Food Loss and Waste Valorisation in Agri-Food Supply Chains

The case of Jerónimo Martins

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Declaração

Declaro que o presente documento é um trabalho original da minha autoria e que cumpre todos os requisitos do Código de Conduta e Boas Práticas da Universidade de Lisboa.

Declaration

I declare that this document is an original work of my own authorship and that it fulfils all the requirements of the Code of Conduct and Good Practices of the Universidade de Lisboa.

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Abstract

With globalization and the population growth, consumption and waste of food products has increased exponentially. This increase, combined with the linear model of production and consumption, has become unsustainable for the environment. To deal with the Food Loss and Waste (FLW) issue, combined with the higher society awareness on sustainability, companies have been pushed to become more sustainable. In this context, this dissertation aims to analyse Jerónimo Martins (JM)'s current situation on FLW and suggest possible strategies to improve its operations sustainability. Therefore, JM, focused on Pingo Doce (PD) supply chain (SC), was thoroughly described and analysed to better understand what measures have been implemented and where most FLW occurs. After concluding that PD stores are responsible for the higher quantities of organic waste, it is suggested three scenarios that can enhance its valorisation. The scenarios provided rely on the possibility of establishing partnerships with valorisation operators, transportation companies and city halls.

Key Words: Agri-food Supply Chain; Sustainability, Food Loss and Waste; Food Valorisation, Jerónimo Martins.

Resumo

Devido à globalização e ao aumento populacional, o consumo e desperdício de produtos alimentares aumentou exponencialmente. Este aumento, combinado com o modelo linear de produção e consumo, tornou-se insustentável para o meio ambiente. Para lidar com o problema das Perdas e Desperdício alimentar (PDA), combinado com o aumento da consciencialização da população sobre sustentabilidade, as empresas têm sido pressionadas para se tornarem mais sustentáveis. Neste contexto, esta dissertação foca-se no PDA do Grupo Jerónimo Martins (JM) e na definição de possíveis estratégias capazes de aumentar a sua sustentabilidade da sua operação. Deste modo, a cadeia de abastecimento do Pingo Doce (PD) foi exaustivamente descrita e analisada de forma a compreender que medidas têm sido implementadas e onde é que se verifica maior PDA. Depois de verificar que as Lojas PD eram responsáveis pela maior geração de lixo orgânico, são propostos três cenários que promovem a respetiva valorização. Os cenários desenvolvidos dependem da possibilidade de estabelecer parcerias com operadores de valorização, empresas de transporte e das câmaras municipais.

Palavras Chave: Cadeia de Abastecimento Agroalimentar; Sustentabilidade; Perdas e Desperdício Alimentar; Valorização de Alimentos; Jerónimo Martins.

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Abbreviations

GHG – Greenhouse gases

SC – Supply chain

AFSC – Agri-food supply chain

SDG – Sustainable Development Goals

FLW – Food loss and waste

GDP – Gross Domestic Product

3PL – Third-party logistics

NGO – Non-Government Organizations

WCED - World Commission on Environment and Development

EU – European Union

TBL – Triple Bottom Line

WFD - Waste Framework Directive

PD – Pingo Doce

JM – Jerónimo Martins

3.1.1

1. Introduction

1.1 Context and Motivation

Globalization led to an improvement on the quality of life and gave companies the opportunity of operating in different markets. Nevertheless, this market's evolution comprises a higher effort from the companies to innovate and satisfy its customers (Saath and Fachinello, 2018). The rearrangement of the supply chain (SC) to become more flexible, to better meet customers' needs in different markets, has impacted mostly the production and distribution stages. The development of practices to meet the demand have increased its impact on the environment, due to the demand's growth and distance to its customers. These factors jeopardize ecosystems and increase greenhouse gases (GHG) emissions (Lopes, 2018). This contributed to the appearance of climate change, natural disasters and more evident unbalance between developed and developing countries.

The agri-food sector is no exception to the reality presented above. It is estimated that around one third of all the food produced never gets consumed (Bagherzadeh et al., 2014), and this Food Loss and Waste (FLW) is responsible, annually, for around 8% of the global production of GHG (FAO,2015) and 1055 billion dollars' worth of misused costs (FAO,2015). On the other hand, one out of ten people in the world is under nourished (World Food Programme, 2017). This mismatch is alarming and becoming more evident with resources becoming scarcer and the global population increasing rapidly. In fact, consumption is increasing while the regeneration capacity is decreasing (WWF, 2016), meaning that the scarcity rate is increasing, jeopardizing even more the food security.

Due to the impacts that FLW has not only environmentally, but economically and socially, sustainability has been promoted not only by companies, but also by consumers and governmental organizations to deal with this problem. In 2015, ONU makes an important step with the outlining of 17 sustainable development goals (SDG) to reach a more sustainable society, where the goal 12.3 intends to halve the FLW per capita by 2030. In fact, it was developed the Plan of Action towards Circular Economy to apply in Europe, where the FLW is one of the prioritizing issues (COM, 2015). The circular economy contributes to reduce FLW in terms of reducing virgin resources to manufacturing and processing by using FLW from other processes and contributes to reduce the amount forwarded to disposal. These projects were developed to reach to standard practices to contribute to development of sustainability. In Portugal, the National Commission to Fight Food Waste (CNCDA) was created to help define national practices to enhance sustainability.

The national agri-food sector represents around 4% of the GDP (FIPA, 2011) with more than 11000 companies incorporating the SC (FIPA, 2009). With that said, it is noticed the importance of the sector to the country, but it's also clear its fragmentation, given the entities multiplicity. To face the problem, projects have emerged, being one of them the Mobfood. This project aims to gather scientific and technological knowledge on AFSC, with the objective of developing and implement collaborative practices to enhance a resilient sustainable SC. The project promotes

the collaboration between key companies with different roles in the supply chain, such as SONAE, Greenyard, ETSA and Olano, but also academic institutions such as IST and FEUP.

To tackle the issue of FLW it's necessary to understand the present reality of how SCs are being managed, where the FLW is generated and how it's being dealt. With the recognition of where companies aren't being efficient in dealing with this issue, it's needed to address how to improve its activities. The adequate valorisation methods to apply differ between products and where the FLW occurs, therefore it's required to analyse which practices to implement according to these factors.

Thus, this dissertation emerges from the need of Jerónimo Martins (JM) to improve its sustainability in terms of FLW generated in PD stores. The goals established towards the reduction of FLW (halve FLW until 2030) (JM,2021) combined with the changing legislation (organic waste will have to be stored and collected separately from the other residues) pushes JM towards more sustainable practices. In this study, it is provided different suggestions to PD stores that enhance FLW valorisation, depending on its location.

1.2 Thesis Objectives

This dissertation was developed with JM. The main goal is to provide recommendations on how PD stores can enhance its organic waste valorisation by partnering with different valorisation operators, local city halls and transportation companies. To achieve the main objective, some middle-term goals are defined and accomplished. Firstly, the literature on sustainable SCs is reviewed, focusing on the case of AFSC. Aspects concerning the FLW definitions and conceptualization was undertaken as well as the main destinations and valorisation methods outlined. Given the relevance of the topic, a study concerning the Top 25 global sustainable leaders of AFSC is outlined, retrieved from Gartner (Gartner, 2020), aiming to gather information on the destinations and valorisation methods used by these companies; Afterwards, JM's SC is thoroughly characterised considering the different stakeholders involved. It is analysed the FLW generated by product and stage of the SC and the measures implemented to mitigate it. JM's description is finalized with the analysis of the role of waste operators in Pingo Doce stores; At last, it is provided different recommendations of valorisation to increase the number of PD stores that could valorise their organic waste.

1.3 Methodology

This dissertation aims to study AFSCs in terms of strategies implemented and monitored towards the reduction of generated FLW, considering both prevention and valorisation measures. To achieve this goal, the following methodology was developed, which follows a 3-step procedure, as can be seen in Figure 1. Following, each step is described in detail.

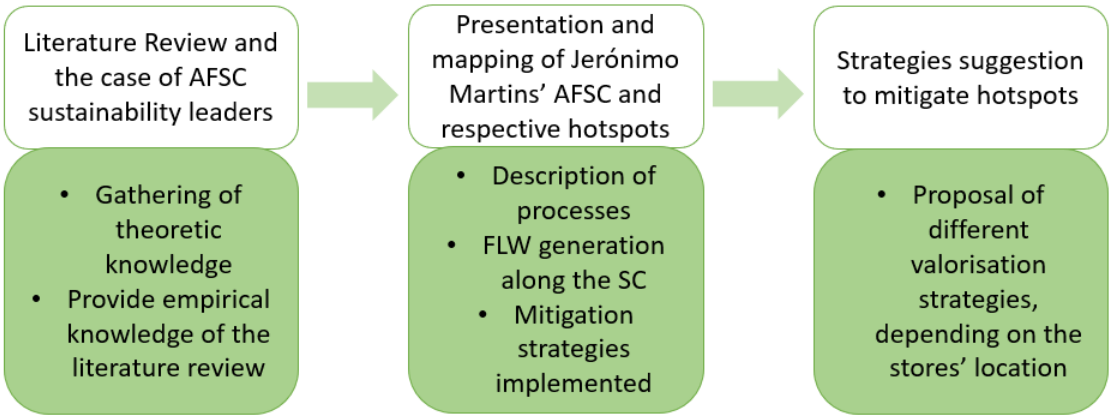

Figure 1 - Methodology

1.3.1 Literature Review and the case of AFSC sustainability leaders

The literature review will be developed to obtain the required theoretic knowledge on the issue of FLW. For that, AFSCs are to be firstly characterised, considering its processes and stakeholders, as well as the role of sustainability and collaborative initiatives that enhance efficiency and effectiveness.

To analyse the FLW reality, it will be researched different studies that sustain the urgency of tackling such issue. Nevertheless, it is required an adequate knowledge on the main concepts of FLW, such as food loss and food waste, therefore it will be researched how these concepts are mostly defined.

A thorough research will be made to find the main causes that lead to the generation of FLW. Such analysis will consider different factors, such as in which stage of the SC it occurs, but also the macro-economic conditions that the AFSC is inserted in and the power balance verified between stakeholders.

Then, it will be researched the main destinations and valorisation methods utilised for FLW. This will consider factors such as the stage of the SC, but also the type of food product.

At last, it will be analysed the pros and cons of a (de)centralized strategy in the SC and which strategy better fits an AFSC.

To better comprehend how the literature review applies empirically, it will be considered the biggest AFSCs in the world, according to Gartner[1]. To provide insights on how companies in the food industry deal with their FLW generation, it will be presented not only the companies' current situation on FLW, and the companies' targets on reducing it, but also which strategies these companies have implemented to reach the objectives and the contribution that the strategies implemented enhanced the progress towards the established targets.

[1] Gartner website: https://www.gartner.com/en/newsroom/press-releases/2020-05-20-gartner-announces-rankings-of-the-2020-supply-chain-top-25

1.3.2 Presentation and Mapping of Jerónimo Martins AFSC

Considering that a 3-month internship took place, this study is focussed on Jerónimo Martins. With primary sources of information, it will be possible to provide a more detailed description of the Group JM, which constitutes one of the main AFSC retailers in Portugal.

In this step, JM will be introduced, starting by its history and market positioning. Its SC is going to be thoroughly described, alongside with the stakeholders and the processes of its direct activities. The FLW generated in its operations will also be described – by type of product and stage of the SC – as well as its main causes and possible solutions to mitigate the problem in terms of prevention and valorisation.

Afterwards, it will be described how JM deals with its FLW. It will consider the different stages of the SC and how the most relevant stakeholders address the issue to prevent and mitigate its generation.

After having a close understanding on the complex operation of JM's SC, hotspots can be found. Thus, recommendations can be provided to mitigate such hotspots.

1.3.3 Strategies Suggestion to Mitigate Hotspots

Considering that in 2024 every commercial establishment in the food industry will have to separate its organic waste, it is important to understand the urgency to plan strategies to efficiently implement measures that are in compliance with the acting legislation.

With a relative low percentage of PD stores that separate and valorise organic waste, it will be studied possibilities that enhance stores to start implementing new measures that allows them to separate and send their organic waste to valorisation.

Therefore, it will be considered improving present partnerships to increase the number of stores that are included in the present agreements, but also establishing new partnerships with new companies that can provide collection and valorisation services in locations where others do not operate. A centralization strategy will also be provided, considering three different operational scenarios of how this strategy can be implemented. This strategy will be suggested for PD stores that do not have any valorisation operator active nearby can send their waste to a store or facility where its location is closer to an operator capable of valorising such waste.

1.4 Dissertation Structure

The dissertation is composed by 6 chapters, each one of them composed as following described:

The first chapter includes the main motivation and contextualization of the thesis, as well as the objectives definition, methodology followed and the structure of the study.

The second chapter starts with the literature review on AFSCs, the importance and obstacles of implementing sustainable practices, having a closer look on the role of collaboration. Then, it's assessed the impact of FLW, its causes and its major valorisation methods studied and implemented to reduce or prevent such generation. At last, it is analysed the characteristics of centralization and decentralization strategies.

The third chapter is composed by a study on the major sustainable AFSCs worldwide, starting by analysing its objectives and progress along the years towards the reduction of FLW. Then, the practices implemented to reach the progresses referred previously are discussed.

The fourth chapter includes a description of the business paradigm of Group JM, as well as of its SC. It is analysed the quantities of FLW generated by type of product and stage of the SC and its main causes. It is also stated which measures PD stores and suppliers have implemented to mitigate its generation. Concluding with the assessment on valorisation operators and their contribution for the organic waste valorisation.

The fifth chapter is composed by the different suggestions proposed to JM to increase the number of PD stores separating and valorising organic waste. It is analysed which strategies better fit to each store considering organic waste generated, the number of other PD stores nearby, the availability of valorisation operators and transportation companies.

The sixth chapter includes the conclusions provided by the dissertation, as well as the respective limitations and recommendations for future work, if JM considers the implementation of this strategy.

2. Literature Review

In this chapter, it will be exposed the main framework of what constitutes an AFSC, as well as its obstacles. Firstly, one needs to comprehend what an AFSC is and if it is converging to become more sustainable. Therefore, sustainability will be defined as well as circular economy, which is a way to achieve sustainability (Teigiserova et al., 2019).

After having a global view that translates the major impacts of the AFSCs on the environment, it will be discussed the most accepted definitions of FLW, as well as its causes and possible valorisation methods, since the AFSC's inefficiencies to deal with this matter is responsible for a significant impact on its economic, social and environmental performance.

2.1 Agri food Supply Chain

In this subsection, it will be given a better insight on what composes an AFSC and its main goals. Sustainability has been playing an important role recently in society and consequently supply chains have started to study how to become more sustainable (Barbosa-Póvoa et al., 2018), which is part of what's going to be presented.

2.1.1 Agri food Supply Chain Characterization

AFSC (represented in Figure 2) is defined as a set of companies that work side by side to manage the flow of goods and services along added value chains of food products in order to create a higher value to customers with the lowest possible cost (Folkerts, Koehorst, 1998; Martínez, 2020). In other words, it includes all processes and activities from production to the end consumer following a "farm to fork" sequence (Pérez Perales et al., 2019). Before the final products are sold to the end consumers, it goes through a series of intermediate alterations. In this sequence, it connects agricultural, food processing and distribution industries (Bukeviciute et al., 2009).

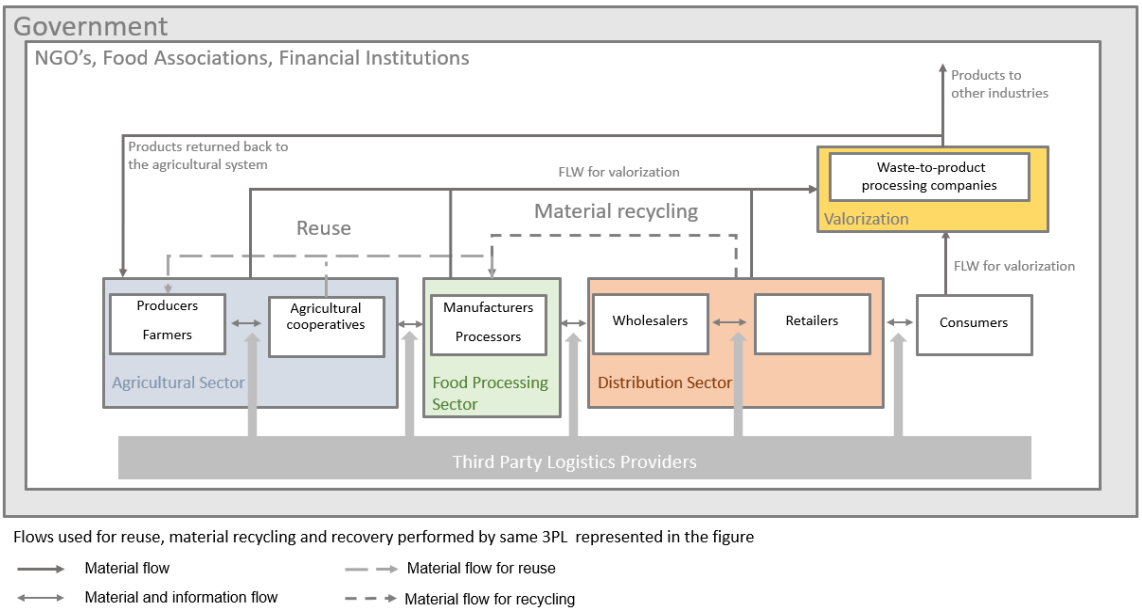

Figure 2 - Generic Agri-Food Supply Chain (Adapted from teigiserova et al., 2019; Veloso, 2020)

The specific type of supply chain is responsible for the production and distribution of agricultural production to the final consumer (Ahumada and Villalobos, 2009). The main stakeholders are the farmers (agricultural sector), processors (food processing sector) that process and add value to the products, wholesalers and retailers (distribution sector), and customers (Tsolakis, 2014). Besides these, indirect partners like government agencies, non-profit organizations, industrial and financial and food associations should also be taken into account even if they don't participate in the chain's activities, since they can impact the business, operationally or financially (Prima Dania et al., 2018).

The main activities of the farmers are the raising of livestock and/or crop production (Cruz, 2018) and their usual customers are the processing sector and retailers (Brah and Schelleman, 2000). The same authors state that, in Europe, both retailers and food processors often pressure producers to guarantee that conscious and better agricultural practices are being performed so that food safety, management of natural resources and animal welfare are not jeopardized.

Agricultural cooperatives, which are defined by the International Cooperative Alliance (2005) as "an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly-owned and democratically-controlled enterprise" (cited by King and Ortmann, 2007), have an important role for the farmers, mainly the small ones because it gives the opportunity for these farmers to influence the economy in a relevant and direct way.

