15 kg
Latin America	225 kg	200 kg	25 kg

Food loss can occur in the stages of:

- Production
- Food processing
- Retail
- Consumption

Food loss can occur in almost all stages in the food chain, and in significant amounts. It can appear from planting, because crops can be infested by pests and affected by severe weather conditions that lead to losses before harvesting. Grains may be lost in the pre-harvest, harvest, and post-harvest stages. Pre-harvest losses occur before the process of harvesting begins, and may be due to insects, weeds, and rusts. Harvest losses occur between the beginning and completion of harvesting, and are primarily caused by losses due to shattering. Post-harvest losses occur between harvest and the moment of human consumption. They include on-farm losses, such as when grain is threshed, winnowed, and dried. Other on-farm losses include inadequate harvesting time, climatic conditions, practices applied at harvest and handling, and challenges in marketing produce. Significant losses are caused by inadequate storage conditions as well as decisions made at earlier stages of the supply chain, including transportation, storage, and processing, which predispose products to a shorter shelf life.

Important in many developing countries, particularly in Africa, are on-farm losses during storage, when the grain is being stored for auto-consumption or while the farmer awaits a selling opportunity or a rise in prices. All outdoor agriculture can experience losses. Thus, encouraging the development of technologies that address these issues can lead to decreasing food waste in the supply chain. Using

machinery to harvest crops can also cause losses because the equipment is unable to make the difference between immature and ripe crops, thus only collecting a part of the crop.
There are also economic factors that can lead to food loss, such as regulations and standards for appearance and quality. Thus, farmers often harvest selectively, leaving the non-standard crops in the field (to use it as fertilizer or animal feed), because otherwise they would be thrown away if the stores of distributors don't accept it. Food loss continues in the food processing stage, and the amounts wasted are relatively unknown and difficult to estimate.
In storage, many quantities of food loss are due to pests and micro-organisms. This is mainly appliable in countries that experience a combination of heat and ambient humidity, in this case the reproduction of pests and microorganisms is encouraged.
Another issue is the packaging that protects foods from damaging during transport from farms and factories to warehouses and retail, keeping it fresh.
Packaging can compromise efforts to reduce food waste in other ways, such as by contaminating waste that could be used for animal feedstocks with plastics.
Retail stores throw away large quantities of food. Usually, this consists of items that have reached either their best-before, sell-by, or use-by dates. Food that has passed the best -before, and sell-by date, and even some food that passed the use-by date is still edible at the time of disposal, but stores have widely varying policies to handle the excess food. Some stores put effort into preventing access to poor or homeless people, while others work with charitable organization to distribute food. Retailers also contribute to waste as a result of their contractual arrangements with suppliers. Failure to supply agreed quantities renders farmers or processors liable to have their contracts cancelled. As a consequence, they plan to produce more than actually required to meet the contract, to have a margin of error. Surplus production is often simply disposed of.
Retailers usually have strict cosmetic standards for produce, and if fruits or vegetables are misshapen or superficially bruised, they are often not put on the shelf. In the United States, an estimated six billion pounds of produce are wasted each year because of its appearance.
Also, consumers are responsible for food waste, directly and indirectly. This could be avoided if they accept suboptimal food (SOF) that has different sensory characteristics (odd shapes, discolorations) or has a best before date that is approaching or passed, but the products are perfectly fine for being consumed.
Another high amount of food is wasted by overconsumption, over buying and over cooking.

Italy

According to the Country Report on Food Waste in Italy:

- 6 million tons of surplus are generated annually;
- The value of the surplus generated amounts to about 13 billion euro;
- The per capita value of the surplus is 101 kg and 220 euro;
- The 55% of food waste is generated by economic players in the sector, 45% in households.

The study of Skaf et al. (2021) reported the average amount of annual per capita food waste for fifteen countries and for Italy was estimated in about one hundred kilograms. Among food waste produced cereals show the highest contribution, about 30%, as well as fruits and vegetables.

Estonia

- Yearly, 355.000 tons of food is thrown away (excluding agricultural sector). That means 972 tons every day, 40,5 big trucks.

Romania

Approximately 2.55 million tons of food are thrown away every year, the largest percentage of which is represented by cooked food.

CHAPTER 1

Definitions of food loss and waste

Food waste is a global problem that has become increasingly important on the public and political agenda in recent years.
Food waste - represents any food and/or inedible parts of food products, which are eliminated from the food supply chain, which must be recovered or eliminated (through composting, anaerobic digestion, bio-energy production, incineration or storage of organic waste. (According to Situation analysis of CNEPSS - The National Center for Health Evaluation and Promotion).
Food waste was defined in the European Union 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.
Food waste are produced on the entire food chain: during the production and distribution process, in stores, in restaurants, in the public food units and in households.
For this reason it is very difficult to be cuantified: in present, in EU an harmonized method to measure food waste does not exist, and that slows more the volume, origin and evolution evaluation achieved by the public authorities along time.
Finding a solution regarding measuring food waste is an important step towards a better understanding of the problem, to a more coherent monitoring and reporting process, and also towards efficient exchanges of good practices at EU level.
The Comission will elaborate in close cooperation with the Member States and with the stakeholders, a common methodology of EU for measuring food waste.
Food loss - represents the decrease in the quantity or quality of food reflected in the nutritional value, economic value or food safety of all foods produced for human consumption, but not consumed by humans.
According to European Comission, FEBA 2015 – 90 milions tons of food wasted everyday. 5% by the retailers, 14% by the catering, 39% by the producers and 42% by the households.
In Italy - 2013, the Ministry of the Environment started working on a national food waste prevention plan, in collaboration with Piata Last MInute, a collaborator in the management of food waste.
For the preparation of this waste prevention program, the main stakeholders of the food chain were involved. The plan seeks to solve the problem of food waste from supply to final consumption. For the time being, food waste of animal origin will not be tracked.
In Romania, the biggest food waste in the urban area: as the rural communities use traditional methods for the waste valorification, in urban area 95% of waste from the cities go to the garbage dump, making impossible the valorification of waste of any kind, both food and non-food.

Globally approximately one third of all food produced for human consumption is wasted, and in the European Union it is estimated that 20% of all food produced is lost or wasted, while 43 million people in the European Union do not get their allow daily meals that ensure adequate nutrition.

The amount of food waste generated in industrialized countries is as high as in developing countries, but the distribution is different:

• in developing countries, over 40% of food losses occur after harvest and during processing;

• in industrialized countries, over 40% of food losses occur at the level of retail sales as well as consumers.

Causes of food waste

Food waste can occur at all points of the food supply chain, namely at the farm, at processing and manufacturing, at marketing, in restaurants and canteens, as well as in the households of the population. The reasons for the production of food waste vary widely and are specific to each sector of activity.

Factors that contribute to food waste include:

• Improper food shopping planning and promotions such as "buy one get one free" lead to buying or preparing too much food,

• Misunderstandings about the meaning of "expire on" and "best before", labels with dates leading to increased amounts of wasted food,

• Standardized portion sizes in restaurants and canteens,

• The difficulty of anticipating the number of customers (a problem for catering services),

• Inventory management issues for manufacturers and retailers,

• High quality standards (e.g. for retail products),

• Overproduction or lack of demand for certain products at certain times of the year, defective products and packaging (farmers and food production),

• Inadequate storage/transport at all stages of the food chain.

At the root of all these problems is a general lack of awareness of the possible solutions and benefits of reducing food waste.

https://ec.europa.eu/food/safety/food_waste_en.

CHAPTER 2

Legislation at national and European level regarding the food waste (FW) along the Food Supply Chain (FSC) and in the flour product industry

2.1 The food supply chain

According to Folkerst and Koehorst 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).

Waste in the supply chain

In order to raise profitability levels among chain members having an efficient waste management is very important.

2.2 Specific legislation

The specific legislation at the European level is presented. Following that the legislation in each partner country is presented: Romania, Italy, Estonia.

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

Developing countries have relatively high food loss (FL) and developed countries have a higher portion of food waste (FW) (Ishangulyyev et al., 2019).

2.4 Current situation in partner countries

Romania

There is in force Romanian Law 217/2016 regarding the decrease in food waste .

Estonia

In this moment there are more initiatives and programs for diminish food loss and waste: "Wise food consumption", Life-cycle of food", "Sincerely, food!", "Eat-climate-friendly food!", "Prevention and reduction of food waste and food loss in schools", "The environmental impact of food", "Respect food completely".

Italy

The Gadda Law 166/2016 was adopted in Italy and focuses on the redistribution of food surplus to those who need.

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

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).

Food waste can be generated during handling and storage, the consumption or damage by insects, rodents, birds or microbes, spillage and damage, such as equipment malfunction or inefficiencies during handling (drying, milling) or processing. Industry and/or government have high food safety regulations or standards that cause some products to be rejected for human consumption although the product may be harmless for consumption.

Causes of waste on handling and storage are: 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. Errors in placed orders.

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 food.

The global food supply chain

From small-scale farmers to big international enterprises, the global food supply chain is a large and intricate network of participants. According to the categories of products, (Van der Vorst, J., 2006) divide food supply chains 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 can be defined as: "…materials that the generator 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 1, a schematic view of all the stages in the food supply chain where food waste may occur is presented.

WASTE FROM BREAD INDUSTRY
Bread is a significant cause of food waste, which takes many different forms.
One of the largest food sectors in the world, the bakery sector has a wide range of production volumes and uses. 25 million tons of bread are produced annually in Western Europe (BREAD4PLA, 2012).

With 60% of the plant sector's production, Germany and the UK are the biggest producers. Another 20% of overall production capacity is produced by France, the Netherlands, and Spain. The UK's bread market is valued more than £3.5 billion and produces over 2.9 million t yearly. (Melikoglu, 2013).
The majority of the items in bakery wastes are cookies, bread rolls, and stale bread. According to BREAD4PLA (2012), about 175 thousand t of bakery waste in Europe comes from solid waste from baked bread that cannot be processed further and is instead usually used as animal feed, disposed of in landfills, or burned. Groundwater pollution and methane production, a greenhouse gas, are two effects of landfilling (organic compounds). Nitrogen oxide emissions may also be released during the incineration of bakery trash. Even though using leftover bread as animal feed is an eco-friendly way to recycle this waste, it has very little value in terms of added benefits (Koutinas A.A., et al., 2014)
The major goal of the BREAD4PLA project was to show that it was both technically feasible and economically feasible to ***manufacture a plastic film that is completely biodegradable utilizing waste materials from the bakery industry.*** The goal of the project was to build and run a pre-industrial scale pilot plant for the production of poly-lactic acid (PLA) from bakery waste materials utilizing a low-energy method using water-based enzymes.
The experiment demonstrated that waste from bakeries provide an excellent starting point for compostable plastic packaging. This was accomplished by examining every step of the process, including the selection and characterization of bakery waste, enzymatic fermentation, PLA polymerization, and pathways for processing plastics, including the use of additives like thermal stabilizers to prevent PLA molecular degradation, and the creation of sheets of packaging material.
From the technical point of view, the main achievement was the demonstration of the packaging production process, followed by its validation using different types of bakery and pastry waste as raw material. ***The primary innovation involved demonstrating the use of bakery wastes as a novel raw material to create PLA packaging and demonstrating that the product performed similarly to PLA packaging made from cereals - while also addressing the problem of food waste disposal.*** Validation tests with different bakery products showed that the packaging developed from bakery waste has a good performance for use within the bakery sector.
(https://webgate.ec.europa.eu/life/publicWebsite/index.cfm?fuseaction=search.dspPage&n_proj_id=3996).
According to some studies, the majority of bakery wastes are breads that have been taken from the market because they are no longer marketable after just 24 hours, but they can also include other ingredients like *wheat, dough, sugar and other edible elements like icing, burnt, or broken products* (Crawshaw, 2004; McGregor, 2000).

Additionally, valuable and easily hydrolysable fuel for industrial fermentation may be found in bakery wastes (Magbunua, 2000). The biopolymer business can employ expired bakery goods to create poly-lactic acid biopolymer (Plascarb, 2013).

Processes

Bakery wastes can emerge at any stage of the baking process:

- They could include baked goods like breads and pastries that didn't have been sold and reached the end of shelf-life and are discarded as waste.
- Inappropriate lot sizes or minimum order quantities may be the cause. Large pre-mixed ingredient pack sizes could result in surplus that needs to be stored or thrown away.
- An insufficiently sized production batch might lead to wasted dough in bakeries.
- They could be subpar goods like burnt goods or ones with default sizes or textures. (Tesco et al., 2014; Chandrasekaran, 2013).

Extrusion, dehydration, palletization, and silage of bakery wastes, among other procedures, can be evaluated when bakery wastes are intended for animal feeding in order to have optimal preservation and storage of the resulting feedstuffs (Heuzé et al., 2018).

General causes of bakery waste

Bakery products are food products, the most common of which is bread; however, many other types of baked goods are baked as well. Moreover, food can be wasted for a variety of reasons such as the *lack of knowledge about the handling of materials or improper storage where losses may occur as a result of pest infestation*.