The food processing industry is responsible for several added-value activities (Cruz, 2018), depending on the type of product it's being dealt with. In the case of fruits and vegetables, it's responsible for cleaning and cutting, amongst others, while in case of a meat products it's generally responsible for the slaughter and disassemble. At this point, the inputs are processed packaged and forwarded to the distributors (Cristóbal, 2018). The demand for these products is increasing in developing economies, where customers are changing for a richer diet in calories, proteins and processed foods (Goedde et al., 2015).

The distribution sector is responsible for the link between manufacturers and consumers, focusing on transportation and storage (Cruz, 2018). Distributors and retailers are major influencers for upstream stakeholders since they're the ones that impose the degree of quality of the products to be supplied and displayed (HLPE, 2014).

Consumers are becoming more relevant for AFSC. Increasing health and nutritional aspects of food products awareness combined with the changes in customers' preferences and sustainability concerns influence the market therefore there's a need to adapt to these trends (Brah and Schelleman, 2000).

Third-Party Logistics (3PL) providers perform an essential role on AFSC given the complexity of the network. In fact, outsourcing activities such as storage, distribution and management of transportation services allows the primary stakeholders to focus on their main activities therefore achieving higher flexibility, effectiveness and efficiency (Hsiao et al. 2006).

Financial institutions, NGOs and Food Associations targets to guarantee affordable, safe and sustainable supplies. Financial institutions invest in knowledge, infrastructure and capacity by

financing the value chain and boosting the system's efficiency. Therefore, small producers are the ones that have the most to benefit with their presence, since they cannot take advantage of the globalised market they're inserted into and have difficulty in adapting to market trends (Patil et al., 2016). Associations like World Health Organization (WHO) and Food and Agricultural Organization (FAO) have a big influence in the agri-food sector since they are the ones to establish standards for food quality and safety.

Governments influence the food supply. According to Brah and Schelleman (2000), national governmental entities develop and implement policy instruments that have impacts on the AFSC and also state that, in the European scenario, domestic governments apply the EU directives and regulations into their national administrative and institutional models. On the other hand, governments also have an important role in the success of this supply chains in terms of sustainable production and consumption, since they try to yield long-term vision and consistent policy framework by handing over benefits that help participants of the AFSC, such as education campaigns and economic instruments (Govindan, 2018).

As can be seen in figure 2, waste-to-product entities have an important role for the sustainability of the AFSC, since it helps reducing waste in every direct entity of the SC. Firstly, FLW can be used by companies present in AFSCs for processing or back to the agricultural process to be used as, e.g., manure. On the other hand, FLW is very attractive for waste-to-energy companies because of the increase of oil prices and due to the presence of many specific characteristics of such products, such as cellulose (Ravindran and Jaiswal, 2016). The same authors suggest the use of extraction/ processing and anaerobic digestion for both plant and animal-based wastes, having yet incineration and hydrolysis for plant-based wastes as valorisation methods. These companies are crucial for the AFSC's sustainability, since these work through circular economy and industrial symbiosis.

Under the structure above characterized, Zanoni and Zavanella (2012) categorised AFSCs in two main types, namely AFSC for fresh products and AFSC for frozen products since they have distinguished specifications. The first type works with more perishable products, therefore presents lower lifespan, needs fast transportation, and needs a relatively low energy consumption which occurs mostly on the distribution stage. The second type presents higher lifespan, transportation with higher duration, and due to storage requirements, higher energy consumption.

The supply chain that is responsible for the fresh products distinguishes itself from the generical supply chain due to the handling of perishable products, which means that the storage of these products can't be done as a way of reducing demand's variability and transportation costs (Ahumada and Villalobos ,2009). This variability, according to Ahumada and Villalobos (2009), can't be compensated through an increase of production to take advantage of scale economies, so this type of supply chain needs to become more flexible to deal with this phenomenon.

Flexibility in a AFSC focused on the most perishable products is very important so it can be able to respond to the changing environment it is inserted into and to high expectations on customer service (Beamon, 1999). Costumer service, deliver flexibility, volume flexibility and reduction of backorders are some indicators that help interpret the level of flexibility in an AFSC.

As mentioned above uncertainty is one of the main risks of Agri food sector and thus informed decision making under this condition becomes crucial (Borodin et al., 2016). In the downstream stages, which is the closest to the final consumer, the agricultural market presents a high demand elasticity since it's a market that presents volatility and is very price sensitive. In the upstream stages, the production management has to deal with several obstacles such as the capital availability, soil quality, seasonality, meteorological conditions, climatic disparities between regions, among others (Weintraub and Romero, 2006).

For these products, expiration date is essential as well as quality control (Zanoni and Zavanella,2012). For that, it's used a tracking strategy so that is possible to keep up with the products along the several stages of production and distribution (Bevilacqua et al., 2009; Thakur et al., 2010). A set of information must be evaluated, such as the visited nodes of distribution network, the type of transportation mode and travel's duration (Storøy et al.,2013).

To implement the flexibility and fastness that an AFSC requires, the stakeholders need collaborative measures (subsection 2.2) at operational level as well as an integrated support system to better share information on performance (Kaipia et al., 2013).

These supply chains are long and dispersed, which means that they are under many risks such as changes in government policies; difficulty on identifying illegal or insecure practices from indirect suppliers; and uncertainty on production conditions related to climatic, social, political or biological changes (Dauvergne and Lister, 2012). To face these risks, companies should increase products tracing and their responsibility along the supply chain and, autoregulate themselves anticipating regulatory changes and sanctions, so as to guarantee a reliable supply (Nadvi, 2008) and the end-consumer satisfaction.

2.1.2 Sustainability in Agri food Supply Chain

The awareness on the importance of conserving the environment has been growing in society which led to a more systematic approach on this complex theme. According to Govindan (2018), the traditional supply chains must restructure, based on the concept of sustainability, since it hasn't been able to efficiently adapt to the increasing, demanding and modified demand. From this, emerged the concept of Sustainable Supply Chains, which aims to integrate the concept of sustainability on the management of supply chains (Touboulic and Walker, 2015).

The simpler definition that is globally understood and accepted is the one that defines sustainability as the ability to satisfy present needs without jeopardizing future generations' needs (World Commission on Environment and Development, 1987). This definition is so embracing that is difficult for its practical implementation (Ahi et al., 2016), that's why it's needed a more applicable definition for the business context (Dahlsrud, 2006). Soon after the definition proposed by WCED, Elkington (1997) approached sustainability considering it is based on three main pillars: Environmental, Social and Economic.

The food sector is progressively under higher pressure in order to adopt sustainability programs, not only because of the need to guarantee food security but also since consumers are becoming more informed and intend to reduce their impact on the environment (Murphy et al., 2013;

Notarnicola, 2017). According to Smith (2008), a sustainable supply chain is seen as an opportunity to attract customers and Wognum et al. (2011) state that not only to attract but also to keep customers, there should exist transparency in the supply chain, since customers want to become more and more informed. Such transparency is a desired goal of sustainable supply chain.

Despite the opportunities that emerge on the goal of achieving sustainability, this might not be enough through the traditional linear economy, where products are manufactured from scratched, sold and then disposed (McKinsey, 2016). Despite being a model capable of supplying billions of people, jeopardizes sustainability once it gives a low significance on ecological and social impacts and focuses on financial factors. This system might get higher negative impacts as the population grows (Sauvé et al., 2015; Korhonen et al., 2018).

To deal with such problem, the concept of circular economy emerged, which aims to minimize waste and resource usage, and keep them in the economy as long as they keep having value (European Comission, 2015). Ingrao et al. (2018) summarised this concept in three principles actions: optimization of resource yields, preservation of natural resources and effectiveness of the system. Unlike the linear concept, the circular economy takes advantage of the product on the end of use phase to make them resources for other utility (Ingrao et al., 2018). With this, the rate of scarcity of some resources can decrease, as well as greenhouse emissions (Sauvé et al., 2015). With the circular economy, there's a reduction of new resources and of residues on the supply chain, which can be achieved by closing material loops (Stahel, 2016). Despite being a more sustainable way to deal with resources, the price of new resources and the strong business culture inherent in society is challenging to implement such concept (Leite, 2018).

Considering that the fundamental objective of sustainable systems is to avoid negative impacts (impacts that harm some dimension considered of the triple bottom line) and enhance positive impacts (impacts that benefit the respective dimension) (Souza et al., 2015), according to Nguyen (2018), food systems are environmentally sustainable if its impacts on the environment are positive or neutral. On the other hand, social sustainability is achieved if society benefits in an equitable way through the food system's activities. At last, a food system is considered economically sustainable if it is profitable in the long-term. FAO (2013) defines a sustainable food system as "a food system that ensures food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition of future generations are not compromised".

Industrial symbiosis is a specific case of circular economy where entities intend to obtain competitive advantage through a collaboration with entities from different industries. This can be obtained by the exchange of energy, materials or by-products (Costa, et al., 2010). This concept emerged as a self-organizing business strategy from the private sector to enhance economy advantages while reducing environmental impacts. This can only be achieved through collaboration between stakeholders (Costa, et al., 2010).

As stated previously, the linear system in which the food industry is operated is extremely wasteful and extractive (Korhonen, 2018). This system, particularly the agricultural activities, lead not only

to environmental pollution, but also land degradation and depletion of natural resources. The rate at which agricultural soil is being exploited is a threat to the environment, biodiversity and the capacity of feeding the growing population. Apart from farming activities being responsible for the extraction of finite resources like potassium and phosphorus in significant amounts, most activities in the food supply chain – from distribution trucks to tractors and food processing factories – use fossil fuels, which contributes highly to global warming (Garnett et al., 2016). In fact, the food industry is responsible for 20 to 30% of the global greenhouse gases emissions (Garnett et al., 2016). On the other hand, Prima Dania (2018) also refers obstacles such as goal differentiation among stakeholders, food security and traceability and increase of public awareness and concerns on having healthy and environmentally friendly food products.

Considering the importance given by the existing literature, there are two main aspects to be considered to achieve sustainability in the AFSC, which are the two subsections that will be discussed below. Firstly, will be discussed the importance of collaboration within the SC so that performance will be dealt in order to achieve global goals of the supply chain instead of having stakeholders in the process of delivering products to the final market with individualistic goals that could harm the entire supply chain performance (Prima Dania et al., 2018; Lozano, 2007). Through information and resource sharing, AFSC can become sustainable more easily. On the other hand, the identification, reduction, treatment and consequent valorisation of FLW is very important to achieve not only resource efficiency but also reduce the environmental impact of the SC. In fact, FLW represents a significant economic loss with high environmental and social impacts, therefore its causes and valorisation methods will be closely explored (FAO, 2015; Bagherzadeh et al., 2014). With an assessment and implementation of valorisation methods to FLW, companies can become more sustainable in all three pillars by reducing environmental impacts, enhancing social welfare and decreasing costs or increasing efficiency.

2.2 Role of collaboration in sustainable Agri food Supply Chains

Collaboration in the supply chain is the process of having two or more entities working together to achieve common goals (Stank et al., 2001; Mentzer et al., 2001; Manthou et al., 2004; Sheu et al., 2006), in order to become more efficient in the planning and execution phase (Cao and Zhang, 2008). This process enhances the core competences of each entity and allows these entities to become more profitable than when acting alone (Carvalho, 2017).

“Collaboration behavioural factors are organisation characteristics comprising a set of features that are important to meet the desires of stakeholders in proposing good collaboration quality in a supply chain system” (Fischer and Reynolds, 2010). Through collaboration, conflicts and misunderstandings can be minimized (Prima Dania, 2018).

The collaboration between stakeholders within the supply chain to deal with sustainability requirements is essential to achieve competitive advantage from which result better outcomes in the three pillars of sustainability (Prima Dania, 2018). This concept can be divided into four main activities which are: Planning, where it’s defined the terms of the relationship between the stakeholders; Forecasting of demand and supply for better production/order planning contributing

to reduction of the bullwhip effect; execution, which is the placement and distribution of the order as respective payment; and, at last, performance analysis to check that the execution occurred as planned (Attaran and Attaran, 2007).

As Pomeroy et al. (2007) stated, higher level of collaboration promotes a higher level of responsibility to each stakeholder to keep or upgrade the level of sustainability as it enhances a conflict reduction. With stakeholders working together, it's avoided individualistic and opportunistic behaviour (Lozano, 2007). Collaboration is very important for smaller producers that can have lack of knowledge on business management, which makes them underrate the importance of the rest of the supply chain and be focused only on their internal activities (Serra and Poli, 2015), but also have inefficiencies in the production process due to technological issues and difficulty in selling their products (Biénabe, 2007). With an efficient collaboration in a sustainable supply chain, producers will be helped by facilitating access to opportunities, benefits and resources.

Based on Prima Dania et al.'s work explained after the table, Martinez (2019) outlined the 10 most important factors that lead stakeholders to build up collaborative and sustainable AFSC (table 1).

Table 1 - Factors of collaboration between stakeholders to promote sustainable supply chains (Adopted from Martinez (2019))

Factors	**Description**
Joint Efforts	Get over potential difficulties in the system
Shared Activities	Promote transparency and increase the dependency between parties that lead to more effective and efficient processes
Coordination	Requires the participation of governmental and non-governmental entities that support environmental services and production and establish benefits to enhance implementation of sustainable measures
Adaptation	Ability to adapt to different scenarios on the planning phase or in routine operations
Power	Important for strategy management in a relation between entities
Trust	Basis of any decision, in order for entities to be able to share risks
Commitment	A relation with commitment and understanding with distributors may be the only way to get by with price fluctuations of agricultural products for smaller producers
Stability	Related with trust and commitment
Continuous Improvement	Crucial for the development of operational processes and management competencies
Collaboration	With a constant leaning process that covers every level of the business, it's created a good collaboration system that supports sustainable production and distribution

Despite collaboration between stakeholders represents an opportunity towards sustainability, there's no explicit procedure to implement it. Therefore, Prima Dania et al. (2018) approached this matter to have a better insight on what are the main factors that influence the level of collaboration between stakeholders within the AFSC. First, the authors analysed what were the

most common requirements that stakeholders searched for in a sustainable supply chain concerning the three pillars of sustainability. In terms of economic performance, stakeholders valued high revenues; productivity; service level and internal efficiency; and low operational costs. Environmentally, it is expected a low level of residues, energy consumption, atmospheric pollution and greenhouse gases emissions. Regarding social aspects, stakeholders seek for increase social welfare, support local business and promote transparent trade between entities.

Ghosh and Eriksson (2019) have recently studied some of the factors outlined in table 1 to understand the implications of stakeholders' power, in the food loss and waste scope. Through a real case study, the authors concluded that food loss and waste can have a big impact along the supply chain when there's a significant unbalanced power between stakeholders, especially between retailers and upstream entities. Cox (1999) stated that the understanding on the relation of power between stakeholders must be well known and incorporated in a strategic or operational definition to guarantee that it is appropriate to the situation. After recognizing the relevance of power, it's needed a way to make it characterizable and applicable, although, since it deals with multiple dimensions, like social and economic, it has incorporated a certain degree of subjectivity which makes it impossible to quantify (He et al., 2013).

Firstly, it's important to understand how power in the supply chain has been defined. Cox et al. (2001) define power as the ability of some entity to impose a certain activity to other entity that wouldn't be able to without power. El-Ansary and Stern (1972) define power in the supply chain as the ability of an entity to control other entity's marketing decision variables in a distinctive stage of the distribution chain. The uneven level of power can lead to an unbalance on the objectives' fulfilment, since the most powerful entity can favour itself, by controlling the other entities' decision making and behaviour (He et al., 2013). The most powerful entity can also harm the least powerful entity through a prejudicial attribution of benefits and responsibilities distribution (He et al., 2013).

According to Ghosh and Eriksson (2019), the unbalance of power can be manifested by factors like shortage of formal registry; commercial risk transparency; changes with retroactive implications; contractual ambiguity; unilateral use of information or premature ending in the commercial relationship. These authors also suggest the use of the margins' reduction as a practical indicator on cataloguing some contractual practice as prejudicial. They also stated that bigger companies can reach better contractual terms when negotiating with powerful companies, therefore, the size of a company is also important.

Ghosh and Eriksson (2019) highlight the change of power in the last year from the producers to retailers in Agri-food supply chain, which led to competitive disadvantage for small entities. The bargaining power of big retailers is much higher comparing with small producers, which allow retailers to impose clauses such as rejection policies or claim lower prices when there are multiple suppliers, which are prejudicial to suppliers (Devin and Richards, 2016). Despite these clauses, retailers can still attribute responsibility to the suppliers to deal with reverse logistics (Ghosh and Eriksson, 2019) which represents a bigger portion of the costs structure, due to the significant different of entities' size. According to the European Union, despite being found a clear unbalance of power and responsibility, these conditions are met by the suppliers and smaller entities due to

the fear of losing business opportunities or retailers terminate the contract that bounds both entities (Ghosh and Eriksson, 2019).

The dependence between entities is connected with power. In fact, when entities are dependent on others, like one entity that only supplies one retailer, it's verified an unbalance on power, with the retailer as being the powerful entity, while if one entity supplies different retailers (where retailers have several suppliers each) these entities are mutually dependent, which ideally leads to an equilibrium of power and responsibility (Pfeffer and Salancik, 1978). Although, due to factors like the size of the entities, alternatives and resources available and reputation, it's empirically hard to verify (Ramsay, 1996). With this, it is easily understood that power is related with the degree of dependence between entities (He et al., 2013). According to Kim et al. (2004), the unbalance in the levels of dependency is the reason on the unbalance on the relative power between entities, which means that the most independent entity in a relationship within the supply chain is the one with the most power leverage. The shortage of alternatives can be an indicator of dependency (He et al., 2013) since the entity depends on the short number of possible relationships.

2.3 Food Waste and Loss in Agri-food Supply Chains

One way to enhance sustainability within the supply chain is the sustainable production and consumption. Sustainable production and consumption are defined as a constant economic and social progress that respects the ecosystems' limitations and guarantees present and future generations' needs for an increase on life quality (Department for Environment Food and Rural Affairs, 2003). As food and agricultural systems have changed, so has the production and consumption habits (Haen and Réquillart, 2014), which emphasises this concept as a goal for sustainable development. In fact, the goal is to meet customers' needs while producing more efficiently and lucratively, utilizing less energy and producing less waste and loss but simultaneously reducing the amount of raw materials needed and increasing the product added-value (Department for Environment Food and Rural Affairs, 2003). According to the United Nations Environment Programme, the generation of food waste and loss is one of the examples that appears due to the production and consumption mismanagement.

Given this problem, in this chapter it will be discussed one of the main topics when approaching sustainability in agri-food supply chains, food waste and loss. Starting from a global contextualization, where can be seen the impact of this matter not only economically but also socially, to approaching after what are the main causes and what opportunities that can be taken from this issue.

2.3.1 Urgency of minimizing Food Loss and Waste

The study of sustainable supply chains, therefore including the agri-food industry, is a relatively recent reality. Food and Agriculture Organization of the United Nations (FAO) was founded in 1945 and its main goal is to assure high standards of food security in order to give access to high quality products globally with the dissemination of the healthy and active lifestyle associated.

According to FAO (2013), 3,3 billion tons of greenhouse gases are produced by not eaten food all around the world and this surplus of produced food also represents a cost for businesses, meaning that an efficient use of resources would represent not only financial savings but also reduction on environmental impact and jeopardy on food security. Bagherzadeh et al. (2014) states that 1,3 billion tons, one third of total food production, is wasted and that European consumers waste around 105 kg/year per capita, while in South Asia is around 8kg/year.

Economically, it's also stated that the annual impact of food wastage of agricultural products is of USD 650 billion (Bagherzadeh et al., 2014), which means that FLW represent a significant inefficiency that affects every stakeholder's economic sustainability present in the supply chain. In order to make evident a potential progress in reducing food expenses, Hanson and Mitchell (2017) analysed historical data on a release of a campaign to reduce FLW closer to families in UK. After 5 years, it would be verified a reduction of 21% in waste levels which represented a ratio of financial return of 250 to 1.

Environmentally, the harvest of not consumed produce represent a total of nearly 25% of the agricultural water usage (Kummu et al., 2012). Besides that, it represents 8% of the total greenhouse gases emissions (FAO, 2015), which is nearly equivalent to the emissions emitted by the EU28.

Based on the literature published on this topic, Martinez (2019) outlined the amount of FLW generated in each stage of the SC, as shown in Table 2. Due to lack of data, not every stage considered in figure 2 is referred in this table.

Table 2 - Quantification of food waste and loss in EU28 (adapted from Martinez (2019))

Stage of Supply Chain	FLW (Mton) with 95% CI	Relative distribution (%)
Production	9,1 ± 1,5	11
Processing	16,9 ± 12,7	19
Food Service	10,5 ± 1,5	12
Wholesale and retail	4,6 ± 1,2	5
Households	46,5 ± 4,4	53
Total	87,6 ± 13,7	100

As can be seen in the table above, households are the biggest contributor for food waste and loss in the EU. This happens since it's verified a medium/high income reality. As income decreases (developing countries), lower the contribution of households and increase on manufacturing contribution due to lack of suitable technology and lack of skilled workers (Baptista et. al, 2012).

The kind of product also interferes with the amount of FLW due to the different characteristics, as fresh products like vegetables and fruits have a shorter shelf life and are more fragile than others such as frozen products (Parfitt et al., 2010). On the other hand, meeting seasonality of fresh products and demand is also difficult to balance, once products may have to be imported and therefore have an even shorter shelf life, which commonly leads to a higher rate of waste, as well as loss due to transportation and dealing with different temperature changes (Jurgilevich et al., 2016). Supply chains related with more perishable products like fruits and vegetables are easily

understood as the ones that create more FLW. In fact, according to REFOWAS (2019), that collected data from German farmers, the average of lost lettuce is of around 25%, while for strawberries are of around 15% possibly reaching values of around 50%. According to FAO (2019), the FLW generated according to type of food is 45% for fruits and vegetables and roots and tubers; 35% for seafood; 30% for cereals; 20% for dairy products, and 20% for meat and seeds.

FLW have an impact on the greenhouse gases emitted, not only on the depletion of resources that are not being used effectively like fertile soil, water and energy, but also in the incineration and landfills (Jurgilevich et al., 2016). Considering the United States scenario, when in landfills, food waste produces methane closely equivalent to 20% of the coal central plants, annually while, in EU scenario, food wastage represents 16% of the entire food chain carbon print (Goossens, 2019).

The three more significant stages of the supply chain that contribute to FLW are the first and second stages, namely production and handling and storage, both with around 24% and the stage with the higher impact is consumption with 35%. As can be seen, these three stages represent more than 80% of the total global FLW, becoming increasingly important its monitorization and fight reduction (FAO, 2018).

From a social point of view, FLW represents one of the biggest obstacles to achieve food security (Bagherzadeh et al., 2014). On one hand, the quality value of food can be seriously affected by the inappropriate use of natural resources on which the future production of food depends (HLPE, 2014). On the other hand, FLW can decrease the food availability and with it its price, which affects mostly the people with low income (Razaei and Liu, 2017).

Regarding environmental impacts, the consumption of resources such as land, water and energy jeopardises the environment. According to FAO (2013), FLW is the third top emitter of greenhouse gases globally, if it was integrated in the country ranking of emitters.

From an economic point of view, HLPE (2014) state that FLW originates an imbalance in production flows, which leads to an increase on the required investment to deal with intermediate stock, as well as an increase in the costs of waste treatment and disposal. The same authors also state that this imbalance leads to an increase of the demand and therefore of the prices.

With the statistics presented it's easy to understand the urgency for dealing with the matter of FLW since it would benefit society in several fundamental pillars. This urgency on dealing with the matter has been recognized in the last years that led to the development of many international efforts that have been emerging regulation from the EU and efforts from FAO to create awareness on the impact of FLW, two initiatives that enhance reduction of FLW through short- and long-term goals.

In Portugal, food waste represents 40% of the waste generated. There are a few counties that have already implemented its collection, although it will be mandatory to separate and collect such waste by 2023 (Pinheiro, 2020). In fact, due to the Directive (UE) 2018/851 of the European Parliament and Council, the State Members have to assure the separation and collection of the

bio residues until 31st of December of 2023. This legislation aims to enhance the upper valorisation methods in the hierarchy (European Commission, 2018).

The next subsections are meant to, firstly, understand the concepts and the different dimensions that FLW can be divided into. After, it'll be discussed the main causes that generate FLW and, at last, the main destinations and valorisation methods that have been implemented by the different stakeholders of the AFSC.

2.3.2 The Concepts of Food Loss and Waste

There are already some studies that approach this issue, although they have crucial differences between them which may lead to different conclusions. One of the key differences lies on the definition of food loss and waste (Bagherzadeh, 2014). One definition is the surplus food that are verified along all stages of the supply chain, from production to consumption (Jurgilevich et al., 2016).

According to Kummu et al. (2012), food losses happen in the early stages of the supply chain, namely in: production, postharvest, and processing of products, and food waste are losses at the latter stages of the supply chain, such as distribution and consumption. Alternatively, FAO (2012) referred food losses as the decrease along the supply chain of edible food mass available for human consumption and, food waste as the deliberate discard of food that still has value. In Fusions Manual (2016), food waste is referred as "any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed of". Lipinski et al. (2013) define food loss as food that incurs in an abnormal reduction in quality, that spills or spoils or ever gets lost before reaching the final consumer, while food waste is defined as discarded food despite having quality for human consumption.

According to Fusions (2016), food can also be distinguished by edible and inedible, as defined by FAO (2012). In fact, the edible food is the one that is firstly produced for human consumption, although there are parts of food that come along this production that is not meant for that, the inedible part of food. Despite producing for human consumption, when edible food expires or becomes not suitable for such consumption, it becomes inedible. Nevertheless, inedible food became waste when it is disposed since human consumption is just one end in several, like animal feed and biobased materials (FAO, 2012). According to Bagherzadeh et al. (2014), FLW can still be separated in two categories: avoidable, which represents food waste and loss that could be prevented (e.g. through better planning) since it's food that still had value at the moment of disposal, while unavoidable food waste and loss consists of inedible or unsellable food (e.g. bones, egg shells). Despite having some studies using these concepts, these are subject to interpretation and aren't universally accepted (Bagherzadeh, 2014).

In the United States, food waste is treated as "Uneaten food and food preparation waste" from not only commercial establishments, like restaurants and grocery stores, but also residences (Environmental Protection Agency, undated), while in the United Nations food waste and loss are distinguished considering food waste as losses caused by retailers and consumers' behaviour (Kornegay et al., 1965) and food losses as reduction of food quantity/quality making it unsuitable

for human consumption (FAO, 2013). There are many more different definitions for these concepts which may lead to the application of different measurement methods and get different sampling results.

By-products are referred as something produced in a process in addition to the main product, sometimes unexpectedly or unintended. Animal by-products may be defined as parts of animals that could, but aren't going to be destined for human consumption (Helkar et al, 2016). Nevertheless, the definition of by-products is dependent of culture, tradition and religion (Helkar et al, 2016). By-products can be sold as is or recycled. On the other hand, co-products are desirable secondary goods from manufacturing activities that can be reused or sold (Colombus Global, 2018). This kind of products can be final products or ingredients for other production process (Colombus Global, 2018).

2.3.3 Causes of food loss and waste

Despite food losses and waste occur along the entire food supply chain, the kind of product as well as the point in the supply chain it occurs leads to different forms for losing value. Following are presented the main causes associated with FLW by stage of the supply chain (Lipinski *et al.*, 2013; Bagherzadeh *et al*., 2014; Cicatiello et al., 2016; FAO, 2018):

- Production – during or immediately after harvesting on the farm – includes crops that are left behind due to poor harvesting technology (mechanical or technical issues), overproduction or to market prices drop leading to financial loss if commercialized in the market. Crops that do not meet quality standards, for not having a suitable size or for not being visually attractive, are also sorted out such as fruits bruised during picking and threshing activities will also be left behind. On the other hand, there are also factors that don't have human interference like weather damage and germ outbreaks.
- Handling and storage – after produce leaves the farm for handling, storage and transport – pests eat edible food, processing entities may receive dead or not suitable livestock (meat or fish) or other products (fruits and vegetables) due to poor transportation and/or conditions. Finally, fungus and diseases also cause loss. Nevertheless, poor storage conditions have also to be considered once they cause a significant amount of losses.
- Processing and packaging – during industrial or domestic processing and/or packaging – edible food not suitable for processing are removed, as well as defective end-products (due to wrong shape, size, appearance, etc). A significant portion of FLW in this stage of the supply chain happens because of the processing facilities' conditions and techniques applied, especially in developing countries.
- Distribution and market – during distribution to market, losses at wholesale and retail markets – quality standards are not met leading to the removal of produce from the supply chain; edible products are not purchased before the expiration date and damaged produce while in market. The lack of information sharing and collaboration

between stakeholders also contribute to the generation of FLW alongside with inappropriate work procedures and poor inventory control and management.

- Consumption – referring to losses in home/business of the consumer, including on-trade and off-trade channel – edible products removed for not meeting quality standards, over-purchase leading to edible food waste, as well as cooked food although not eaten.

Besides the influence of supply chain's stage on FLW generation, the country's macro-conditions, such as the geographic, economic and development situation also influences the amount and location where the FLW occurs. Figure 3 shows that developed countries verify the higher rate of FLW in the front-end stages of the supply chain, i.e., distribution and consumption, whereas developing countries fight to reduce their FLW in the back-end stages of the supply chain, i.e., in the harvest, post-harvest, processing and warehousing technology (Baptista et. al, 2012).

Baptista et al. (2012) distinguish the generation of FLW according to a country's demographic typology. In developing and transitional countries, the lack of suitable technology for an efficient harvest, combined with the dietary transition to fresher and healthier products and the pressure caused due to the increasing globalization of trade leads to the contraction of the agricultural sector (Parfitt et al., 2010). This causes not only a reduction on local supply but also implies bigger and complex supply chains that can cause an increase of FLW generation rate. The imports growth rate increases the dependability of these countries to satisfy its needs of nourishment (Parfitt et al., 2010). Usually, this type of countries is in Sub-Saharan Africa, South America and South Asia, like Nigeria, Paraguay and India.

In contrast, in industrialized countries the readiness, abundance and price of products leads to waste since it's faced a generally high-income reality where companies try to sell in big quantities, by lowering prices through discounts or promotions, and invest in strong advertising (Parfitt et al., 2010). This consumerist economy increases consumption as well as waste. Most of countries described are in Europe, North America and Industrialised Asia, such as Germany, USA, and China.

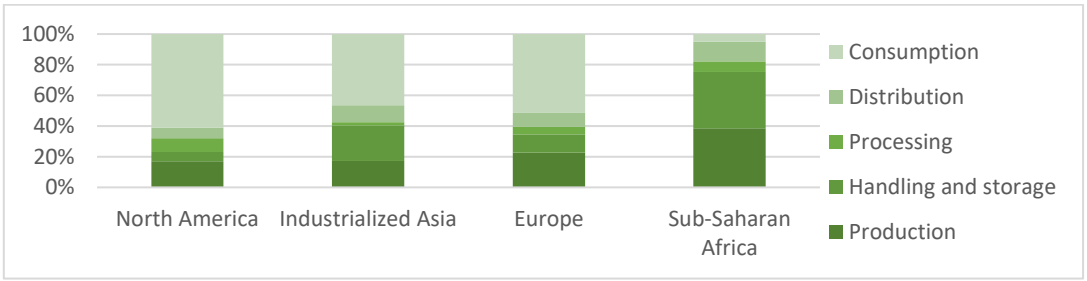

Figure 3 - % of kcal lost and wasted (adapted from WRI (2013))

Alongside with the characterization of FLW by supply chain's stage and the economic and development environment, Canali et al. (2016) divides the FLW causes in three major groups: Social, technological and institutional, separating the last group in corporative and legislative.

Table 3 highlights some of the most significant causes that contribute to the appearing of FLW along the supply chain.

Table 3 - Causes of FLW (adapted from Canali et al., 2016)

Type	Causes
Technological - Derived from collateral effects of modern technologies	· Animal stresses in industrial livestock farming · Automation of tasks (harvest, handling, processing, etc.)
Technolofical - inefficient or misuse of modern technology	· Poor conditions of storage and handling (in both supply chains and households) · Inneficient packaging (defected products packaged, packet size) · Suboptimal use of labelling · Easeness on equipment use
Corporative -Management solutions within one business unit	· Sub-standard food production · Food contamination · Labelling errors · Imperfect products changes in food preparation · Poor starage and transportation conditions · Inaccurate forecast · Portion sizes
Corporative -Management solutions coordinated between more than one business unit	· Overproduction and overstock due to order's schedueling · Short tolerance from retailers · Risk transfer to suppliers/ customers on disposal costs · Free returning of unsold or damaged products · Possibility of canceling orders on last-minute · Power unbalance in the supply chain
Corporate - other economic variables	· Low prices on farm products enhancing unharevsting, product destruction and overproduction in developed countries · Lack of investment in developing countries, hampering the implementation of proper facilities (storage and processing) · Low prices of food for developed countries' households
Institutional - standards on food quality and marketing and agricultural policy	· Marketing standards for fruits and vegetables · Farm overproduction due to subsidies · Fishery policies (fishing quotas, minimum size of caught fish)
Institutional - policies on food security, consumer information and health and animal welfare	· Compliance with safety standards on deadlines of prepared food, expiration dates of opened packages, starage temperature · Differentiation on implementation and regulation of safety rules between countries and food industry sectors · Increasing effectiveness of contaminants' detection · Differences on contaminats' toleration between countries and products · European restrictions on reusing animal residues for food or animal feed · Legislative restrictions on food donations
Institutional - policies on taxation and waste	· Low fees on waste disposal relatively with real impact on operational and environmental costs · Energy production from food waste prioritized over recovery or redistribution Lack of fiscal benefits on food donations

Table 4 - Causes of FLW (continuation) (adapted from Canali et al., 2016)

Type	Causes
Institutional - policies on taxation and waste	· Low fees on waste disposal relatively with real impact on operational and environmental costs
	· Energy production from food waste prioritized over recovery or redistribution
	Lack of fiscal benefits on food donations
Social - Hardly changable social dynamics	· Globalisation of agri-food markets and changing dietary habits
	· Low and young membered' households
	· "busy" lifestyles with relatively high income level
	· Gender-based habits
Social - Hardly changable customers' behaviours	· Aesthetical importance on food products
	· Food safety concerns
	· importance given to products (supposed) freshness, indirectly interpreted by expiration dates
	· Preference for wide possibility of choice
	· Demand's variability
Social - consumer behaviour changeable through sensibilisation	· Inadequate food storage and handling
	· Lack of correct planning on food shopping
	· Poor food information and skills
	· Neglection of packaging instructions
	· Misuse of packaging that help extent product's life
	· Lack of motivation to avoid FLW
	· Promotion sales' temptation
	· Special events like Christmas
	· Unplanned purchases

As previously referred, it's also important to refer the power unbalance between entities as a cause that leads to FLW. As it is important to analyse which factors lead to an increase on FLW. For that, Cox (1999) stated that the relative power is more interesting to characterize than the absolute one. It's important also to consider the relationships dynamic, which means that depending on the relationship considered an entity can be either the most powerful entity or the least powerful (Pfeffer and Salancik, 1978). Ghosh and Eriksson's (2019) empirical investigation is once again highlighted when studying the most decisive factors for power since they studied the correlation between the types of contracts with the unbalance of power between entities. According to Mena et al. (2011), the obligations on deliveries or unsold products in some contracts can lead to FLW, where the breakage risks and costs of the powerful entities are put on the least powerful entities. In Australia, it was studied that the supermarkets' rejection policy was the main cause of FLW on fruits and vegetables where these could be excluded due to shape, size or colour (Devin and Richards, 2016).

2.4 Main destinations and valorisation methods for FLW

Waste valorisation is the process of converting waste materials into more useful products including chemicals, materials, and fuels (Arancon et al., 2013). After understanding the impact of FLW on stakeholders and the planet, it is consensual that these need to be reduced. In fact,

since there are different kinds of FLW in the different stages of the supply chains, possible policies and solutions also differ.

The target of reducing FLW can be obtained not only through policies and solutions that effectively reduce these losses and wastes but also through prevention (Hanson, 2017). On one hand, prevention can be achieved through a more efficient use of resources along the supply chain, reducing waste and loss by not producing it. On the other hand, not disposing edible food or food that somehow has still market value, helps minimize waste. By educating stakeholders, these FLW identified along the supply chain can be reduced (Bagherzadeh et al., 2014). In fact, there are already some studies that try to reduce FLW by minimizing or valorise them, or a combination of both. Many suggest the production of biogas and biofuel by chemical processes (Arancon, 2013; Engelberth, 2020). Despite that, methods that can be put in practice by the stakeholders present on the agri-food supply chain will be closer analysed.

In the table 5, it's listed the most common destinations of FLW, by FLW Standard (Hanson et al., 2016) and Manual Fusions (Tostivint et al., 2016).

Table 5 - Main FLW destinations according to respective documents (adapted from Hanson et al., 2016; Tostivint et al., 2016)

FLW Standard	Manual FUSIONS
Animal feed	Animal feed
Biological raw material/ biochemical processing	Biological raw material/ biochemical processing
Composting/ aerobic digestion	Unharvest/ abandon on soil
Codigestion/ Anaerobic digestion	composting
Controlled combustion	Anaerobic combustion
Landfill	Cogeneration
Land application	Bioenergy
Unharvest/ abandon on soil	Incineration
Sewer/ wastewater treatment	Landfill
Rejection/returns/residues	Sewer
	Returns

By the table above, it's verified that many destinations exist in both manuals, meaning that it's relatively easy to identify and describe them in a small number of groups. Nevertheless, the main issue is in the prioritization process between destinations. Therefore, the European Commission developed the Waste Framework Directive (WFD), which is a rectified directive from Directive 2008/98/EC that defined clauses on waste treatment, that established a hierarchy of destinations (Cristóbal et al., 2017) guided by some key principles for waste management.