In the production of bread, the reasons are mainly related to non- compliance with the quality standard for technical reasons, such as:

- a common technical reason for waste is that the bread does not have the right weight and shape;
- the bread falls off the production line;
- problems with packaging;
- bread is not baked properly in the oven

Causes of bakery waste in production (Handling and Storage) of flour products

In the study carried out by Iakovlieva, 2021 were identified several causes of bakery waste and production losses. These causes of losses of bakery products can be classified such as:

- Those brought on by irregular causes and issues with the mechanisms used in the production process (caused by machine error/faults) (human errors). Systematic causes develop over a long period of time, yet they frequently have little impact on the process of making bread;
- Mistakes and unexpected events have a direct impact on what leads to irregular baking waste.
- Human mistake is the main source of bread waste. This includes mistakes made when adding raw materials in accordance with the recipe, bread that burns during baking, and bread that isn't sold.
- Large bakeries have noted technological issues related to poor product quality and failure to meet quality standards for finished goods, mechanical damage and production waste (excess flour), damaged packaging, low weight, low bakery product condition (shape, color, structure of bakery products, incorrect package size), and bakery products with defects.
- According to the study, wastes from sub-optimal ways of processing the bread, formulation changes on the assembly line, and transportation damage were minimal.

Other causes of bakery product waste include the following: weather, seasonality, habits, customer demand, and special occasions like holidays. The demand for bakery goods may shift as a result of any of these factors, and bakeries may find it challenging to predict this variance.
According to the same study, wastes due to technical failures with power outages was found but were of minor importance for bakeries. Moreover, the frequency and values of other potential causes of waste, for example, *incorrect delivery of flour or other raw materials, were not noted*. Furthermore, another cause of bakery waste of large bakeries is overproduction. Overproduction is used as a simple means of avoiding "stock out" at the retail outlet. In addition, the return of bread from the retailers was highlighted for large producers and the common cause of this waste was unsold bread (TBA products). Therefore, losses of bakery products depend to a large extent on how specific actions and processes are managed in the bakery sectors (Iakovlieva, 2021).

Degradation and spoilage according to product characteristics.
Bread aging and microbial spoilage are the two main reasons for the alarmingly high contribution of bakery products to food waste worldwide (34.7% of the total amount of bakery products in Germany in 2015) (Leverenz et al., 2018). During the shelf life of bread, several important changes contribute to the decline in consumer acceptance of stored bread. These changes include physico-chemical processes such as core hardening, water migration within the core and crust, loss of flavor and microbial spoilage.
While amylopectin, the second major macromolecule responsible for the starch fraction in flour, crystallizes over a longer period of days, amylose positively influences the solidification of the crumb structure within the early hours following baking. (Lorenz K., Maga J., 1972). In addition to the recrystallization of starch, this retrogradation process is also responsible for the molecular redistribution of water. As a result of the long-term processes of starch retrogradation and water migration, as well as the evaporation of volatile ingredients, consumer perception might change even within the first few days of storage (Leverenz et al., 2018).
The ratio of the water vapor pressure over a substrate to that over pure water at the same temperature and pressure is known as the **water activity.** Having a high aw-value can encourage microbial development, whereas a high osmotic pressure can cause dehydration, which inhibits growth and may even cause cell death. Water activity thus serves as a check on food spoilage. Bread is susceptible to all types of spoiling due to its relatively highwater activity and the relatively low lower limits for bacteria, yeast, and molds (Alpers et al., 2021).

In the study "Impact of storing condition on staling and microbial spoilage behavior of bread and their contribution to prevent food waste" conducted by Alpers T. from the Research Group Cereal Technology and Process Engineering, Brewing and Beverage Technology it is mentioned that the staling and microbial spoilage of bread are the two main reasons for the alarmingly high contribution of bakery products to food waste all over the world.
Within the storage period of bread, several important changes contribute to the decreasing of consumer acceptance of stored bread.
The changes include physicochemical processes such as the crumb firming process, water migration within the crumb, crust and the environment, the loss of flavor and microbial spoilage.
The staling process describes the mechanism of bread aging and is initiated immediately after baking.
In the first hours after baking, the recrystallization of amylose positively impacts the solidification of the crumb structure, whereas amylopectin, the second main macromolecule accounting for the starch fraction in the flour, crystalizes over a longer period of days.

The long-term processes of starch retrogradation and water migration are further accompanied by the evaporation of volatile components, leading to a change in consumer perception even within the first days of storage. The physicochemical changes taking place during the storage period of bread can be traced by textural analysis.
Another factor that influences shelf life is fungal contamination. As spores are commonly considered to be inactivated during the baking process, contamination arises from the surrounding, machines, workers (production and sale areas), consumers in the storage environment.
In the bread products the commonly detected fungi are *Penicillium* spp*., Aspergillus* spp*., Bacillus* spp*., Cladosporium* spp.
In order to avoid preventable food waste, several preservation methods are commonly involved in production, handling and storage processes. Beside adequate and sanitary production conditions, handling and storage processes. Beside adequate and sanitary production conditions, the usage of sourdough has been reported to reduce the growth rate of fungi, thus prolonging the shelf life of bakery products.
Visual inspection of the products was shown to represent an adequate tool for microbial safety control. In the bread slices there are no mycotoxins quantified after ten days of storage in plastic bags at room temperature.
The obtained data suggest, growth indication is not necessary. Further, we have shown that is possible to increase the shelf life of bread products within the limits of common households storage methods. The fact that the proper temperatures for reducing fungal growth accelerate the firming process limits the possibilities for appropriate storing methods.
Thus, the presented results rule out some possibilities for prolonging shelf life. It has been demonstrated that humid atmospheres promote spoilage. Therefore, appropriated construction of bread boxes or packaging materials (e.g., improved water permeability or moisture scavengers) can help to extent the shelf life of bread. Further, sanitary conditions are essential for the storage of bread and represent a simply accessible way to prolong the stability of bread.

Bakery waste management

When it comes to managing bakery wastes, it is important to keep in mind that the location and ownership of the bakery items affect waste management. Several ways to collect bakery products have been identified, including bakery products from the store that are returned and turned into ethanol, animal feed, or donations. Based on the information from the study, the most often used methods for managing bakery waste are:

- Biofuel (ethanol, biogas etc.)
- Donation
- Reuse of waste of bread
- Animal feed
- Composting
- Disposal in landfill.

Bakery waste such as dough is processed in another way, namely, raw materials and ingredients are processed into bread in a continuous production process. Moreover, wasted bakery products are transported directly from various bakeries within the framework of regulated waste management activities. A small amount of the waste in large production sections can be used as animal feed or repurposed for producing other dough for other products or testing purposes. The bread waste from small- and medium-sized bakeries that was donated to charity was sometimes used as animal feed, but mostly used to produce biogas through anaerobic digestion (Iakovlieva, 2021).

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

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%). 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. (2020) 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. The authors classified the size of these losses into two categories, presented in table 1:

Table 1
Losses in the form of Food Waste at the processing in the baking and confectionery industry

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

Another study conducted is ***"Process investigation and Exploration strategies to minimize waste in biscuits manufacturing industry" – Bandara Smua, Dr. Dissanayake KDDN; Department of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka.***

The aim of the research was to investigate the biscuit manufacturing process in order to find ways to minimize wastages in production process. Main factors considered in this research were process capability study, waste analysis using Pareto charts and Labor detailing. The process was investigated by carrying out a process capability study. Root causes to the waste were identified using Pareto charts. Labor detailing was used to suggest suitable improvements related to labor force.

Another study achieved is ***Impact of storing condition on staling and microbial spoilage behavior of bread and their contribution to prevent food waste*** by Thekla Alpers, Roland Kerpes, Mariana Frioli, Arndt Nobis, Ka Ian Hoi, Axel Bach, Mario Jekle and Thomas Becker from the Research Group Cereal Technology and Process Engineering, Brewing and Beverage Technology, Technical University of Munich, Freising, Germany.

The high loss rate of bread is generally known to contribute to the alarmingly high numbers in worldwide food waste. Correct storage techniques are believed to enable the reduction of preventable food waste. Therefore, the influence of storage parameters on staling and spoilage behavior of bread within the limits of common household methods was investigated in this study. The aim was to generate reliable data for staling and spoilage using different storage methods (PE-layered microperforated paper bag, plastic bag, and fridge and bread box) to bridge the gap between consumer's needs and scientific research questions.

Everyday routines of life, such as visual inspection, were compared with microbiological techniques and were found to represent an adequate tool for microbial safety control. Visually undetectable fungal growth has not been found to result in the production of mycotoxins (fumonisins B1 and B2 and ochratoxin A) in quantifiable or harmful concentrations. Thus, disgust should prevent any foodborne health risks as the visual appearance should lead to avoiding the consumption of spoiled food before mycotoxins are produced in amounts causing adverse health effects within the limits of this experimental setup. Additionally, the storage temperature especially was found to influence the kinetics of staling process, as a reduction accelerated the staling process. Further, crumb moisture loss was found to contradict a long shelf life but, on the other hand, an elevated humidity was shown to provoke excessive microbial growth and should therefore be observed when designing suitable storage methods. Further, the correct choice of bread type stored and a good sanitary practice represent simply accessible ways to prolong the storage period of bread loaves. (Alpers et. al, 2021)

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

Research performed over a period of two years (2017-2018) by Gorynska-Goldmann et al. (2020) focused on reduction of food losses and on identifying more sustainable actions for the management

of resources in the baking and confectionery industry. The authors consider 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 2:

Table 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 (main categories)**	**Unavoidable losses, technical inefficiencies, and malfunctions**
Storage of raw materials	Mechanical damage	- expiration date
	Magazine pests	- human errors
	Signs of spoiling, molds and impurities	- 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	- breakdowns
	Hygiene and sanitary requirements	- returns of unsold bread
Transport of the finished product	Errors in placed orders	- breakdowns
	Damaged packaging	
	Incomplete packaging	

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

Some of the causes for losses in the packaging stage (Gorynska-Goldmann et al., 2021) are:

- Damaged packaging
- Breakdowns
- Hygiene and sanitary requirements

- Unavoidable losses and returns of unsold bread
- Damage in the final transport of the product (damaged packaging, breakdowns, incomplete packaging)

According to Scripto et al, 2020 the flour process failures, failure modes and effects are:

- Package substitution in the production
- Lack of workers in secondary packaging
- Inaccurate filling machine
- Inaccurate speed of conveyor belt resulting in bottlenecks
- Delay in shutdown the filling & packaging during machine failure
- Blunt sealer blades
- Heater sealer disconnects
- Poor packaging quality

In order to reduce some of the causes mentioned above it is possible to use smart packaging.
The benefits of using this king of packaging are:

- Extension of shelf life
- Improve the food safety
- Improve sensorial properties
- Maintaining food quality
- More information about the product
- Warning regarding possible problems

Smart packaging is classified into main categories: active and intelligent packaging.
Active packaging is one of the most dynamic technologies used.
Active packaging includes using:

- Antimicrobials
- Antioxidants
- moisture absorbers
- modified atmosphere packaging (MAP) – oxygen and CO_2 scavengers
- flavor / smell capturers

For active packaging :

- antimicrobial effect – agents used: organic acids (sorbic acids, benzoic acids, acetic acids, propionic acids, ascorbic acids), nanocomposite films (chitosan, gelatin and corn starch), bacteriocins (nisin), enzymes, inorganic or metal oxide based nanoparticles, macromolecules, ethanol.
- Antioxidant effect – agents used: synthetic and natural antioxidants
- Moisture absorbers – agents used: desiccants as silica gel
- Modified atmosphere packaging (MOA) – O_2, N_2, CO_2.

The intelligent packaging is based on using indicators, sensors and data carriers, for example:

- Freshness and microbial spoilage indicators – agents used: glucose, organic acids, volatile nitrogen compounds, biogenic amines, ethanol.
- Biosensors – agents used: optical, calorimetric, electrochemical devices, nanobiosensors.

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

According to Gorynska-Goldmann et al. (2021) there are 6 recovery points for FW:

- Making and handling intermediate products and dough

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

Knowing the possible causes, the risks, but also the ways to reduce food waste in bakeries, contributes to reducing economic, environmental, and social costs

Taking into account the survey made by (Gorynska-Goldmann et al., 2020), it could be identified 12 types of risks of losses (food waste) for the bakeries operating sections as follows:

2. raw materials failing to satisfy the accepted quality criteria;
3. improper raw materials storage conditions;
4. errors during the preparation of mixtures of raw materials for specific recipes and when weighing them;
5. physical impurities;
6. improper conditions of performing individual stages of the production process;
7. unqualified and untrained employees;
8. secondary impurities;
9. improper conditions of slicing and packing;
10. improper marking or damage of the final products;
11. microbiological hazards;
12. overproduction;
13. damage during the transport of final products.

Moreover, 6 potential retrieve points during the baking processes were indicated:

1. making and handling intermediate products and dough;
2. portioning and forming of dough,
3. baking,
4. customized packing,
5. shipping (storage),
6. transport by own.