Anaerobic digestion is a method that's becoming increasingly common and it registers approximately an operational profitability of 4,90€/ton of food waste for facilities that have a capacity of 250 ton/day (Chen et al., 2017).

The constant update of this document makes it essential for the analysis of this subject, once it incorporates vital information such as the action plan for circular economy in the EU and the sustainable development goals, since 2015. The scope recently changed in order to establish

protective measures on human health and on the environment by preventing or reducing the waste production and the impacts associated, as well as increasing resources utilization efficiency in favour of enhancing circular economy in EU and competitiveness on the long term (European Commission, 2018).

With this, the WFD hierarchy previously mentioned must be the basis of the development of residues prevention and management policies. The EU developed a prioritized list where destinations are decreasingly listed by preference. Nevertheless, since food residues have characteristics that doesn't fit always to the list presented, "Champions 12.3", which is a partnership created by the United Nations in 2015 between people from different areas (government, scientists, cooperatives, etc.), developed a list more suitable for FLW, by combining the WFD hierarchy with the destinies of FLW Standard. This partnership aims to reduce by half the global per capita food waste (Champions 12.3, 2015). Adapted from Hanson (2017), the table 6 presents not only the hierarchy of destinations to achieve the target 12.3, but also a characterization of the groups that each destination fits in, which are listed by preference. Group 1 describe the destinations that contribute to the achievement of the target 12.3 by prevention and redistribution for human consumption (A) or by high valorisation (B). Group 2 have the destinations that don't contribute to the target but constitute some valorisation (C) or don't have any valorisation (D).

Table 6 - Hierarchy of destinations to achieve target 12.3 (Adapted from Hanson, 2017)

Destinations	Description
1. Prevention and redistribution	1.A
2. Animal feed	1.B
3. Biological materials/ biochemical processing	1.B
4. Codigestion/ Anaerobic digestion	2.C
5. Composting/ aerobic digestion	2.C
6. Land application	2.C
7. Unharvest/ abandon on soil	2.C
8. Controlled combustion	2.C/D
9. Landfill	2.D
10. Sewer/ wastewater treatment	2.D
11. Rejection/returns/residues	2.D

This approach recognises just some of destinations as contributors for the accomplishment of the target 12.3. Champions 12.3 (undated) suggest that an entity can better recognize its food flows and share their results by quantifying the data and register the results by destination.

HENVI Science day, which is part of the Forum for Environmental Information, serves as a platform for environmental scientists to present annually their latest research findings and provide a discussion forum among policy makers, scientists, researchers and other interest groups, distinguished the different policies and solutions that can be applied in three different branches (Jurgilevich et al.,2016). Below are shown some of the policies discussed in the latest years of the forum.

Firstly, in the food production, possible policies and solutions are to support local farming through tax incentives for nutrient recovery and reuse or by investment support as well as support the use of recycled nutrients substituting imported ones (Pagotto et al., 2015). Another way to deal with FLW is by considering all stakeholders when creating regulation and support local producers that already practice mixed farming (have both livestock and plant production) enhancing circular economy (Pagotto et al., 2015). One holistic example is the recovery of nutrients present in manure leading to resource savings and farmers resilience's promotion. Another example is the use of smart agriculture and local food movement, which incentives the direct sale from farmers to consumers through programmes like food circle buying clubs and seasonal food box subscriptions. These programmes help reduce packaging, increase freshness and transparency of products because of the shortening of the supply chain and develop stronger relationships between farmers and customers.

Secondly, some possible policies and solutions that can be applied to the food consumption in order to reduce FLW are to educate consumers on sustainability as on the effects of FLW on the environment, trying to promote sustainable habits through awareness and campaigns. Promotion of plant-based diets to reduce meat consumption (Boer et al., 2014) and demand higher quality standards on proper labelling about the product and its production process can lead to reduction of carbon footprint and have more informed consumers, respectively. These policies can be applied through establishing, for example, a vegetarian day in schools, promote consuming smaller and organic portions of meat, and "dumpster diving" which relies on collecting free food thrown out by supermarkets, but that is still edible (Jurgilevich et al.,2016).

At last, food waste and surplus management are also considered and one of the policies that can be applied is the promotion of a more sustainable production throughout the entire supply chain by closing as most material loops as possible along the supply chain (circular economy and industrial symbiosis). Revise food standards ("ugly" food is not waste) and legal barriers (redistribution of unclaimed food) in order to reduce loss and waste. Support businesses that practice industrial symbiosis, re-manufacturing or that work in cascades is very important so that the amount of waste is reduced as well as the raw materials needed for production of future products (Lozano, 2014). Incentive sustainable choices in packaging and schemes like a deposit-and refund and prolong shelf-life by better regulating packaging can also reduce FLW by not disposing edible food. Some applied solutions are the use of cascades by creating value from materials considered as waste; production of biogas and deriving nutrients from food waste and impose supermarkets to donate their food waste instead of throwing it away (Jurgilevich et al.,2016).

Table 7 was developed by Martinez (2019) through the combination of previous works from FAO (2016) and Hanson and Mitchell (2017). With these studies, it's possible to resume some of the solutions, in terms of prevention, to the obstacles mentioned previously, also by distinguishing the issues regarding loss or waste.

Table 7 - Solutions to deal with FLW (adapted from Martinez, 2019)

	Problem	Solution
Loss	Losses in production and harvest	· Create and promote sustainable social, economic and technical practices · Improvement on harvest techniques
	Poor storage and inadequate techniques	· Capacity development, market information, energy access, inputs improvement · Better access to infrastructures · Development of energetically efficient supply chains
	Poor processing and packaging	· Availability of raw materials and technology, access to energy and modern markets · packaging improvement lengthening freshness, portion optimization
	Transportation and distribution issues	· Development of transportation capacity, logistic solutions
Waste	Waste in production and harvest	· Efficient planning, recovery network programmes · Add value to non-valued harvests
	Wholesalers and retailers' inefficiencies	· Adequate management, labelling and planning · Lower quality standards (accept "imperfect" products) · Rethink promotion policies
	Waste on consumption entities	· Consumer education, conscious consumption, planning · Consumption of "imperfect" products
Applicable to the supply chain regardless the type of residue		· improve forecast · Investment on innovation · Development of platforms to share good practices · Favour the possibility of donate unsold products

On the other hand, ENCDA**,** which is the Portuguese National Strategy to Fight FLW proposed by the Portuguese National Commission to Fight FLW (CNCDA), has established three strategic targets: prevention, which is stated to be the best tool to mitigate the problem, since there's a lower need to reduce waste when at the start there's a lower amount of FLW. The second objective is reduce and develop a harmonized method throughout the EU capable of measuring where and how much FLW is being reduced. At last, the third objective is the monitorization by all stakeholders so that there's a developed awareness on how each one should behave to achieve FLW reduction (CNCDA, 2017).

These strategic objectives are reached through nine operational objectives. In order to achieve prevention, it's suggested to increase awareness on FLW, not only to consumers but also retailers and other stakeholders by sharing good practices and technological applications (Bagherzadeh et al., 2014; CNCDA, 2017). Awareness on FLW should also be increased as soon as possible in new generations so that sustainable habits are implemented at a young age, by implementing pilot projects in schools and approach these themes in schoolbooks as well (Jurgilevich et al.,2016). Step up operators' formation in a way that technicians and volunteers mitigate risks on products' handing so that logistics and food conservation efficiency increase. At last, developing a proactive policy for results communication so that everyone can access FLW levels as well as its evolution. (CNCDA, 2017)

To achieve reduction, it's suggested to increase innovation capability and enhance good practices in FLW reduction by getting synergies between stakeholders and universities as well as through programmes dedicated to science to get funding for development. The reduction of administrative barriers in order to facilitate procedures of donation as well as behaviours that reduce FLW, that sometimes can get difficult to implement with today's regulations (Pagotto et al., 2015). The collaboration between stakeholders can take a crucial role mainly socially speaking since conditions can be created so that private companies can donate food at risk of expiring to people that can't afford it, as well as between stakeholders in the supply chain (CNCDA, 2017).

To achieve monitorization it's suggested to develop a harmonized measurement system to quantify FLW throughout the supply chain to have a better understanding on its origins and tendencies. With this system implemented, it's easier to acknowledge where to proceed to achieve the goal of minimizing FLW. At last, it is suggested to develop a reporting system in the different stages of the supply chain that will allow accessing internally and externally each country's performance as will grant these data to be used by companies and universities for development, investigation and innovation to reduce FLW (CNCDA, 2017).

On the other hand, with a more chemical-based literature, the different type of products, dividing them into plant and animal-based products, have distinguished valorisation methods, as presented in the following table.

Table 8 - Valorisation methods by type of product (Aspevic et al., 2017; Ayala-zavala and González-Aguilar, 2011; Gowe, 2015; Elleuch et al., 2011)

Animal-based	**Plant-based**
Rendering	Source of dietary fiber
Chilling and freezing	Food additives
Use of organic acid	Antimicrobal and flavouring agents
Fish silage	Colorants
Salting	Source of protein
Enzimatyc protein hydrolisis	
Chemical protein hydrolisys	

Considering animal-based products, despite having nutrients available, it's easy to get food spoilt due to microorganisms. These microorganisms can be from the food itself or from the processing environment, due to contamination of the skin or employee hygiene, respectively, amongst others. Therefore, there are multiple techniques that prevent the spoilage of these kind of raw materials and, therefore, the generation of FLW (Aspevik et al., 2017).

With the methods presented before, there are many applications for fish and meat co- and by-products. In fact, food ingredients are an option especially for parts that are traditionally considered edible such as liver and kidney. Production of gelatin is supported by animal parts such as bones (Aspevik et al., 2017). On the other hand, feed and pet feed are also two destinations for these processed co- and by- products (Toldrá et al., 2012), considering feed as the process of feeding animals in the aquaculture sector and monogastric land animals and pet feed as for feeding companion animals such as dogs and cats. The last referred method is the use of these products for health promoting products, since these by- and co-products are rich in

biologically active molecules with health-promoting effects, such as blood pressure lowering and antioxidant activities (Aspevik et al., 2017). Rendering is used mostly to manufacture protein powder and fat or oil (Aidos et al., 2001). Lately has been explored human destination as a destination for co- and by- products, although it's difficult due to regulation barriers and lack of awareness on the importance of the acceptance from the consumers (Aspevik et al., 2017).

The plant-based valorisation methods have many applications, such as anti-browning additives to avoid enzymatic browning, antioxidants and thickener agents (Ayala-Zavala and González-Aguilar, 2011). The third method presented is useful for food preservation, for example, lemon extract can be used in cheese packaging to increase its shelf-life (Conte et al., 2007). On the other hand, colorants are useful for this kind of products because colour is very valued and synthetic colorants are becoming rejected by consumers. The properties of fruits and vegetables can also be used for pharmaceutical and cosmetic industries (Gowe, 2015). Become a source of protein allows plant-based by- and co-products to compensate the deficiencies and high cost of animal-based protein.

2.5 Centralization VS Decentralization strategy

A centralization strategy is based in having a single facility, like a warehouse, that supplies other facilities, like stores. On the other hand, decentralized supply chains have a more direct supply since the warehouse echelon can be excluded. When analysing which strategy is better suited for the considered supply chain, risk pooling and risk diversification are 2 factors that should be taken into account (Schmitt, et al., 2015). Risk pooling provides less demand variance, which leads to lower costs of inventory and overall expected cost (Eppen, 1979). Risk diversification occurs when the SC works with decentralized facilities. When a disruption of stock takes place, its impact is reduced and contained in that facility, which means that decentralized systems reduce variance cost (Lawrence and Zuo-Jun, 2006). Therefore, when disruptions occur, it's preferred to have a decentralized strategy so that the number of facilities affected by such disruption is reduced – Lower variance cost compared with centralized systems. With such analysis, Schmitt and Snyder (2012) concluded that systems where disruption is a probable scenario, decentralized systems are preferred.

When choosing between both strategies, there're trade-offs between costs of warehousing, inventories and transport, but also the cost of lost sales and service level desired (Milewski, 2020). A centralized inventory strategy has as main benefits the warehousing costs, reduction of inventories and the ability of assuring more often full truck loads. However, deliveries might have to travel longer distances, increasing transportation costs, especially if the deliveries are made in small quantities. The required flexibility and speed of the deliveries are also factors that increase transportation costs. Therefore, despite having a higher inventory availability in centralized systems, transportation costs are most likely higher and the service level might decrease due to eventual delays – higher lead time (Milewski, 2020).

The type of business is crucial for deciding which system to implement. Businesses where the cost of maintaining inventories is very high, such as the food industry, the centralized system may

be more effective. The transport service's quality and costs are also essential for the implementation of centralized systems. The effectiveness of such implementation often depends on the cooperation with the transport operator (Milewski, 2020). As it is referred in the section 2.2, collaboration between stakeholders is very important for an efficient operation of an AFSC.

In a study developed by Milewski (2020), where multiple simulations have been made to analyse the impact of transportation in both centralized and decentralized systems, the author concluded that, independently of the type of product (cheap or expensive), the distance of the journey is the most important factor compared to sales volume, demand volatility, number of warehouses, width of the product range, amongst others factors. In fact, the vast majority of cases show lower total costs when distances are up to 500 km to the DC. These scenarios were developed considering every transportation mode available for distances from 350 km to 1150 km.

The transportation of merchandise in a centralized systems can be more effective when using specialized transportation operators, since these companies can gather many orders from different companies to consolidate the transportation and, therefore, provide lower rates of transportation. This can be applied for both internal and external costs of transportation, since the total cost is divided by all the companies that are taking advantage of this service (Milewski, 2020).

In the latest report, it's stated that the member states of the EU produce 88Mt of bio-waste from municipal solid waste every year, where around 40% is landfilled (European Commission, 2010). Composting is registered as the most used destination for this waste, with anaerobic digestion increasing as an alternative solution (European commission, 2008). Despite of the composting and anaerobic digestion's multiple benefits, it can generate bio-aerosol, heavy vehicles traffic and odours and the associated harmful effects to human health for the neighbourhood (Domingo and Nadal, 2009; Giusti, 2009). Therefore, a shift for smaller and more decentralized facilities can resolve the problem partly due to: (1) the decrease of waste materials stored before having it collected for valorisation; (2) facility's benefits maximization for the local community – use of heat for household activities; (3) shorter distances travelled which reduces air pollution, traffic, noise and transportation costs; (4) increased public acceptance justified by the benefits above described. The lack of availability of organic waste to feed the anaerobic digester is one of the most difficult obstacles to sustain the implementation of decentralized plants (Righi S. et al., 2013). The study developed by Righi (2013) to analyse the best combination of valorisation methods between anaerobic digestion, codigestion and composting. This included that environmental impacts of transportation, anaerobic digestion, composting, landfill disposal, power production and fertilizer production and dewatering. It was considered different scenarios and these were studied in terms of potential global warming contribution, acidification potential, eutrophication potential, ozone depletion potential and photochemical ozone creation potential. After analysis, it could be concluded that the combination that provided the best performance is the one that combines composting with anaerobic digestion. Nevertheless, it is important to refer that transportation should be minimized and citizen participation is crucial. With an aware community that separates adequately its residues, the processes become more simplified and its efficiency enhanced (Righi, 2013).

2.6 Chapter conclusions

This chapter firstly started by characterizing the concept of AFSC and its main challenges and stakeholders involved. After the understanding of such concept, it was discussed the importance of sustainability on an AFSC and its challenges, following the role of collaborative practices to achieve sustainability. Afterwards, the focus of the next sub-chapter is the FLW, starting by discussing the emergency of dealing with such problem and a brief contextualization on the impacts of FLW in the SC. To face such problem, it was necessary to, firstly, have a clear idea of the concepts used. Then, the different FLW causes were collected, as well as the main destinations used to avoid FLW's generation and disposal.

After the literature review, it's evident the impact that the FLW has in the AFSC and how much it harms its goal for achieving sustainability. Despite becoming an increasingly more discussed matter, FLW is difficult to develop and agree upon the measures suggested to implement, since many definitions of basic concepts have not yet been established. Nevertheless, the need for reducing FLW along the AFSC, as well as a more sustainable approach to deal with it, is consensual. For that, there's a need to not only monitor where the FLW occurs but also the destinations for these misused resources, so that these can still be of value for the economy, the environment or the society. The collaboration within the AFSC has a major role for better efficiency and effectiveness to achieve sustainability and reduce FLW, nevertheless it is important to consider the power balance between entities for an adequate implementation of such practices.

In order to better deal with the FLW generated in different facilities of the SC, it's suggested to implement a centralized strategy, where it can be transported with higher frequency, allowing it to reach the valorisation facilities with higher quality characteristics. With such characteristics, the FLW can be used with higher efficiency.

The next chapter intends to have a closer look on the practices that the biggest AFSC in the world have been establishing to become more sustainable and more closely how have been reducing their FLW.

3. The case of the worldwide AFSC leaders

In this chapter, the best AFSCs worldwide, according to Gartner's criteria, will be analysed. After a theoretical contextualization, the practices that the AFSC listed in the top 25 companies have been implementing to become more sustainable will be discussed. The focus of the case study is to understand how companies have reduced their FLW, their goals for the next years and the path they're following to achieve them. The choice for Gartner's top 25 was due to the companies' influence not only in the food sector, but in supply chain management in general, since (i) these are innovative companies that are generally ahead of competitors in terms of sustainability; (ii) they're market leaders with large market shares in their respective markets and, therefore, have the tendency to generate bigger environmental, social and economic impacts; and (iii) they are capable of influencing the market environment and their customers.

The companies that are going to be discussed are the ones in the food sector represented in the top 25 supply chains in the world: Nestlé (fifth place), Pepsico (sixth place), Walmart (eleventh place), Coca-Cola (thirteenth place), Diageo (fourteenth place) and Starbucks (nineteenth) (Gartner, 2020).

The information gathered for this chapter is mostly from sustainability reports, but information from scientific articles and news were also utilized. With this information, is possible to characterize the best practices to implement in the sector that the companies are inserted into, because these companies manage the most innovative and sustainable supply chains worldwide.

The first sub-chapter will explicit the goals established by each company to reduce the generation of FLW in their activities, analyse the progress and quantify it, when possible. The second sub-chapter will analyse the practices implemented to achieve the goals targeted in the previous one.

3.1 Progress towards the goals to reduce FLW

In this sub-chapter, the main objectives that the identified companies intend to achieve to reduce their FLW is discussed, as well as its progress to achieve them, quantifying it when possible. It will also be described how these companies have been dealing with the generation of FLW in terms of valorisation methods.

From the analysis of the companies mentioned, it's verified that most of these companies explicitly state their goals towards reducing FLW in their sustainability reports, as well as its progress to achieve them. Although, the information about the practices implemented towards sustainability is less detailed.