This critical analysis leads to several **methods of preventing FW** during processing, packaging and transport of the flour products.

1. Properly supervised production vicinity, elimination of damaged equipment, supervision over plastic and glass, elimination of dangerous items that may be potential sources of impurities.
2. Reduction, to the minimal possible extent, the presence of dangerous items, e.g., glasses and jewelry are not allowed in the production process, staples are not permitted to be use.
3. Employment of qualified employees. Medical check-ups of the employees prior to employment.
4. Training of 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.
5. Cleaning and disinfecting machinery and equipment according to the sanitary schedule in place, using proper agents and correct concentrations.
6. Supervision over machinery and equipment—inspections and overhauls scheduled according to operation and maintenance documentation.
7. Observance of legal regulations on the supervision of machinery and equipment.

8. Pest control, e.g., window nets, impenetrable building, insecticide lamps, preventative activities performed and supervised by outsourced pest control specialists.
9. Strict observance of work position instructions.
10. Qualified supervising personnel for the technological process and training for this.
11. Control of technological parameters.
12. Supervision over the process of packing and control before releasing the goods for sale.
13. Packaging of proper quality to ensure safe transport.
14. Training for employees on handling and packing the goods.
15. Supervision over the packing process.
16. Releasing safe, but reduced quality goods for sale (deformed, minimal defects, poorly shaped) at reduced prices.
17. Optimizing production volume.
18. Allowing for seasonality of production.
19. Means of transportation certified for the transport of foodstuffs.
20. Control of temperature and sanitary condition prior to loading.
21. Training for drivers.
22. Verification of recordings from washing and disinfecting the load compartment.
23. Qualification of transport service providers.

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

Causes and consequences of losses:

1. **Making and handling intermediate products and dough**
   Causes:

- Improper organization of the environment in which baking and confectionery products are made
- Secondary impurities
- Human factor

Consequences: Production losses and customer complaints

2. **Portioning and forming of dough**
   Causes:
   - improper conditions of production of baking and confectionery products
   - secondary impurities
   - human factor
   - improper handling of the production process

   Consequences: Production losses and customer complaints

3. **Baking**
   Causes: Improper operation of oven, supervision over device
   Consequences: production losses

4. **Customized packing:**
   Causes:
   - Lack of supervision over machinery and equipment
   - Employees' errors and neglect during bulk packing activities

Consequences: slicing losses, losses identified during storage of the final goods or in retail

5. **Shipping (storage)**
   Causes: overestimation of orders
   Consequences: production losses in the final product

6. **Transport by own:**
   Causes:
   - improper means of transportation, unfit for transporting foodstuffs, no sanitary approval,
   - improper sanitary and hygiene condition of the means of transportation

   Consequences: losses in transport

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

Causes to prevent losses along the grain chain processing (adapted after Mesterhazy et al., 2020):

- Biotic factors (pests, pathogens and weeds)
- Abiotic factors (temperature, humidity, rain, floods, etc.)
- High susceptibility of the grain crops
- Bad storage
- Applied technology
- Consumer behavior

The methods of preventing are:

- Using fertilizers, pesticides, fungicides
- Grain should be cleaned before storage
- Tests for toxins
- Temperature control
- Monitoring the fungi formation during storage
- Consumer awareness

CHAPTER 5

Causes of FW in the bakery industry. Causes of FW along the production chain. Reception of raw materials. Dough preparation. Dough modelling. Measures to reduce FW in the bakery industry

Measures to reduce waste in the bakery industry

5.1 Research and studies carried out on the causes of FW along the production chain. Reception of raw materials. Preparation of the dough. Modeling the dough. Measures to reduce FW in the bakery industry

a) The researchers from the Food Research Institute from Institute of Wisconsin – Madison, USA have conducted a study named "*Microbial food spoilage – Losses and control strategies*".

" Food spoilage is a metabolic process that causes foods to be undesirable or unacceptable for human consumption due to changes in sensory characteristics.

Cereals grains are exposed to a variety of bacteria, molds and yeasts during growth, harvesting, drying and storage. Molds are the most important contaminants because of the low moisture levels in grains, but molds do require some moisture so efficient drying and good storage facilities are necessary to prevent their growth. Microbial population decreases during milling and storage of grain. Molds cause spoilage by altering the appearance of grains and flours, and some species also synthesize toxic secondary metabolites called mycotoxins.

Molds are also the primary spoilage organisms in baked goods, with *Aspergillus, Penicillium,* and *Eurotium* being the most commonly isolated genera. *Penicillium* tends to be the more important sourdough bread and in breads stored at cooler temperatures. Freshly baked bread do not contain viable molds."

b) Another study was conducted at the Department of Food Science and Agricultural Chemistry, Macdonald Campus of McGill University, Quebec, Canada. The study's name is "*Shelf life and Safety Concerns of Bakery products – A Review*, it was conducted by James P. Smith, Daphne Philips Daifas, Wassim El-Khoury, John Koukoutsis and Anis El-Khoury and was published in Critical Reviews In Food Science and Nutrition, 44:19-55 (2004), DOI: 10.1080/10408690490263774.

"Bakery products are an important part of balanced diet, and today, a wide variety of such products can be found on supermarket shelves. This includes unsweetened goods (bread, rolls, buns, crumpets, muffins and bagels), sweet goods (pancakes, doughnuts, waffles and cookies) and filled goods."

c) The study *Mould spoilage of bread: the problem and some solutions* was elaborated by J.D. Legan – Flour Milling and Baking Research Association, Chorleywood, Richmansworth, UK and published in International Biodeterioration & Biodegradation 32 (1993) 33-53.

"Bread is one of the most important staple foods in the world and can be spoiled by many moulds, of which *Penicillium* species are by far the most common. However, the dominant spoilage flora varies with the type of bread and the storage temperature. Mould growth can be reduced by a range of techniques including the following: attention to hygiene within the bakery to reduce the opportunities

for mould spores to gain access to the product; pasteurization of bread once packed, use of preservatives, use of novel ingredients with mould-inhibiting properties."

d) Another study in the field is *Microbial Spoilage of Bakery Products and its Control by Preservatives* conducted by P. Saranraj and M. Geetha from The Department of Microbiology, Annamalai University, Annamalai Nagar, Chidambaram and published in the International Journal of Pharmaceutical & Biological Archives 2012; 3(1):38-48.