As the companies' destinations and valorisation methods used are mentioned, these are going to be fitted in the hierarchy of destinations to achieve the target 12.3 (table 6), by writing in front of the method, in brackets, the respective level at which they are inserted into.

3.1.1 Nestlé

To reduce the impact on FLW, Nestlé states that by 2020 intends to achieve zero operational waste disposal in every site in its supply chain, accelerate progress towards halving food waste by 2030 and reduce waste in the consumption stage by making understandable labels to every

consumer (Nestlé, 2019). Despite verifying an increase of production in 2002, the generation of by-products/waste was reduced by 13%, whereas the recovery rate of this waste was of 72,6%, a value that has been increasing since then. Since 2009, Nestlé reduced 96% of their operational waste for disposal at their sites of the supply chain (Nestlé, 2002; Nestlé 2019). All the operational waste generated in Nestlé's facilities is recycled into liquid fertilizer (*2.C anaerobic digestion*) or transformed into biogas (*1.B. Biochemical processing*) (Nestlé, 2019).

Nestlé states to have a significant portion of their food suppliers in developing countries, which influences, as stated in the previous chapter, due to lack of access to technology, infrastructure and knowledge, the production stage is responsible for a significant amount of FLW.

To deal with such inefficiency, Nestlé works with their smallholders, the farmers, to not only make them understand their environmental impact but also the economic gap that occurs with such inefficiencies. For that, Nestlé helps finding more efficient food-handling processes (*1.A. Prevention*) (Nestlé, 2019). In 2019, Nestlé developed a project in Nigeria that helped smallholders to reduce their post-harvest activities' waste generation through the implementation of low-cost technologies, such as maize shellers. On the other hand, Nestlé partnered with World Resource Institute to access the causes of FLW in their suppliers in dairy products and with Earthworm for products produced in Indonesia and West Africa (Nestlé, 2019). #Sindesperdício is a platform developed by Nestlé and other multinational companies in the food sector to improve the mismatch observed between under-nutrition and FLW generation on South America (Nestlé, 2019). In 2019, Nestlé identified palm oil, dairy, cereals, fruits and vegetables as the five commodities that most contributed for the amount of FLW produced, located its hotspots and worked along the farmers to devise solutions to improve this (Nestlé, 2019).

3.1.2 PepsiCo

The companies present in the beverage sector that are being analysed, mainly PepsiCo, Coca-Cola, Diageo and Starbucks, give less attention to FLW, since the main environmental impact of these companies is in the consumption stage due to the empty bottles or cups.

PepsiCo intends to achieve zero waste in its manufacturing operations and has developed projects focused on valorisation methods for the waste generated (Mace, 2016; PepsiCo, 2019). For example, PepsiCo's agricultural team in Turkey has invested in anaerobic digestion (*2.C*) technology to deal with the organic waste generated, several years ago. In the UK, around 75% of the electricity used in the factory in Leicester is generated from FLW via anaerobic digestion (*2.C*) (Clancy,2013).

Starting in 2013, it has been feeding waste created by the production of company's snack foods to generate biogas. With such activity, has been covering 35% of the electricity needed in their food plants (Clancy, 2013). PepsiCo also developed a process to create environmentally friendly fertilizer from its by-products (1.B Biochemical processing). With this, it's supplying several farmers across Turkey generating a new income stream, as well as reducing FLW in its operations (Clancy, 2013).

Both Nestlé and PepsiCo joined, in 2020, the Champions 12.3 initiative “10x20x30” that aims to reduce their FLW by half until 2030. This voluntary initiative allows everybody to check the progress of these companies towards this goal. EPA will direct each “Champion” to use the FLW Protocol, which is a collaborative measure that introduced the FLW Standard for quantifying and reporting on FLW within the supply chain. Walmart was one of the companies that developed this initiative (Retail Best Practices, 2020).

3.1.3 Walmart

Walmart aims to achieve zero waste, including food waste, in their operations globally, starting by achieving it in 2025 in Canada, Japan, USA and U.K (Walmart, 2019). In 2019, Walmart registered the following waste mix: 71% to reuse/recycling; 19% to landfill; 4% to donations to people in need; 3% to animal feed; anaerobic digestion, composting and incineration have 1% each. This mix represents the total waste generated, although the focus of this projects relies only on the FLW. Nevertheless, this represents that 80% of the total waste generated was diverted from landfill (Walmart, 2019).

The main practices implemented to tackle FLW are the donation of unsold food, acceleration of sell-through and recovery of inedible food and allocating it for animal feed, composting and anaerobic digestion (Danigelis, 2018).

Through the measures implemented, Walmart U.S., in the fiscal year of 2019, had already reduced the food waste in 90 million units in the fresh products’ department compared with the previous year and has already reduced more 57 million units relatively to the previous fiscal year, and sold more than 320 million food units through food discount programs close to their expiration dates (Walmart, 2019; Walmart, 2020). In 2019, has donated more than 720 million pounds of food globally and more than 640 million pounds of food just in the U.S. to food banks and other charities. Has also donated funds to buy equipment to increase the charitable meal system’s capacity to transport and deliver fresh products (Walmart, 2019; Walmart, 2020).

Since 2005, Walmart and Walmart Foundation have already contributed with more than 120 million dollars and more than 4,5 billion pounds in food donations to support the Feeding America program, which involves more than 200 food banks in the U.S. (*1.A Redestribution*) (Walmart, 2019; Walmart, 2020). In 2014, Walmart, along with Sam’s Club and participating suppliers and customers, have raised 100 million dollars to support Feeding America, with the “Fight Hunger. Spark Change” campaign, created by Walmart. Since 2016, Walmart Foundation donated 18 million dollars to reduce food waste and strengthen food banks in Canada (Walmart, 2019; Walmart, 2020).

In several markets, such as in the U.K., Asda stores, which are a Walmart’s branch, sell “ugly” fruits and vegetables, under several labels, which reduced 1,5 million pounds of waste in 2019 (Walmart, 2019). Through the adjustment of the fresh products’ requirements to accept size and other cosmetic variations (“ugly” food) that don’t affect the quality of the product to minimize rejection rate (*1.A Prevention*), Walmart avoided more than 1,4 billion pounds of waste of going to landfill globally, and 1,1 billion just in the U.S. (Walmart, 2019). In these products, discounts

are offered to encourage the customer to purchase such products. In these perishable products, Walmart focuses the supply chain's efforts on trying to reduce the days required to go from the point of origin to the store, having even created a customized field-to-store network for highly perishable products (Walmart, 2019; Walmart, 2020).

To support the food banks in Canada, Walmart supports organizations that help expanding access to charitable meals, support access to benefits and development of meal programs in community sites and schools, and to those that provide nutritional education (Walmart, 2019; Walmart, 2020). The Walmart Foundation committed itself to award 15 million dollars to organizations that would be able to help reducing FLW and strengthen food banks in Canada from 2017 to 2020 (Walmart, 2020), from these 11 million dollars have already been awarded. Besides these efforts, Walmart also supported organizations such as World Wildlife Fund to conduct a research and analyse policies that enhance the reduction of FLW (Walmart, 2020).

Walmart is one of the biggest retailers in the world and it states that is implementing the best practices in distribution and retail activities to achieve sustainability in the supply chain by working with the upstream suppliers and empowering downstream consumers. In fact, through the Gigaton project, Walmart encourages their suppliers to measure and report the food waste generated and to introduce practices for donating, recycling and reprocessing, but also to standardize their expiration date labelling (Walmart, 2019; Walmart, 2020). On the other hand, when food is no longer edible, Walmart converts it into energy, such as in Argentina, Chile and other countries that take advantage of the anaerobic digestion's (*2.C*) characteristics to create fuel and fertilizers. Animal feed (*1.B*) or compost (*2.C*) are also destinations used for inedible products (Walmart, 2019; Walmart, 2020).

The primary method to avoid food waste in Walmart's operations is by increasing sales of its food products, but also by strengthening the forecasting's accuracy and ordering tools to have a more adequate inventory flow and product turnover (*1.A Prevention*). Enhancing distribution centers' efficiency (*1.A Prevention*) and offer discounts on food close to its expiration date are also practices implemented (*1.A Prevention*). Offering discounts to products close to the expiration date not only helps customers to save money, but also reduces the amount of waste generated (Walmart, 2019; Walmart, 2020).

Walmart Foundation's philanthropic investments focus on investing in prevention efforts to stop FLW of being generated (*1.A*) and on the redistribution and recovery of edible food that would go to waste (*1.A*), specially from retail and farms (Walmart, 2020).

3.1.4 Coca Cola

Coca Cola, by 2030, aims to double its small-scale food suppliers' productivity and incomes, specially of women, family farmers, indigenous people, fishers and pastoralists. It has been working with its Indian and Brazilian suppliers to develop agricultural activities that enhance not only automation but also production yields (*1.A Prevention*). With such approach it intends to secure equal access to land and other resources and inputs, financial services, knowledge, markets and opportunities for value addition; Wants to guarantee sustainable food production and

implement resilient agricultural practices capable of increasing production and productivity, maintaining ecosystems, strengthening the capacity to adapt to climate change, droughts, extreme weather and other natural disasters and progressively improving soil and land quality; Aims to substantially reduce its operation's waste generation through prevention, reduction, reuse and recycling; At last, committed, in 2018, to reduce 50% of its FLW generation in its operations in Great Britain (Coca Cola, 2019).

In 2018, Coca Cola reported that its FLW generation is just 3392 tonnes (0,1% of the total production), where 58 tonnes were redistributed for human consumption and 4180 tonnes to animal feed. None of the manufacturing operations send waste to landfills and most of the supply chain doesn't either in 10 years (Coca Cola, 2019).

Coca Cola favours redistribution to human consumption over the other destinations and in half of 2019 had already more than doubled that redistribution and reduced significantly the FLW destined to anaerobic digestion (Coca Cola, 2019). Partnering with FareShare in the U.K., since 2014, Coca Cola donates its stock surplus to charity (*1.A Redestribution*). Nevertheless, FareShare has stricter regulations, which made Coca Cola partner with Company Shop Group to give the food FareShare can't redistribute an additional opportunity for human consumption (Coca Cola, 2019).

Coca Cola has also entered in a regional alliance alongside with Nestlé, Heineken, Unilever and Diageo to give awareness on waste management systems in West, South and East Africa (Coca Cola, 2019).

Coca Cola has a system of destinations for products that the company can't sell or that doesn't want to sell for being unsaleable due to its expiration date; for having packaging or labelling faults; for having an ingredient unwanted, or just because it doesn't meet the company's standards. Those that meet the suitability criteria for animal feed are hauled to those customers (*1.B*); if it doesn't, it is hauled by a waste contractor for anaerobic digestion (*2.C*). On the other hand, if the product is still fit for human consumption it is hauled via spare capacity to charity organizations such as FareShare or Company Shop Group (*1.A Redistribution*) (WRAP, 2019).

3.1.5 Diageo

Diageo has set the target of achieving zero waste to landfill in 2020 in all of their sites, including food waste, and has reported to have sent to landfill, in 2019, just a little more than 0,4% of the total non-hazardous waste generated (Diageo, 2019). Diageo does not differentiate food waste of material waste (such as bottles), nevertheless the measures implemented affect both material and food waste.

Diageo is part of a distillers' consortium that has invested nearly 30 million pounds, since 2013, to build a Combined Heat and Power plant to produce animal feed from the FLW of their operations (Zero Waste Scotland, 2015). It is also known for investing in the biggest renewable energy technology by a non-utility company in the UK to produce electricity from its by-products through anaerobic digestion and biomass combustion. This investment is responsible for

generating 80% of the electricity and 98% of the steam needed by the production plant (Zero Waste Scotland, 2015).

Diageo operates according a hierarchy to minimise waste, where the first option stands for omitting waste (*1.A Prevention*), which means that the best way to fight waste generation is to not generate it at all; on the other hand, if omitting is not possible, reducing is the second-best action (*1.B Redestribution*); followed by reusing (*1.A-2.C*), recycling (*2.C*) or, at last, disposing (*2.D*) (Diageo, 2020).

Diageo was introduced to the Industrial Symbiosis Service and attended a workshop about Food and Drink Synergy in 2008. This gave insights to the company on how to deal with its packaging, food and processes waste. Through the workshop, created a network of customers for its waste and reduced significantly the waste destined to landfill (*1.A Prevention*). To the FLW, Diageo developed a composting solution (*2.C*) to avert it of going to landfill (Investni, undated).

Diageo has a website called Diageo Bar Academy where it gives some suggestions to enhance the reduction of FLW, such as “root to tip” cocktails that suggests the usage of an entire plant instead of just parts of it in the preparation of such drinks (1.A Prevention). On the other hand, has suggested bar owners to buy local products and to plan their cocktail menus with months in advance to deal better with the seasonality of the products (1.A Prevention). The proper use of preservation techniques is also recommended to reduce FLW and economic loss (1.A Prevention) (Diageo, undated).

3.1.6 Starbucks

To reduce FLW, Starbucks committed in 2016 to achieve zero waste by 2020 (Starbucks, 2018). To accomplish this goal, Starbucks developed the FoodShare program, in 2016, which donates the unsold products of Starbucks’ stores for people in need. Since 2019, this program started working alongside with Second Harvest, which is the largest food rescue organization in Canada, to donate perishable and chilled food products for those in need (*1.A Redestribution*) (Versolatto, 2019). Even after donating unsold products such as pastries and baked goods, Starbucks wanted to increase the variety of products donated to reduce the amount of unsold goods going to waste, therefore included products like breakfast sandwiches, salads, yogurt, protein boxes and dairy products (Versolatto, 2019). Since June 2020, Starbucks has already donated more than 25 million units of food from 60% of their stores in the U.S..

At Starbucks, fluid milk is responsible for 36% of the total FLW generated followed by other beverages and, only in third place, coffee with 17%, whereas about 30% is sent to composting, and in fourth, grains with 12%. Despite the relatively low amount of waste generated by the grains, this is the most pollutant in terms of carbon impact, due to the high emissions in landfill (Starbucks, 2018).

To deal with the high volume of FLW verified, Starbucks has also been developing valorisation methods for energy recovery from food waste generated in its operations. According to Starbucks report, the food waste occurring in the stores are mostly sent to sewage and landfill (Starbucks, 2018). Although, Starbucks Hong Kong has been investing in the development of biorefinery

technology to convert FLW into succinic acid, which is a chemical responsible for the manufacturing of products such as plastics and detergents (1.B Biochemical processing) (Bladon, undated).

Table 9 is a sum up of the information on the companies developed above. In the table, the objectives placed by the companies to reduce their FLW, the practices implemented to accomplish such goals and the progress towards its fulfilment are outlined.

Table 9 - Sum up of the companies' approach to tackle FLW

Company	Objectives	Practices implemented	Progress
Nestlé	Accelerate progress towards halving FLW by 2030 Zero operational waste to disposal Reduce FLW through understandable labels	Collaborative practices with suppliers from developing countries towards reducing FLW in upstream stages Collaborative practices with competitors to improve social welfare Anaerobic digestion Production of biogas	Reduction of 96% of operational waste since 2009 Waste for disposal reduced 50% from 2018 to 2019
PepsiCo	Halve waste generation until 2030	Anaerobic digestion Developed a friendly fertilizer from by-products	Leicester's factory is 75% from FLW 35% of the total electricity needed for every plant is from FLW
Walmart	Achieve zero waste Achieve zero waste in 4 countries in 2025	Reuse/recycling Donation of unsold products Composting Anaerobic digestion Animal feed Acceleration of sell-through Support programmes that give awareness on responsible and sustainable consumption Lowering of quality standards for F&V Development of the Gigaton project Creation of the Walmart foundation	Reduction of FLW in 90 million units, in F&V, in 2018. Constant reduction verified 320 million food units sold through discount programmes to avoid expired food, in 2019 4,5 million pounds of food donated, since 2005
Coca-Cola	Double small-scale food suppliers' productivity and income Increase sustainable management of resources	Collaborative practices with suppliers from developing countries towards reducing FLW in upstream stages Anaerobic digestion Donation of edible products Animal feed Collaborative initiatives with companies in the sector to give awareness on waste management	Reduction of 50% of FLW generation in Great Britain, in 2018 FLW represents 0,1% of production No FLW goes to landfill

Table 10 - Sum up of the companies' approach to tackle FLW (continuation)

Company	Objectives	Practices implemented	Progress
Diageo	Zero waste to landfill, in 2020	Animal feed Anaerobic digestion Biomass combustion Industrial symbiosis Composting Collaborative practices with suppliers Increase awareness on sustainable consumption Reuse/recycle Investment in renewable energy technology to take advantage of its by-products	80% of the electricity needed provided by by-products 98% of the steam needed provided by by-products
Starbucks	Zero waste, by 2020 Donate every unsold food from the stores, in the U.S.	Donation of unsold products Composting Sewage FoodShare program Investment in biorefinery technology	Increase diversity of unsold products to donation 25 million products donated, since June 2020

3.2 Chapter Conclusions

In this chapter becomes clear that, for the companies studied, the traditional linear SC is unviable for the future of the markets and to the society itself. Therefore, the effort dedicated in adopting practices that enhance circular economy and industrial symbiosis is clear. The reduction of FLW is mostly based on prevention and redistribution of products that didn't meet the market or were reaching their expiration date. It's evident the clear goal of the companies addressed in reducing their FLW generation not only through the development and implementation of new processes that increase the company's SC efficiency, but also by contributing socially to the community through donations. Another practice that has increased is the industrial symbiosis, which is used to avoid sending unfit products to the market to disposal profitably.

This is not only evident through the goals stated explicitly by the companies on their reports of sustainability and its respective progress, but also on campaigns that promote sustainable behaviour and on the effort dedicated on having closer relationships with the company's suppliers, distributers and retailers.

Despite most objectives haven't yet been accomplished in full, the continuous improvement on the companies' activities, the development and implementation of new practices and the fact that these companies have joined projects that contribute to a more sustainable management of SCs support the commitment that these companies intend to improve and become more sustainable.

The development process of the analysis is limited due to the lack of information available in some aspects, such as accessibility on information of every project and practice implemented and limited information on quantitative metrics in terms of FLW improvement.

4 Case Study

4.1 Jerónimo Martins

Jerónimo Martins (JM) is a portuguese family company acting in the food industry founded in 1792, that is present in three distinctive geographical markets: Portugal, Colombia and Poland. In the recent years, JM has been growing and expanding, having more than 118.000 workers by the end of 2020. This group is specialized in food distribution and retail, having different companies for each area. In the latest years, JM has been trying to increase its presence and independence in some products, by taking control of the production of such products through upstream vertical integration: Best Farmer (livestock production), Terra Alegre (dairy) and Seaculture (aquaculture). JM has a big presence in its acting markets, with more than 4400 stores, 9.293 million € in sales and 312 million € as net profit, in 2020.
In this chapter, it will be explained how JM reaches its current place as leader through a historical background, as well as an explanation of its present structure and developing investment areas for a better understanding of its actual positioning and the direction the group intends to go.

4.1.1 Historical Background

The Group's history starts in 1792, when Jerónimo Martins opens a shop in Chiado. Due to its good reputation, Grandes Armazéns Reunidos do Porto started to show interest in acquiring the establishment Jerónimo Martins & Filhos. After the purchase, JM restructured itself and started to focus on the industrial segment. In 1949, JM partners with Unilever, splitting the ownership of the company with Unilever having 45% of the shares. More than 30 years later, JM creates Pingo Doce, entering in the food distribution business. To acquire the adequate know-how and expansion support, several partnerships with retailers took place, leaving JM with around 51% of Pingo Doce. In the same decade, JM enters in the wholesale business through the acquisition of 4 Recheio stores and, two years later, Arminho, the biggest cash-and-carry chain of the country. This acquisition strategy intended to give Recheio the resources required to gain competences and position itself as supplier of the HORECA (Hotels, Restaurants and Cafes) channel.
In 1995, JM starts acting outside of Portugal, buying Eurocash, in Poland, which at the time had 48 cash-and-carries. That marks the beginning of Bierdronka. This new company that is part of the Group JM had three types of stores: Hypermarkets, cash-and-carry and Supermarkets Discount, although the main focus turns to the Discount concept, since it was the most successful. In just four years, JM was also acting in Brazil. However, with the fast growth of both national and international markets, the Group didn't have enough resources. Due to the required investments to deal with the expansion in all markets, the Group accumulated a significant amount of debt. A *Profit Warning* informing the poor results was then released. In order to reverse and stabilize its financial situation, the Brazilian market was dropped and investments were reduced. After rebalancing its results and regaining its position in the market, JM focused on increasing the variety of products and developing its own white label. In 2003, Pingo Doce started to do take-away through its new business Meal Solutions and creates a new business, Amanhecer, which

is constituted by smaller stores and its concept is of being a nearby store. In 2013, JM enters the Colombian market with its new business called Ara, partnering with local industries for a better understanding of the consumers' habits. With such information, Ara intends to not only offer a variety of products that attract consumers, but also to develop private labels that differentiates Ara from the competition. Just one year later, JM creates Jerónimo Martins Agroalimentar (JMA), a new business area that allowed JM to increase its independence over the suppliers of some products. JMA is responsible for livestock (Best Farmer), dairy (Terra Alegre) and aquaculture (Sea Culture) production. Nevertheless, JM is present in other segments, including the specialized retail. In 1990, JM and Hussel performed a joint-venture (49% owned by Hussel Iberia) that offers chocolates and confectionery. Later on, JM created a chain of coffee shops called Jeronymo and, at last, opened stores specialized in beauty and health called Hebe, in Poland.

For a better view of the Group Jerónimo Martins' most important events, a chronogram was developed (Figure 4).

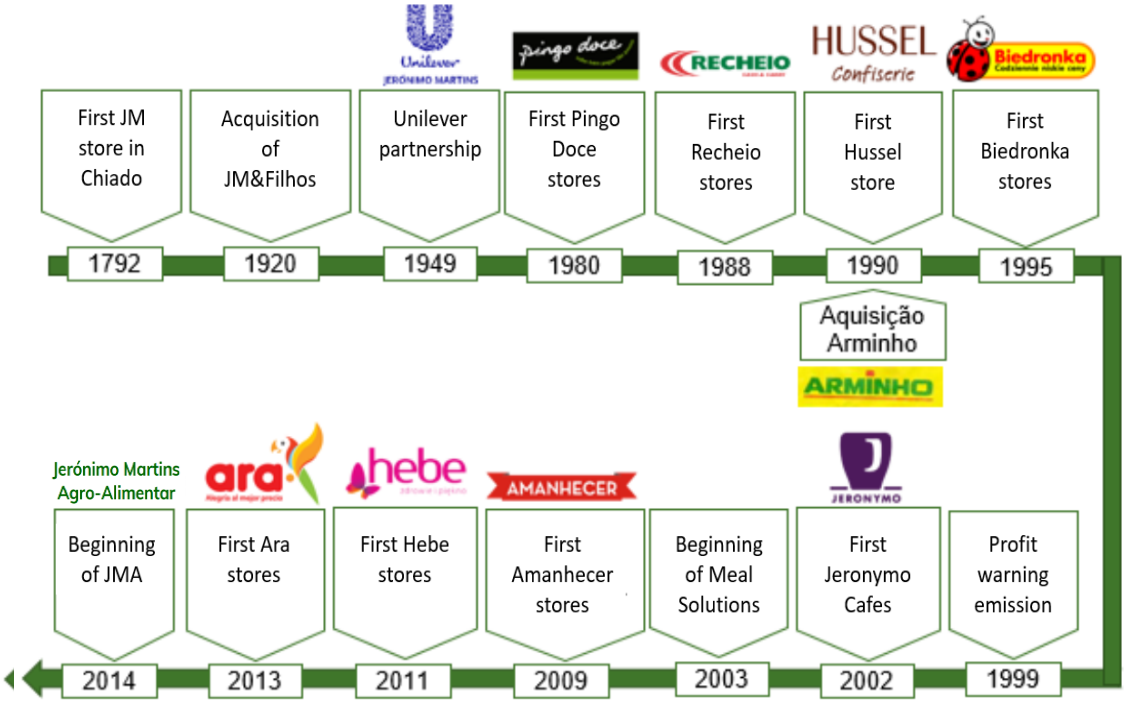

Figure 4 - Chronogram of Group JM most historical moments (Fialho, 2020)

Through the historical background, it can be verified that the investments made focused eessencially in diversification and expansion and were significantly supported by partnerships or acquisitions, making JM more capable of guaranteeing the required know-how and resources to successfully implement its strategy.

4.1.2 Market Positioning

According to the annual report "Global Power of Retailing" developed by Deloitte, the Group Jerónimo Martins has maintained its 50th position worldwide, compared to the previous year (Deloitte, 2021). In Portugal, JM is listed in the PSI-20, being considered 1 of the 18 most valuable companies in the Lisbon stock exchange market. Today's market leader in the food distribution

sector is SONAE MC with 26,8% (-0,9% compared to 2020) of the market, while JM has 22,9% (-1,4% compared to 2020). Despite these two companies have a strong position compared to the remaining retailers, COVID-19 has made Lidl and Intermarché win a small portion of the market share of the leaders, increasing 0,6% and 1% respectively (Rita Gonçalves, 2020). In Poland, Bierdronka is the clear market leader with 25,7% of market share.

The Group JM has been consistently growing in sales, mostly due to the expansion strategy implemented of increasing the number of locations (Figure 5). Due to COVID-19 pandemic, the level of economic uncertainty increased, which led to a small decrease in sales in 2020.

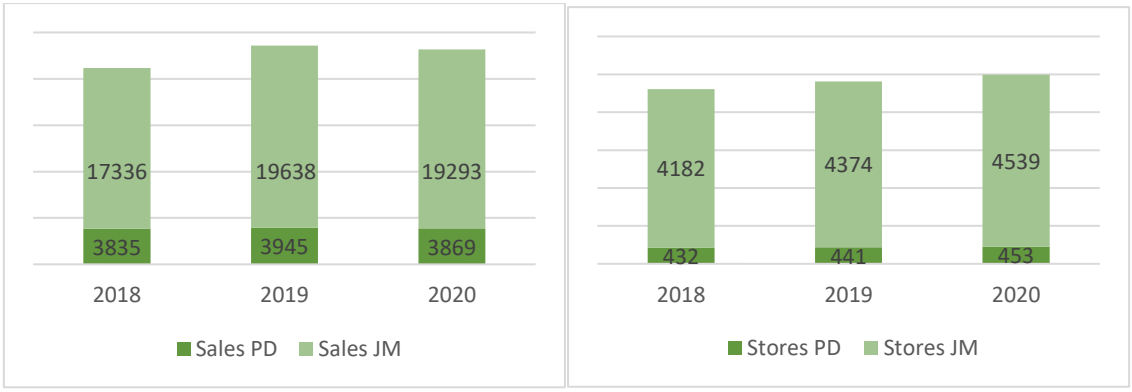

Figure 5 - Sales (in millions) and number of stores of PD and Group JM

Food distribution and specialized retail are the two main activities in which the Group JM is the most specialized, although the first one contributes for 98,6% of the sales (JM, 2020), Pingo Doce, Biedronka, Recheio and Ara are the ones operating in this area. Nevertheless, JM has been investing, since 2014, in the food industry with the creation of JMA. With this company, the Group can better assure the supply needed, guarantee that the processes operate according to legislation and with good practices, and it is another level of the SC in which the Group can present profitability.

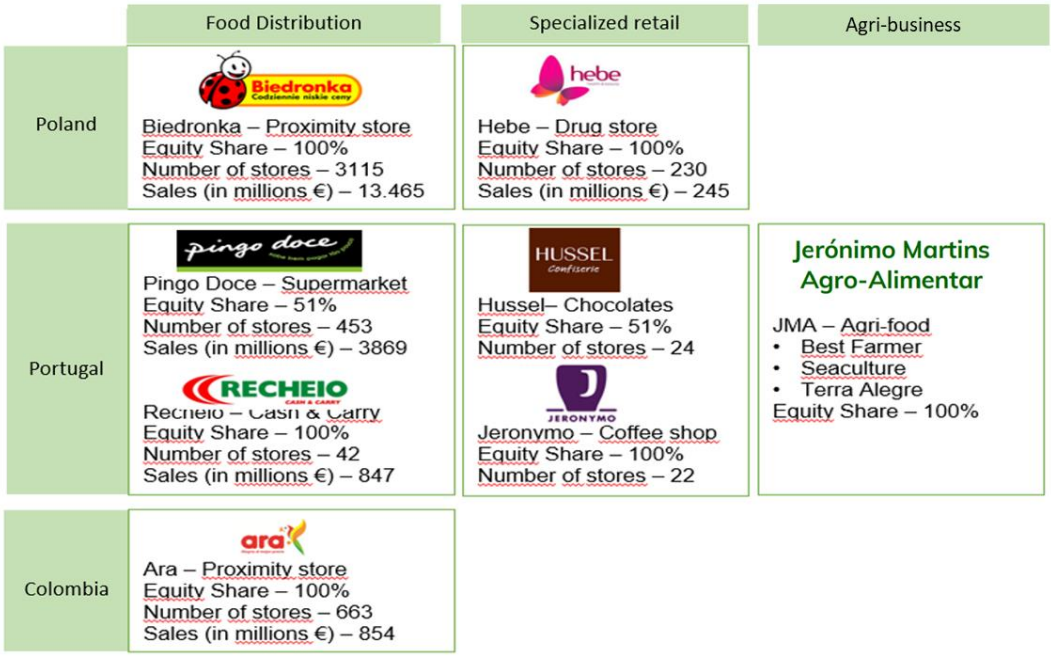

Figure 6 - JM businesses portfolio

For a better understanding of the present structure of the Group JM, Figure 6 includes the different companies that are part of the group, in which market they operate, the sales volume of each company and respective number of stores, JM's share of each company and in which area they operate.

As can be verified in the figure above, Biedronka represents 69,8% of the total sales volume of the Group JM, followed by Pingo Doce with 20,1%, and Recheio and Ara with 4,4% each, which means that the market that most contributes to the sales volume is Poland. On the other hand, it was invested 470 million € where 64,3% was destined to Biedronka; 19,4% to Pingo Doce; 7,9% to other businesses such as JMA, Jeronymo and Hussel; 6,3% to Ara; and 2,1% to Recheio. According to the sales contribution and allocated investment, one can observe that JM invests in the businesses that mostly contributes to the sales volumes, Biedronka and Pingo Doce. On the other hand, the investment in the category "other businesses" has significantly increased compared with previous years because of the investment allocated to JMA in order to increase production capacity and resources.

Pingo Doce sells four types of food products: groceries, drinks, specialized and non-specialized perishables. Specialized perishables, which is the category most responsible for the FLW generated in the SC, integrates F&V, bakery/pastry, fish, meat, take-away, cod and products destined to restaurants. These products are characterized by having short life cycles, meaning their quality and value reduce very fast, leading to high rates of FLW. F&V are divided between bulk and processed. The first does not have an expiration date, while the second ones are submitted to a transformation process, where they are given a certain expiration date.

Meal Solutions and white label brands are two of the many strategies used by Pingo Doce to help the growth tendency of sales to be maintained. Innovative, differentiated products are developed to attract new customers that are present in different segments. The market tendency to become healthier contributed to the appearance of new meals and brands that include bio products, produced sustainably.

According to Costa (2016), 23% of the Portuguese eat away from home, and 15% uses home deliveries or take away services at least once a week. Taking this into account, Meal Solutions becomes a cheap option for consumers that want food ready to eat, both from the premade meals and meals in PD restaurants. Recently the strategy changed and the kitchens were centralized. With single kitchens supplying large regions, homogeneity is guaranteed in the different products produced. In 2018, Meal Solutions produced 10.000 tons, which represents 5 million meals and 3% of the sales of PD. Christmas and Easter are the holidays in which more meals are produced and sold and sales have increased 42% compared with the previous year (Costa, 2016). PD is the only supermarket chain in Portugal that owns centralized kitchens.

A study states that private labels tend to grow three times faster than manufacturer brands (Cadent Consulting Group, 2018) and, according to the "Grande Consumo" magazine, it has already reached 45% of market share, in Portugal (Grande Consumo, 2021). These numbers justify why JM has been strongly investing in developing white label products. In the first semester of 2016, private label products represented 34,5% of PD sales and it's expected to grow. The

process of developing a JM product starts by creating a strategic plan based on a consumer profile and consumption tendencies in the market where the stores are inserted in; Then, suppliers are searched to achieve the quality desired for the product; After that, the quality board evaluates the proposals given by the suppliers; Then, the product is tested closer to the target consumers; The next steps are the design of the package and the approval of the product; At last, after going through this process, the product reaches the shelves of the stores. The consumer profile is crucial, because the consumer preferences change between markets and businesses. Therefore, Recheio and Pingo Doce have different private label brands in their stores. While Recheio is focused in supplying companies present in the HORECA channel, which means having products with larger volume, PD aims to sell to the final consumer, where the focus is to provide quality products with low prices. The effort PD has dedicated to the development of quality white labels products has already been recognized by being considered two years in a row the favourite white label brand of the Portuguese people, according to the annual study developed by a GFK, a company that develops market studies (Silva, 2019).

4.2 Supply Chain

This sub-chapter aims to provide a more detailed overview of JM supply chain. The operations of different stages of the SC will be described, as well as the stakeholders involved. There is a principal and a secondary flow of products, and a third flow responsible for the collection of FLW for its valorisation, which is outsourced (other materials are also collected but only organic products are being considered) (section 4.3). The main flow integrates Suppliers (Section 4.2.1); Distribution Centres (DC) (Section 4.2.2); Transports Department (Section 4.2.3); and Pingo Doce Stores (Section 4.2.4). The secondary flow integrates the previous stages mentioned plus the central kitchens (Section 4.2.5). While the principal flow is associated with the products seen in the shelves of the stores, the products in the secondary flow are transformed before reaching the store, to the take-away or the store's restaurant.

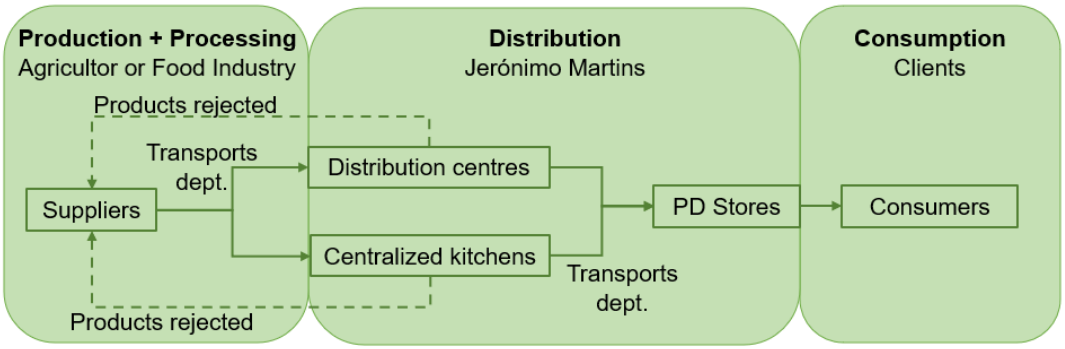

Figure 7 - Generic flow of F&V products in the SC (Fialho, 2020)

Since the SC is long and requests many stakeholders, JM has to assure an efficient and effective flow management, from the suppliers to the stores. To do that, JM has the Logistics and the Supply Chain department, which are responsible for the efficient integration between the stakeholders so that the products are delivered in the right time, location and quantity. In Portugal, these departments are divided in three: North, Centre and South regions. Each region is

responsible for supplying the stores in the respective area. While the SC department is focused on non-perishable products, the Sourcing department is focused on some of the specialized perishable products, such as F&V and meat. This department is responsible for supplying the stores according to the stores' orders. Therefore, it is responsible for negotiating with suppliers and it also states the price to apply in the stores. Some products are negotiated through an auction-type deal, where the different suppliers can see the quantities and prices offered by the competitors so that they can update the offer. The final word comes from the Sourcing department, which means that the lower price can be overruled by a more expensive offer.

The main challenge that these departments face is to minimize the time and cost variables, while maintaining or increasing the customers' service level. In the Logistics department, 45% of the total costs is allocated to the Transports department, and the time from the supplier to the store changes along with possible delays of the suppliers or transportation companies.

4.2.1 Suppliers

JM publicly established goals of reducing their FLW generated in its SC operations. For that, suppliers must be aligned with the company's objectives. For example, the Sourcing department of F&V have four criteria for the selection of eligible suppliers: product quality; trust; supply capacity; and sustainable practices. Every supplier that fulfils these criteria and is asked to supply JM stores, has to deliver the quantity previously agreed in the timetable established, complying with the specifications – brix, packaging, labelling and calibre. If these aren't met, JM can refuse to receive the products and even seize the contract with the supplier.

In 2020, the Group JM registered 89% of its products being supplied by local suppliers, with Pingo Doce and Recheio together registering 82%. The Portuguese market is the one with the lowest value partially justified by having 35% of the private label products supplied from non-local suppliers (JM, 2020). On the other hand, around 95% of the Pingo Doce F&V suppliers are from local suppliers (JM, 2019). These values show the importance given by the Group on supporting local communities, which aimed to have at least 80% of its products supplied locally. One reason that leads to have non-local suppliers is the seasonality of some products, such as F&V, which makes the Group resort on importation. The imported products can reach the JM stores through direct contracts with foreign suppliers, although a local supplier can also be the one to reach to the foreign supplier to buy the product it and reselling them to JM.