"Spoiled food may be defined as a food that has been damaged or injured so as to make it undesirable for human consumption. Bakery products are an important part of a balanced diet and a wide variety of such products ca be found on supermarket shelves. Hovewer, bakery products, like many processed foods, are subject to physical, chemical and microbiological spoilage. While physical and chemical spoilage limits the shelf life of low and intermediate moisture bakery products, microbiological spoilage by bacteria, yeast and molds is the concern in high moisture products. This review assesses the following topics: economical importance of bakery products, microbial spoilage of bakery products, physical factors affecting microbial growth, control of microbial growth in bakery products by using chemical preservatives and biopreservatives."

e) "*Impact os Storing Conditions on Staling and Microbial Spoilage Behavior of Bread and Their Contribution to Prevent Food Waste"* is another study in the bakery field elaborated

5.2 Causes identified along the production chain

The causes of bakery waste can be classified into different categories:

- Those resulting from problems with the mechanisms in the production process (due to machine error/faults)
- Irregular causes (human errors)

Systematical causes occur over a long time but are in many cases insignificant in the bread production process.

The causes of irregular bakery waste are related to what happens as a result of mistakes and events.

The most common human errors include:

- Error when adding raw material according to the formulation
- Bread that is burned during baking and unsold bread
- Technological problems due to poor quality and failure to meet quality requirements for finished problems
- Mechanical damage and production waste (excess flour)
- Damaged packaging
- Low weight
- Poor condition of bread and bakery products (shape, colour, structure of bakery products, incorrect size of package)
- Bakery products with defects were noted by large bakeries

Another notable cause of bakery waste in the large bakeries is overproduction. Overproduction is used for avoiding "stock out" at the retail outlet.

In addition, the return of bread from the retailers was highlighted for large producers and the common cause of this waste was unsold bread.

The causes of bread defects that appear commonly:

- Poor quality flour
- Unripened flours from new wheat
- Flour with low content of enzymes
- Burnt wheat flour

- Poor quality gluten flours
- Using poor quality yeast
- Wrong management of the technological process
- Preparation of dough - Dough fermentation carried out in too short time / too long or at a temperature too low / too high
- Storage of bread in too close or overlapping rows
- Transporting warm bread or placing it in close or overlapping rows

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

The causes of food waste generated by microbial contamination of raw materials and the technological process:

- Bacterial spoilage
- Yeast spoilage
- Mold spoilage
- Mycotoxins

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

In order to reduce the microbiological losses the following measure are applied:

- Reformulation
- Freezing
- Use of preservatives
- Modified atmosphere packaging (carbon-dioxide, oxygen absorbers)

CHAPTER 6

Causes of FW in the pasta industry. Causes of FW along the production chain. Reception of raw materials. Dough preparation. Dough modelling. Measures to reduce FW in the pasta industry.

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

Study conducted by Bresciani et. al. in 2002 reports that worldwide, 14,3 million tons of pasta are produced annually.

6.1.1 Raw materials quality:

- **Durum wheat flour**

Durum wheat is a variety of spring wheat that's typically ground into semolina and used to make pasta. It can also be ground into a finer flour and used to make bread or pizza dough.

Durum wheat and common wheat have similar nutritional profiles. However, due to differences in genetic makeup, durum wheat is best used to make pasta, while common wheat is more suitable for making bread.

Durum has a high protein content of 12.0% to 15.0% (12% mb), yellow endosperm and white bran. For the miller, durum is **a large, very hard kernel with the potential for very high extraction of high quality, low ash semolina** that is ideal for fine pasta.

- **Semolina**

The semolina quality parametrs include: ash, moisture, protein content, starch properties, non-durum adulteration, α-amilase content, ash content (Bruneel et al., 2010).

6.1.2 Formulation and production process

The formulation of pasta has a major influence on the extrusion pressure in particular. Traditionally, pasta is made with simple ingredients such as the semolina of durum wheat and water. The amount of protein in the flour is of great importance for manufacturing and cooking pasta products, which also increases the nutritional quality and maintains better structure. The presence of exogenous proteins, such as Gluten (glutenin & gliadin) can improve the Farinograph properties such as chewiness of the final product. Some researchers have indicated that the addition of egg albumin or casein provides a higher resistance to breakage and cooking tolerance Moreover, casein can also reduce the uptake of oil absorption while frying. Proteins from soybean have been used for improving the pasta colour. Whey protein when added to the pasta formulation has proven to possess specific functional properties for human gastro health (Bresciani et al., 2022).

The quality of the final pasta is influence by the gelatinized starch apart from the protein network formed. Commonly, starch is added for aiding in the smoothness, mouthfeel and appearance of the end product. Either type of starches, native or modified can be used in pasta formulation, having a low gelatinized temperature and higher viscosity, providing improved quality and glossiness to the noodle or spaghetti. Starches extracted from potato, tapioca and corn starch can improve the cooking properties. Starch from mung beans has shown to produce translucent noodles. Pre gelatinization is often done to starch to improve adaptability and solubility in the manufacturing process, especially in instant and ready to eat fried noodles. Apart from that, pregelatinized starches will give better viscoelastic properties for spaghetti strings.

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

- **Milling – wheat co-products** – the main cause is wheat pre-cleaning; joint production in order to produce a certain amount of semolina, a certain amount of bran is produced and used in alternative production, especially animal feed.
- **Milling waste** – the main cause is wheat pre-cleaning .
- The pre-cleaning plant removes the impurities before the wheat is stocked in the silos. These losses are partially used for animal feed. The non-edible parts are disposed as waste.
- **Pasta production scraps** – the main cause is equipment cleaning **-** the food loss and waste in this stage of production is mainly the consequences of the production line's cleaning and changing of pasta shapes, not usable for human consumption and also the part that is edible.
- **Pasta production waste -** the main cause in transport, packaging – mostly pasta fallen on the ground (unsuitable for animal feed) happens for different reasons, i.e. filling of mobile silos, emptying of mobile silos, packaging and transport of unpackaged pasta.