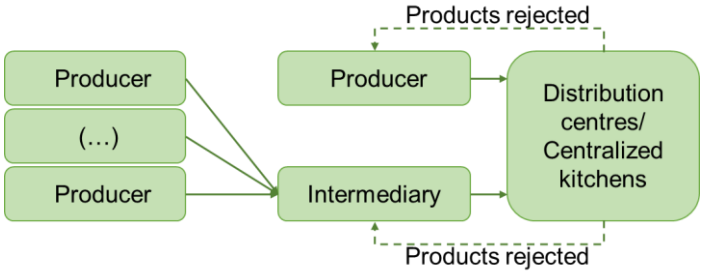

Figure 8 - Working process according to type of supplier (Fialho, 2020)

There are two different types of suppliers: producers and intermediaries. Producers focus on its own production. On the other side, intermediaries, which represent the majority of suppliers of

F&V, have partnerships with other suppliers that supply the produce. Intermediaries might have its own production or not. Usually, producers supply intermediaries because these cannot supply the quantities asked by JM, or are not able of fulfilling the packaging and labelling specifications that the products must have. Figure 8 shows the flow of produce, according to the type of supplier.

4.2.2 Distribution Centres

The DCs are where the merchandise is centralized and consolidated. This stage of the SC allows JM to receive the different products from the respective different suppliers and to consolidate the orders of each store. DCs can have different warehouses, according to the products specifications. Despite having eight DC, JM only has three warehouses to deal with F&V: Alfena, Azambuja and Algoz, to supply the north, centre and south region, respectively. Depending on the product in question, the temperature required might change, as can be seen by the F&V that must be kept in a temperature between 6ºC e 12ºC, while dairy products must be stored between 0ºC e 4ºC (Annex – Fig. B1). Excepting the non-perishable products, Just-In-Time (JIT) is the flow used in every product in JM's SC – where most products are not kept for more than 24 hours in stock. With such model, it is used a Push strategy – where JM intends to take the products to the consumers independently of the orders – with daily rotation of products. This is the most fitted strategy for perishable products. The non-perishable products have stock in the warehouses, working with a Pull strategy – where products are sent to stores to balance their stock based on orders – and present relatively low rotation.

Every DC has four main steps for dealing with the products: creation of a buying order; reception of the products; execution and expedition. While the first step is responsibility of the Supply Chain/ Sourcing department, the remaining steps are responsibility of the workers on the warehouse in which the product arrives. Depending on the warehouse, the daily cycle of operations might change. Looking to the F&V warehouses, the reception of the products is made between 6h and 21h. These must be verified by the Quality Control department to assure that the specifications are fulfilled. After receiving the products, these are allocated to each store according to the respective orders previously made. After executing the orders of the stores, the pallets are vita filmed and allocated to gates where these will be put in trucks and taken to the stores. The expedition phase starts at midnight and ends at 6h. In the F&V case, products are rarely removed from the stores to be returned to the warehouse. This only happens when there's a recall of merchandise and it is required to remove the product from sale because it might be inadequate for consumption.

4.2.3 Transports department

The Transports department is responsible for the routing of the products from the DCs to the stores. It is focused in optimizing the routes according to the stores' orders, minimize associated costs, and deal with the delays that the transporters might incur. To analyse such objectives, the department uses the following Key Performance Indicators (KPIs): number of cases transported per pallet; number of pallets transported; deliveries punctuality; occupation and utilization rate of

the trucks; distances travelled. Nowadays, the routing is partially developed by a software called Routyn TMS, where destinations, orders and rules such as schedule limitations and truck capacity are introduced and it returns a suggestion of routes to deliver the orders. Since the program isn't fully implemented and is still under study, some modifications are made by hand by the workers of the department to have a more efficient solution.

Usually, the stores start by receiving F&V and fish in the morning, then receive the products from the Fresh warehouse, that include the dairy products, meat and processed meat such as ham. Afterwards the stores receive the non-perishable food and non-food products. Therefore, each store receives partial deliveries of the order. This occurs due to the temperature specifications that each product must comply. Since each truck carries mostly products from one warehouse, there are two types of paths that are used. The first one (A) is used mostly by hiper-markets, when a store has ordered enough quantity to reach at least close to a full truckload. On the other hand, when stores order small quantities compared to the full capacity of the truck, it is added to the route other stores (B). The two paths described concern the delivery to the stores, nevertheless, there is a third possible path (C) that includes a backhauling process, which is used to monetize the return of the truck to the DC. This occurs when the route of the truck ends nearby a supplier. This process has been increasing in the latest years in the Group's operation, and in 2020 has avoided 13.011.000 km travelled, resulting in a saving of 11.948 ton CO_2e (JM,2021), just in Portugal.

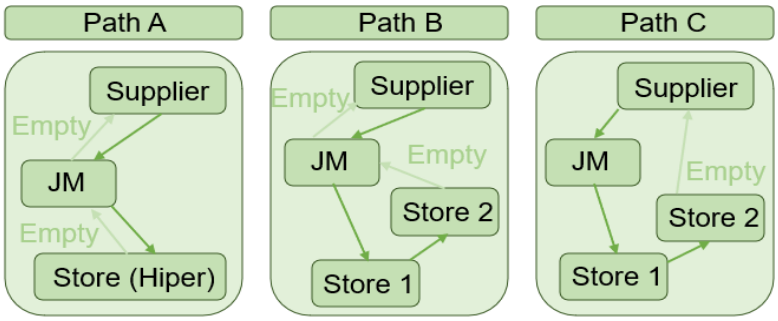

Figure 9 - Types of path transports department can arrange

Transportation of merchandise is not the Group's core business, therefore it is an outsourced activity. JM has many partnerships with transportation companies, seven of which have a fixed contract: TFS; ZAS; Paulo Duarte; Oscar; Fundatir; TPCF; Edgar&Prieto. However, ZAS has an Open Book contract, which means that JM pays for the costs of the transportation if the company gives full availability of the trucks for JM's activity. With these partnerships, JM has a 350-truck fleet, with different capacity and refrigeration specifications. Around 140 trucks are fit to transport F&V, and fish which is transported simultaneously with F&V. Other companies might be contracted to give an extra transportation capacity, according to the needs of the company.

4.2.4 Pingo Doce Stores

Pingo Doce stores have been increasing in the latest years, having reached a total of 453 stores in 2020, mostly covering the big cities in the centre and north of the country. This unbalance of stores verified in the south has increase the difficulty of JM to negotiate direct deliveries from the

suppliers to Algoz, the DC responsible for the distribution in the South of Portugal. Such is justified because most suppliers' orders do not reach full truckload, making the delivery less profitable for them. To deal with such obstacle, JM resorts to Transhipment. The products are delivered by the suppliers to one of the DC in the Centre region and JM delivers them to the DC in the South region. To minimize the unbalance and enhance the appearance of new PD stores in the South region, JM has adopted a franchise model, where the Group takes a creditor position and shares the profit with the franchised.

There are three types of PD stores: Hiper, Mega and Supermarkets. These differ according to the size of the store, the products assortment and storage capacity. According to the type of store, there is a predefined assortment of products that the store should have available, although it is the store manager that is responsible for ordering the products and respective quantities. For the perishable products, such as F&V, the priority is to present quality products in the store, and assure that the products with higher turnover are always available.

4.2.5 Central Kitchens

The kitchens are integrated in the Meal Solutions business and it is where the meals offered in the Take-away and restaurants are prepared. There are three kitchens - Gaia, Aveiro and Odivelas -that prepare the meals in the Hipermarkets and Megas, which are the ones that offer prepared meals in their assortment. The kitchens mostly prepare soups (15 tons/day), main courses (12 tons/day) and desserts (2 tons/day), although they also offer courses from a menu with recipes developed with a partner chef, which have to be ordered previously and then picked at a store of the customer's choice. The volume of food prepared reaches its highest in the Easter and Christmas holidays. The kitchens incorporate the secondary flow of merchandise of JM SC and are supplied mostly by the same suppliers as the ones present in the primary flow. Although, due to the quantities needed, they receive bigger formats of the products, similarly to the HORECA channel, to minimize the preparation time.

The kitchens' operation starts by defining the menu, which is responsibility of Chef Vítor Esteves. At this stage, the recipes are tested and the courses selected are scheduled to have an adequate orders' planning. The remaining steps are completed by the teams working on the kitchens, starting by receiving the merchandise. In this step, there is a verification of compliance of the specifications required, although it is more complexed than in the DCs since it receives different types of products. After receiving the products, some are put in stock, while others, such as F&V, are dealt with according to a JIT model, which means that these are utilized in the same day of reception. Nevertheless, between the reception of products and the next step, the preparation, the products are held in refrigerated chambers. At 10h, it is available in the informatic system the set of courses that are planned for the day. Along with the courses, it is available the set of instructions that must follow, including the tasks and respective quantities. The preparation phase of F&V tends to be shorter than the confection phase since some products are received already cut and washed. The confection is made following a strict recipe with detailed temperatures, duration of cooking and quantities. After the confection phase, the large doses cooked are packed

in smaller doses, as the ones that can be found in the stores. After the packaging, the end products are held in low temperature until they get shipped and sold to the consumer. With this process, the food can achieve five days of lifetime. The end products of the kitchens are shipped to the DCs, where these will be put together with the rest of each store's order in the Fresh warehouse.

When products do not have the desired look or portion, these are distributed to the employees or given to charity. Odivelas' kitchen collaborates with ReFood to redistribute products that are in perfect quality conditions but are not fit for sale. ReFood is a social organization that redistributes prepared food donated by restaurants and other businesses that overproduce meals. On the other hand, kitchens have a system that acknowledges which products in stock are close to the expiration date and notify the operator that a certain batch should be used to avoid it to go to waste.

4.3 Food Loss and Waste

With the increasing concern towards sustainability and food security not only from consumers, but also from the company itself, the Group JM has developed several practices and initiatives to deal with FLW in terms of prevention and valorization. Aligned with Champions 12.3, JM intends to halve the FLW generated in its processes until 2030. Besides this goal, JM also targeted to reduce the amount of a maximum of FLW to 16,1 kg/ton of food products sold until 2023. Considering the year 2020, 85,8% (+1% compared to the previous year) of the total waste generated went through recycling and other valorization methods. Despite the amount of waste has increased, this is due to the increasing sales of the Group as it can be confirmed by the decrease of the ratio between the total residues divided by millions of euros of products sold (from 27,83 ton/M€ to 27,03 ton/M€) (JM, 2021).

JM uses the Food Loss and Waste Protocol (JM,2020) methodology to measure and report the FLW in its SC. The 10 steps that compose such method are integrated in JM approach to deal with FLW as follows:

1. Define goals – JM measures and monitors the FLW generated in its activities to analyse the causes of such generation and search for possible measures that enhance its minimization;
2. Review accounting and reporting principles of FLW;
3. Establish scope – In the Figure 10, JM establishes the scope considering the following criteria:
    1) Timeframe – JM considers the annual period for the accounting of FLW;
    2) Material type – JM considers edible and inedible parts of animal and non-animal products as FLW;
    3) Destinations – JM takes into account all applicable destinations types and aggregates them into three different levels: (1) compost, controlled combustion and anaerobic digestion, contributing with 61% of the FLW valorised; (2) landfill,

incineration and water treatment correspond to 24,2%; (3) animal feed and biological processing are responsible for 14,8%. (JM, 2021)

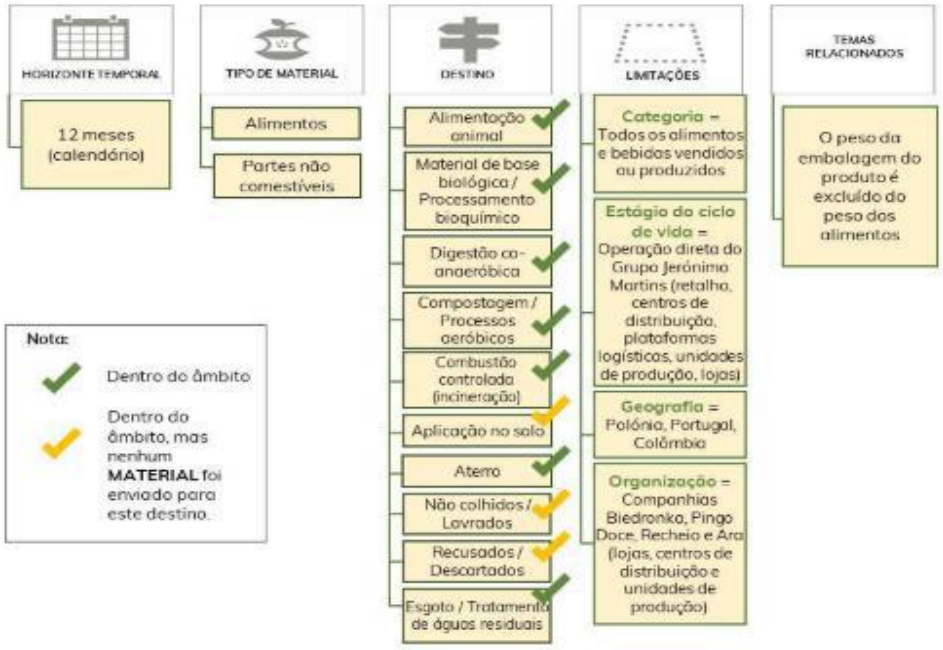

Figure 10 - FLW scope for Group Jerónimo Martins (JM, 2019)

4) Boundaries – JM considers every food or drink products sold or produced in the direct activities of the Group, which means that it is only taken into account the production and distribution sites, stores and distribution platforms that are full responsibility of JM. This means that only part of the product lifecycle is considered. Includes all countries (Poland, Portugal and Colombia) where JM has operations.

4. Describe the quantification methods used – For the FLW calculation, unknown losses are added with the known losses based on shrink records. Unknown losses are quantified by the SAP ERP system that calculates the value through the difference between the stock plus sales and the purchases values (Eq.1), When there is no wastage, the difference is zero. Although, when it is negative, it means that there is a wastage verified equal to the module of the negative value. There is still the rarer scenario, when the difference is positive, which can occur due to labelling errors or stocks miscalculation.

$$Wastage\ (Kg) = Stock(Kg) + Sales\ (Kg) - Purcahses(Kg) \qquad (Eq.1)$$

Operational losses can be either known or unknown depending on the motive that led the merchandise not being commercialized. Operational errors that justify lost merchandise - due to theft, labelling errors, weight changes, amongst others – corresponds to unknown wastage. On the other hand, known losses corresponds to identified merchandise that do not fulfil the required specifications – contaminated/damaged packaging, merchandise close or past the expiration date and “ugly” products.

5. Collect and analyse data – When analysing the operational losses, donations and other situations not generating FLW are not considered, neither when the loss value is positive.
6. Calculate FLW stock results, considering the respective uncertainty.
7. Assess uncertainty – Since not every product has its liquid weight labelled, JM resorts to approximations. Nevertheless, the uncertainty has been decreasing being around 6%, while in previous years was considered 11% (JM, 2019).
8. Revise – Whenever required, due to setting new targets or when tracking the amount of FLW, a new base year needs to be selected and its FLW inventory calculated.
9. Publish FLW inventory – Annually, JM publishes a report about the ten stages of this method with the respective results. The KPI most used to analyse FLW is the weight of food waste (kg) divided by the weight of food sales (tonnes).
10. Goals setting and monitorization – JM aims to halve FLW until 2030, facing 2016. There is also an intermediary goal established, to maintain FLW into a maximum of 16,1 kg of food waste/ton of food sales

According to the methodology, JM has been registering an increase in FLW in the latest years, reaching 16,9 kg/ton of food products sold in 2020. Such increase is mostly justified by the increase of sales of perishable products (F&V, bakery/pastry, take-away, meat and fish).

As it can be seen in the Figures 11 and 12, PD registers the highest unbalance between the FLW generated and the number of stores, justifying the development of this dissertation. On the other hand, Biedronka and Ara generate a lower percentage of FLW, considering the number of stores associated.

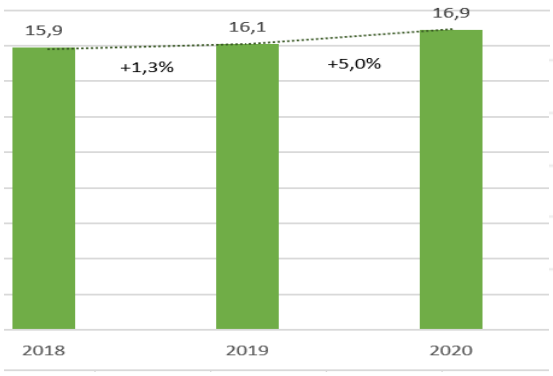

Figure 11 – JM's FLW evolution (kg/ton of food sold) (JM, 2019)

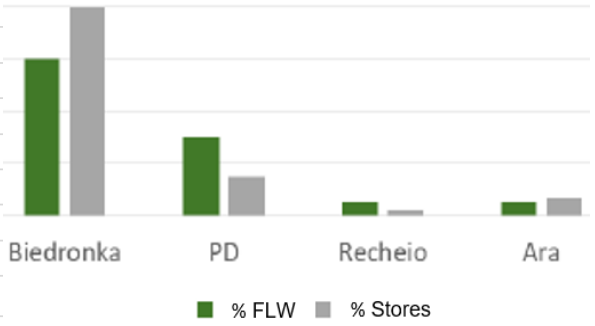

Figure 12 – FLW and number of stores distribution per insignia (Albuquerque et al, 2018)

Due to the evolution of FLW generated by JM operations, essentially by PD, it is intended to analyse and minimize the FLW in JM's SC. However, since the information on the suppliers' level is not available, the focus of this dissertation is on the direct operations of the Group. FLW is an important matter for the Group, since it can be hindered monetarily, environmentally and reputationally. Therefore, it will be analysed the causes that generate the FLW in terms of (1) Stage of the SC (section 5.3.1) and (2) Type of product (section 5.3.2).

4.3.1 Food Loss and Waste by Stage of the Supply Chain

In Portugal, the stages that most contribute to FLW are the production and distribution. After having visited some of the infrastructures along JM SC: one of the biggest F&V supplier; warehouses; PD stores; and central kitchens, it can be concluded that the higher rate of FLW is generated in the suppliers and PD stores. Since there was a direct contact with different stakeholders from different stages of the SC, Figure 13 explicit the main reasons for products being taken from the main flow. Suppliers and stores are the stages that present a higher variety of justifications.