6.3 Measures to reduce FW in the pasta industry

Loss generated during the grinding of the grain and the pasta production amounted to around 2%.
The research carried out has shown that the greatest waste is concentrated in the consumption phase. The product wasted at the final level (household and hospitality sectors) amounted between 10% and 40%, especially in school catering with an average value of 25%.
Unavoidable losses - Technical inefficiencies and malfunctions-Methods and changes in processing - here let's point out from each partner what they found and develop in the course handout only for flour products
During the primary and secondary production stages (mill and pasta factory) the food loss and waste is limited to a 6,65 % of the edible parts.
Almost all of the food loss and waste of the edible parts during the production stage is used in alternative productions, such as animal feed.
Considered as one of the most important steps in producing pasta, the drying process, was optimized during the last years. It's also one of the causes of food waste in the pasta production.
By drying, the water is eliminated: the method of drying will depend on the body's physical and chemical properties.
For pasta drying is the most critical steps of the production process that needs to be controlled. The main reason for which the pasta are dried is to lower the moisture content from 31% to approximately 12-13%. The finished product has to be hard, to retain its shape and can be stored without spoiling.
For pasta to have a higher quality it needs to be dried properly, meaning that the internal moisture has to remain uniform.
If the pasta are dried too fast, they will crack, and the finished product will have a poor appearance and a very low mechanical strength. Also, if they are dried too slowly they tend to spoil and become moldy during the drying process.
If the drying process is done in a correct manner, the pasta will remain firm but also flexible enough and they can be bent to a considerable degree before breaking.
In order to dry pasta the evaporation of water from the product needs to be controlled and modulated properly.
In the drying process the best results are obtained by applying a preliminary low drying temperature for reducing pasta moisture, and after applying the high drying temperature. (Barilla Food loss and waste report, April 2017)

The pre-drying technology used these days makes possible obtaining: partial blockage of some enzyme activity and virtually total blockage of any product of fermentation; after it allows an uniform gluten distribution making possible the capacity of gluten in order to hold back the starch particles.

The pre-drying stage decreases the oxidation of the yellow pigments contained in the semolina and therefore the dried product has a brighter colour.

This phase can also provide a better shape stability and maintain the product's capillarity, essential for redistributing the water particles during the next steps of the process.

The next step of drying has to envisage the alternative phases of water evaporation from the surface and of inside redistribution. The speed of this phase is inevitably less than that of pre-drying, duet o the product's structure, passed on to the elastic state, has become more rigid, capillary action has decreased and so the migration of the remaining particles of water is slower.

Lately, the high-temperature drying technology has been widely applied by the pasta manufacturers.

https://www.italianfoodtech.com/drying-of-pasta/2/

For reducing the food loss and waste in the pasta industry, the Food Loss and Waste Accounting and Reporting Standard (FLW Standard) will be applied.
Also, applying Circular Economy strategies for obtaining a more sustainable supply chain for the pasta. By using modern technologies in order to obtained pasta with a high quality and thus reducing pasta waste.
For example, using precise hydration systems for the dosage phase.
And also using modern drying systems that reduce the drying period but keep the pasta quality at a high level.
Another measure that can be applied for reducing food waste in the pasta industry is using specific logistic management systems.
One of the places where pasta waste occurs is the packaging part. Using the latest packaging systems the shelf life of the pasta can be extended.
Using industrial pasta as feed or for lactic acid production are another viable options (Principato et al., 2019).

CHAPTER 7

Causes of FW in the biscuit manufacturing industry

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

According to Arepally et. al., 2002 there were advances in the methods used for manufacturing biscuits especially regarding the safety and automation.

Thus, the human intervention is reduced to minimum and the process of choosing raw materials is given more attention.

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

One of the causes of food waste identified is the contamination that can occur due to physical, chemical and biological hazards.

One of the main contributors to the contamination are raw materials. It is extremely important to monitor the quality of materials, intermediate products, finished products and processing conditions in order to respect the requirements of the regulation in force.

Another cause of the waste is the packaging in very big packages.

Also, another cause is the variability in the manufacturing process for the defects in finished products that decrease the product quality, productivity, profitability, and ultimately consumers satisfaction.

The contaminants resulted from raw materials or equipment are:

- Physical contaminants
- Chemical contaminants
- Biological contaminants
  - Contaminants deriving from the baking process – one of the most important contaminants is acrylamide.
  - Contaminants deriving from the storing stage – chemical deterioration, such as lipid oxidation can appear during storage.

It is best that the product package to protect the product from water vapor, oxygen and to prevent moisture absorbtion and oxidation of lipids (Pasqualone A, et al., 2021).

Mostly, waste can result from mistakes made during baking or leavening phase or machinery malfunction in the packaging phase leading to unpacked biscuits or incorrect packaging.

Defects of the final product can also cause food waste. Most common are breakages and blistering.

Examples of biscuits breakage appear due to:

- Machines
- Methods
- Operator
- Tools

Blistering in biscuits appears due to:

- Tools
- Operator
- Material method
- machine

Other defects that can occur in biscuits are:

- foaming
- biscuits without color

- rough texture
- cracking

7.3 Causes of food waste identified in the packaging stage

The main causes of food waste that can appear in the packaging stage are:

- overproduction
- improperly shaped food
- damaged packaging

The package can have the following flaws:

- Off registration
- Met layers
- Sealing defects
- Pinholes
- Underweight packages
- Overweight packages
- Loose packaging (Jaiswal, Y., & Khazonde, V.R., 2020)

7.4 **Prevention techniques for food losses in biscuit manufacturing industry**

One of the stages of the manufacturing industry in which contamination can occur is the reception of raw materials.
In order to prevent contamination the cereals are treated with UV light, ozone or pulsed light.
Another effective technique for reducing the thermal load that produce acrylamide is using alternative baking technologies like vacuum baking and radio frequency heating but also product reformulation.
Other way is to use intelligent packaging that will allow to absorb substances from the environment or from the packaged food in order to extent the shelf life of food (Pasqualone A, et al., 2021).

CHAPTER 8

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

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

Pastry industry is one part of bakery industry. Pastry is baked food made with a dough of flour, water and shortening/fat that may be savory or sweetened. Sweetened pastries are often described as bakers' confectionery. Since pastry industry is considered as part of bakery industry it is difficult to find food waste information separately for pastry industry.
The study elaborated by Gorynska-Goldmann et al. (2021) points out as the main causes of food waste in the pastry industry: spoiling, moulding and impurities mainly caused by improper storage and handling or low quality of raw materials.

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

The main causes of food waste in the pastry industry according to Gorynska-Goldmann et al. (2021) aree:

- Improper organization of the environment in which baking and confectionery products are made. Secondary impurities
- Human factor
- Lack of supervision over machinery and equipment
- Improper handling of the production process
- Improper operation of the oven, no supervision over the device.
- Employees' errors and neglect during bulk packing activities
- Overestimation of orders
- Improper means of transportation, unfit for transporting foodstuffs, no sanitary approval.
- Improper sanitary and hygiene condition of the means of transportation.
- Reception of raw materials. Incorrect storage of raw materials (wrong temperature, humidity), bad hygiene, poor pest control.
- Dough preparation. Not correct measuring of the ingredients or aberrance from technological scheme can lead to spoilage/waste in production. Also, technical breakdown of machinery. Dough modelling can be very different depending on the product and the way of production (manual or mechanized).
- Proofing and baking. Aberrance from technological scheme and technical problems with proofers/ovens can lead to waste in production (over proofed dough, under or overbaked/burned products).

The most common defects and remedies for pastry products are:

- Unevenly spread sheets

- Torn sheets
- Dry or stuck sheets
- Salted sheets
- Clumps of flour
- The dough has a cut appearance with oil on the surface
- Dough consistency is too soft
- Insufficiently raised shells
- Incorrect size shells
- Inadequate weight
- Inadequate height
- Incomplete and uneven glazing
- Matte appearance
- Sticky icing
- The fat is separated from the rest of the components
- Raw dough is too hard or too soft
- After baking, the dough shows white spots or voids on the surface
- Hard consistency after baking
- The product leaves traces of fat
- Too crumbly dough which does not keep its shape when cut
- Reddish color, unpleasant taste and smell
- After combining with the fat, the dough changes its consistency
- The dough brakes at the first turn
- The dough is flattened and insufficiently raised after baking
- The product is undercooked in the middle

8.3 Measures to reduce FW in the pastry industry.

The shutdown of this equipment results in high levels of food waste.
Proper maintenance of the equipment prevents food wastage. The equipment is the heart of any bakery business, and it only works as well as it's maintained. When the critical equipment fails to work at peak, it costs time and creates waste. 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.
Low qualifications of freshly hired and insufficiently skilled employees can also be one reason of the losses of production, so good training of the staff is important.
Tracking leftovers in production and retail level helps to adjust production and errors in placed orders. Providing opportunities for the R&D and production departments to improve efficiencies also helps to reduce food loss. Packaging innovations can extend shelf life and protect products during transport. Implementation of a food loss prevention program would be of great importance in the pastry industry.

CHAPTER 9

POSSIBLE STRATEGIES TO PREVENT FW

9.1 Studies regarding possible strategies to prevent FW

If there will be investment made in the production, harvesting, handling and distribution of safe and nutritious food with a good quality for human consumption it will contribute to the reduction of food losses and food waste.

If food losses are reduced food availability can be improved and also food access and smallholder incomes (SGD 2).

In order to make a good use of the surplus food and to reduce food insecurity while being beneficial for the environment it is recommended to use recovery and redistribution.

Along the food supply chains food loss and waste represent economic losses for all actors involved, including consumers.

It is also a proof of an inefficient use of resources (e.g.: labor, water, energy and land) that leads to the appearance of negative social impacts and has an effect also on climate change. Most of this effects are avoidable.

In order to a better reduce of food loss and waste it is very important that the partners and stakeholders are collaborating. In order to maximize the positive impacts for reducing food loss and waste there is a need to develop the governance structures and human capital but also increase investment in infrastructure, innovation and technology.

In order to adapt the regulatory framework it is recommended that the public awareness to be raised and also tailor the policies that will facilitate the identification of targeted incentives.

A better availability of the data regarding the place in which the food loss and waste and also the factors that are at their base will benefit for the elaboration and development of policies, strategies and interventions in order to reduce the food loss and waste.

The process that raise the awareness degree in the public and private sector and also for the civil society will facilitate establishing targets at local, national, regional and global level, will increase the awareness degree, will concentrate the efforts, will mobilize the resources and will guarantee the involvement of actions with a high impact in order to achieve the Agenda 2030.

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

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

- maintaining the storages clean, dry and very well ventilated.
- using wooden grates to stack the flour sacks

- using insecticides for the insect control
- using proper sieves for the flour

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

Examples for methods for reducing fungal and mycotoxins during storage:
- wheat flour with *Staphylococcus aureus, E. coli,* can be decontaminated by dry heating at 290 °C for 5 min.
- Pulse for 10 ms at 395 nm wavelength are used for flour contaminated with *Saccharomyces cerevisiae* and with *Salmonella.*
- irradiation treatment can be used for wheat infested with insects

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

Main defects and measures in the processing of the bakery flour products:

- The use of inappropriate raw materials in the dough preparation stage - **measures**: airing the flour, gluten addition, alfa-amylase addition, malt addition
- Wrong management of the technological process – **measures**: yeast addition, shorter fermentation time, adjusting the oven temperature
- Storage and handling of bread after baking – **measures:** placing bread in bread crates, boxes, racks and shelves (Caldeira et al., 2019).

9.4 Possible strategies to prevent FLW in the bakery industry

- Ensure proper conditions of raw materials storage
- Reducing bacterial contamination of raw materials by using preservatives and modified atmosphere packaging
- Control of technical parameters in order to reduce loss in the stage of forming, modelling and baking the dough
- Maintenance
- Proper measuring
- Monitor sales
- Proper handling
-

9.5 Possible strategies to prevent FW in the pasta industry

- using smart technologies for removing impurities and for monitoring storage parameters
- using modern equipment for mixing dough
- Using modern drying equipment
- implementing smart technologies for monitoring the production parameters
- intelligent packaging in order to extent the pasta's shelf-life
- using metal detectors, plastic detectors
- using modern logistics management systems

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

9.6.1. Prevention techniques for food waste in the biscuit sector

- Careful choosing the raw materials

- Applying product reformulation and alternate baking technologies
- Using intelligent packaging that will increase the product shelf-life

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

- A better control of the oven temperature in order to avoid foaming
- Controlling the quantity of sugar in order to avoid obtaining less coloured biscuits
- Controlling the amount of starch in order to avoid cracking of the biscuits

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

- Monitor technological waste
- Donate unsold products
- Staff training
- Equipment maintenance

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

Good practices in FLW prevention. FLW standards and guides

Very important for the entities in the production and commercial sector is that they must develop inventories for waste and loss.
The causes and factors that lead to FLW must be documented but before that it is very important to identify the key performance indicators (KPIs).
The principles of FLW accounting and reporting are:

- Relevance
- Completeness
- Consistency
- Transparency
- Accuracy

The main food waste prevention actions are:

- Redistribution
- Food valorisation
- Consumer's behaviour change
- Supply chain efficiency
- Food waste prevention governance

9.8.1 Methods of quantifying food waste

- Direct weighing
- Counting
- Volume determination
- Waste composition analysis
- Records
- Diaries
- Surveys
- Mass balance

- Modelling
- Proxy data

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

The method commonly used is creating a flow diagram that can show the movement of food products.

9.8.3 Principles for reducing food waste in flour product industry

- cooperation along the whole value chain (transparency, holistic thinking, working together, more cooperation).
- internal communication in companies (instilling ownership, require consumer support, frequent communication with the customer, communication with the authorities, sharing knowledge, participating in new research collaborations to a larger level (Food Loss and Waste protocol (flwprotocol.org)).

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