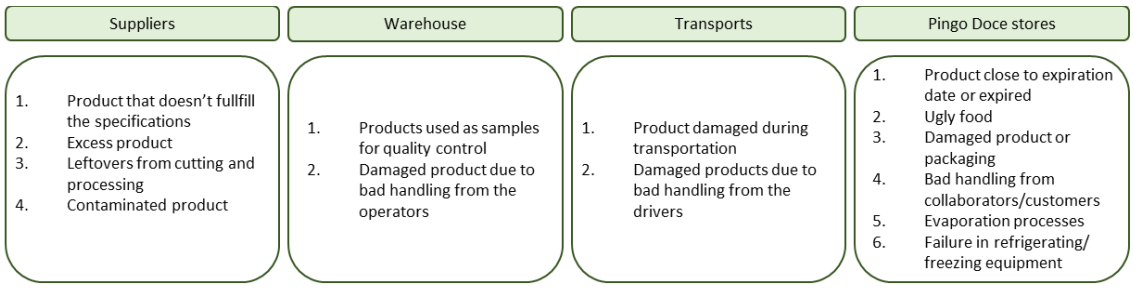

Figure 13 - Main causes that lead to FLW in the main flow of the JM SC

For the F&V suppliers, it is very difficult to control the output of the harvests, which means that most of the FLW incurring in such stage is due to the unfulfillment of the products' specifications required. When products get rejected at the warehouses or centralized kitchens, the suppliers have to support the transportation cost of the return of the products. Overproduction is the other main reason for FLW, since the suppliers' priority is to assure the delivery of the desired quantities in the desired conditions to their customers.

In the warehouses, the FLW is very reduced since the products are checked to understand if the specifications required are fulfilled before they are received. Since the warehouses work in a JIT system and the products are kept in the warehouse less than 24h, there is not much time for the products to lose quality and lead to Loss. With the JIT system, it is verified a Push strategy in the stores, which contribute for higher rates of FLW in the stores. Therefore, the FLW verified in the F&V warehouse is mostly due to quality control and bad handling from the workers.

In transports, the companies that take the products from one stage of the SC to the next, or when doing transhipment, have to guarantee that the merchandise reaches its destination in the same conditions as when it was shipped. When this does not happen, the transportation company must pay JM for the FLW generated. Such FLW is mostly caused by dangerous driving or bad handling from the drivers.

In PD stores, the FLW generated is mostly caused when there is a mismatch between supply and demand. The gradual degradation of the products displayed leads to a decrease of quality which makes them less attractive for the consumers. The inefficient replenishment of the store can also cause FLW.

In the secondary flow, where the central kitchens operate, the waste generated is low since they also operate in a JIT system and the merchandise received is previously checked to assure these fulfil the specifications require. Therefore, the reasons that mostly justify the waste generated are

the operational errors of labelling and packaging, as well as human errors in the confection and preparation stages.

It can be difficult to allocate responsibilities on the generation of FLW in the SC, since this is one of the indicators that evaluates an entity's performance. Therefore, one entity should only receive merchandise after confirming it fulfils the quality requirements. That is why the reception of merchandise is a critical step for JM, since the FLW that can be generated after the reception of the products is the Group's responsibility, which makes it crucial to have the Quality Control department verifying the incoming merchandise before receiving it. On the other hand, suppliers have easier ways to valorise the FLW incurred than JM, which makes it preferable that the FLW generated is the supplier's responsibility rather than JM's.

4.3.2 Food Loss and Waste by type of products

In this section, it is analysed the relative weight of FLW of the different type of products available in PD stores. In a first stage, it will be analysed the four areas of food products: Specialized perishables; non-specialized perishables; drinks and grocery. As can be seen in the Fig. 14, the specialized perishables is the product category that contributes the most for the generation of FLW, in which the F&V are integrated. Later, it will be analysed the weight of the different products that compose the specialized perishables category. The data used is extracted from an Excel file with the products and respective weights that result into FLW in PD stores in 2018 (Albuquerque et al., 2018). The values are calculated using the net weight of the products and these are exposed as percentage due to confidentiality motives.

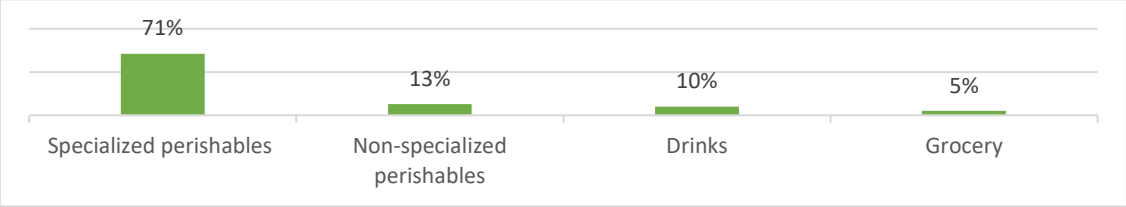

Figure 14 - FLW by food product in PD stores (Albuquerque et al., 2018)

In PD stores, the specialized perishables products are composed by F&V; Pastry/Bakery; Butcher; Fishery; Take-away; Cod; Restaurant. It is therefore relevant to understand how each of the seven types of products contribute for the FLW generation through the net weight of the products. As can be seen in Figure 15, F&V contribute the most with 48%. On the other hand, products from butcher and fishmonger contribute with 15% and 8%, respectively. These lower values are justified by a more stable demand and more efficient stock control. Also, because these products tend to be more expensive, allowing PD stores to react with promotions when demand decreases.

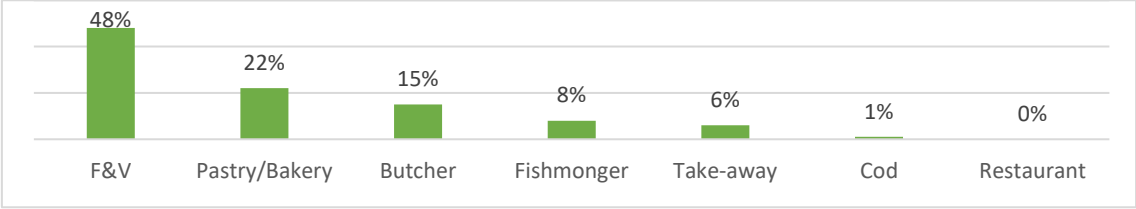

Figure 15 - FLW in specialized perishables in PD stores (Albuquerque et al., 2018)

In the F&V category, the products sold in bulk represent higher rates of FLW than processed products, since products in bulk do not have expiration dates. This leads to more subjective processes by the workers to analyse its quality and if it can be kept for sale or consider it waste. With this analysis, it is concluded that F&V are the products that most contribute for the generation of FLW in PD stores.

4.4 Processes for Prevention and Valorisation of Food Loss and Waste

JM has established a hierarchy of preferable valorisation destinations for its FLW (Annex – Figure A1) to enhance a better distribution of products: animal feed and biochemical processing/natural based materials (15%); codigestion/anaerobic digestion, compost/aerobic processes and controlled combustion (61%); landfill and sewer (24%) (JM, 2019). The first step in dealing with FLW is to analyse if it fulfils the food security criteria. If it does, the products are donated, as it happens with products close to the expiration date, “ugly” products or products with incorrect labelling or packaging. Products destined for donation are dependent of the interest of institutions to receive them or their availability to collect them in the stores, warehouses or centralized kitchens. The institutions are previously certified by the Group in order to guarantee the correct destination of the products following legal requirements and the Group’s environmental policies. In 2020, donations increased 19% compared with 2019, reaching 18.900 ton. Since 2015, that the quantity donated has been increasing, having almost doubled. (JM,2021)

JM’s priority is to recover the FLW generated and, if possible, with financial return. The waste management done by JM intends to valorise and reduce the FLW with alternative processes that decrease the amount of natural resources.

The next chapter intends to explore the processes developed along the JM’s AFSC to deal with the FLW generated. Since the stages in which FLW generated is higher are in the supplier and distribution phases, the processes that suppliers (section 5.4.1) and stores (section 5.4.2) developed are the ones addressed and described.

4.4.1 Suppliers’ Processes

After visiting one of the largest JM suppliers of F&V, Luís Estevão Salvador, it can be verified that some processes are already implemented to reduce and valorise the volume of FLW generated:

- Technique improvements – Investment in technical support to obtain information, considering agricultural knowledge and demand, on what, when, how much and how often to plant a certain product.
- Investing in infrastructures – Development of large refrigerated storage places that allow the company to keep stock for longer periods of time.
- Reprocessing FLW – Supplier searches for alternative destinations for FLW to obtain financial return. The products must guarantee food security, which most do, although they do not fit the required specifications imposed by the retailers. The most common flows are defined as follows: (1) supplier receives the inputs (F&V) and part of these products fulfil JM’s specifications and are transported to JM facilities.; and (2) if the products do

not fulfil the requirements, these are subject to a reprocessing stage to create new products such as soups, juices or processed F&V. Other alternative is to sell the products to other stakeholders, such as centralized kitchens or cattle suppliers.

Some alternative destinations that JM suppliers have developed and implemented are as follows:

- Processed F&V – This alternative emerges from the transformation and processing of products that were firstly destined to be sold in bulk. These products are sold to the consumer ready to be consumed – 4th range products - after having been washed, cut and packaged.
- Central kitchens – Kitchens use processed F&V to produce their meals. However, food loss in F&V products in bulk can be used to produce meals. This alternative allows the kitchens to reduce their material cost in 11,6% and allows the suppliers to increase their sales. For example, all french garlic and some types of cabbage, 65% of the courgette and 70% of green beans that are used in processed F&V to produce soups, do not fulfil the retailer's specifications.
- Soups and Juices – Despite not being part of the SC of F&V, these products result from the transformation of F&V. This alternative emerges as a solution for suppliers to diversify their activities while valorising losses.
- Secondary Market – When the alternatives enumerated cannot be a solution for the losses incurred, the suppliers try to sell their products to other retailers with less demanding specifications. For example, suppliers can sell the products for valorisation companies or to cattle producers, including JMA. JMA contributes with measures that reduce and prevent FLW. Subproducts and products not calibrated are bought from suppliers of the food industry to use as animal feed. This measure was firstly introduced in 2018 and has been increasing significantly, reaching 10.800 ton in 2020. This quantity represents an increase of 20%, facing the previous year. On the other hand, the usage of "ugly" F&V for processed products has been stable in the last 5 years, making the quantity used by JMA becoming closer to the one used by the companies of the Group in the distribution sector.

Despite being the supplier choosing the alternative to apply, JM intends to have a proactive position in enhancing a valorisation approach by the suppliers. Therefore, JM takes into account how sustainable a supplier is and works alongside them to develop private label brands with the companies that have such processes implemented. The initiative of using "ugly" products in processed F&V has been one of the most prevalent in JM valorising methods, having reached 13.300 ton, just in 2020 (JM, 2021).

Nevertheless, there are suppliers that do not have the required infrastructures to meet the specifications required by JM. Smaller suppliers that fit in this category tend to use intermediaries that can guarantee the match with the retailers' specifications.

4.4.2 Stores' Processes

The highest amount of FLW in JM direct activities is generated at the stores, which means that it is a priority for the Company to reduce it. Therefore, it is asked that the workers always perform the following monitorizations:

- Stock control – Keep track of expiration dates, products quality and stock rotativity; Implementation of FIFO or FEFO systems depending on the type of products.
- Shrink control – Keep track of products with lowest and highest shrinks; Values of shrink.
- Sales control - Keep track of least and most sold products; Sales seasonality; Shopping periodicity; Quantities sold per sale.
- Breakage control – Keep track of the products with more and less breakages; Values of breakages.

With these monitorizations, employees can have a better understanding of the business, making them more capable for planning the store's needs and respective replenishment. The goal is to achieve a balance between orders and demand, where there is no lack of products, without keeping much stock. To achieve this goal, JM has developed processes to reduce FLW in the stores, such as:

- Educating employees – Train employees in the "Escola de Formação JM" about the issues of each product category; the perishability and rotativity of products; Identify plagues and moulds; How to replenish each product; daily screenings; …
- Develop products – Create a department in store called "Atelier de fruta" focussed on donating F&V with flaws, to remove the bad parts of the products and enhance its purchase. Enhance the tasting of F&V so that consumers can try a product with lower visual quality, increasing awareness that "ugly" products can taste as good as the "pretty" one.
- Infrastructure investment – Create circular expositors to provide the customer an easy and equal access to every product, leading to lower risk of damage.
- Review promotions' policy – When products' expiration date is close, products are put in promotion, with a price reduction, to reduce losses. The discount is pre-established and depends on the type of product. This process is called Markdown and has avoided 4.700 ton of different products going to waste, just in 2020 (JM, 2021).

A precise stock control by the employees is crucial for most of these processes, to, in a timely manner, identify which products should be allocated to each operation.

An effort to have a better management of the products that cannot be sold has also been done, as well as measures that prevent FLW generated at the households, such as:

1. The bread that despite not being possible to sell, it can be grated and sold as breadcrumbs or used for some take-away products such as breaded meals. This initiative avoided 187 ton of food to go to waste.
2. Products like roast chicken and piglet that are not sold in time, but are in perfect conditions for consumption, can be shredded and used in salads and pizzas, or even in sandwiches sold in the take-away or in packages as shredded chicken or piglet. This measure avoided 104 ton of product going to waste, with the chicken contributing with 94%.

3. Fruits with large size such as watermelons, melons and pineapples are cut in half so that it becomes more attractive for consumers to buy, because it becomes cheaper and allows the consumer to take just the quantity desired. This method leads to smaller amounts of FLW both in the household and in stores.
4. In the private label brands of Pingo Doce and Recheio, there has been an effort to adjust the size of the portions and packages so that waste in the household can be prevented.
5. Pingo Doce developed a book called “Zero Waste at the Table” that provides information and recipes that encourage people to use leftovers; techniques that improve how food is stored; and educates how expiration date labels should be interpreted.

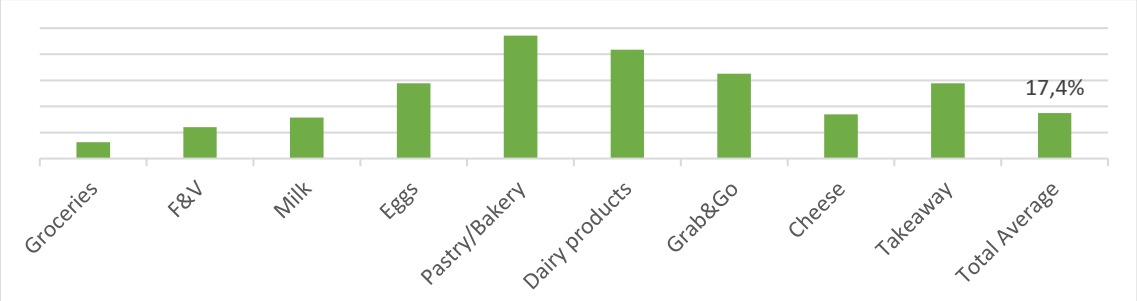

Figure 16 - % of food products sent to donations

Figure 16 was developed, where it can be analyzed the percentage of food products that is sent to donations, due to not fulfilling the requirements to be fit for sale, in each category. Due to confidentiality issues, the values stated are not real, but approximate. It is verified that PD stores register higher donations for bakery/pastry and in dairy products. F&V register a lower value since this type of products do not have expiration date and are subject to the subjective screening of employees and many times these products are not safe for human consumption. The overall donation rate of PD stores is 17,4% of the total FLW. This rate is smaller than JM intends, however there are regulations and conditions that must be fulfilled before the products can be accepted for donation. Despite being one of the most prioritized destinations for the FLW generated in store, it is one of the most difficult to manage since the company must guarantee food safety for the institutions so there are no risks for the people when consuming the product, and stores rely on those institutions’ logistics to assure a regular donation of food products.

4.5 Waste Operators

As referred previously, JM has actively promoted waste valorisation. However, while Biedronka registered 91,7% rate of valorisation, Pingo Doce registered 65,2%, in 2020 (JM, 2021). This is mostly due to the acting legislation in each country that encourages more or less the companies to valorise their waste. Nevertheless, JM, in Portugal, has partners along the SC for the collection of a significant part of their organic residues – which includes solid FLW, such as F&V, food leftovers, bakery/pastry leftovers, coffee grains and tea bags, but also flowers, sheets, napkins and tissue paper. Although, since the distribution stage is where the most significant quantity of organic residues is generated, this study will focus on the PD stores. While the sub-products from animal origin are collected by only one operator in 99,5% of the stores, the partnership for the

collection of organic waste with some private operators/public companies and some local municipalities, depending on the location of each store, covers only 33,8% of the stores. This mismatch is mostly due to a lack of local infrastructures to treat the waste. The collection of the organic waste is mostly done in the big centres of population, such as Porto, Lisboa, and some surrounding municipalities, as it can be seen in the map (Figure 17). The stores that do not have active partnerships to collect the organic waste do not separate them and instead, send them as unsorted waste. Therefore, these stores do not have the registration of their quantities of organic waste.

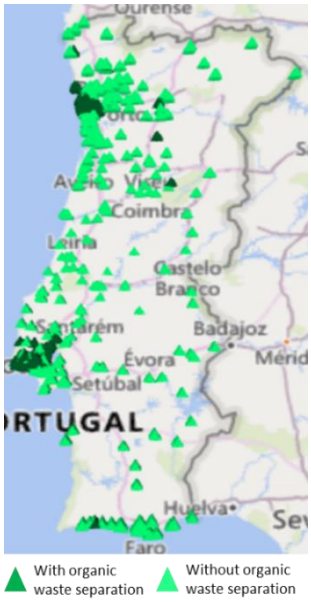

Figure 17 - Map of PD stores

In terms of operations, a store should keep track of the quality of the products. When a product is not fit for sale, it should be managed as organic waste, if possible, and the storage and other practices varies from store to store

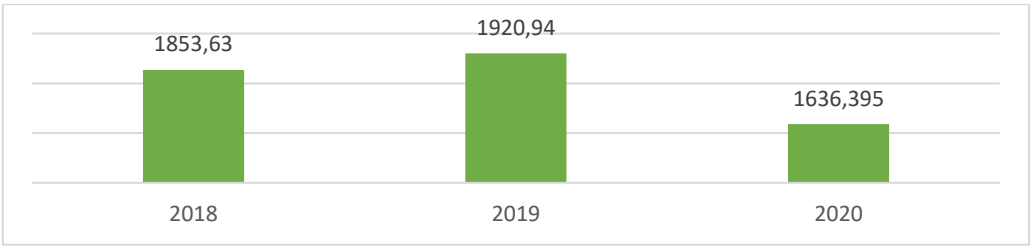

Figure 18 - Organic waste collected (in tons) from PD stores by private operator

According to an Excel file provided by JM, Figure 18 demonstrates the evolution of the organic waste collected from the stores. There was an upstream tendency until it was verified a significant decrease in 2020 mostly justified by the Covid-19 pandemic that led to a decrease in sales, therefore also in losses, in the first semester. The values demonstrated in Figure 18 only concern the stores that separate the organic waste and that have private operators for its collection, since no data has been provided about the stores that have their residues collected by other entities. Stores that have their collection of waste done through a municipality partnership do not keep track of the quantities collected, since these companies do not have the obligation of registering such data (e-GARs are not created for the collection process). Once the organic waste is collected, the entity responsible for its valorisation decides which process is better fitted, according to the waste's composition.

Taking this into consideration, it is concluded that the organic waste collected from partnerships other than the referred above also have a significant influence in the amount of organic waste collected, since the values presented in Figure 18 refer only 45,8% of the stores that have such service. Therefore, despite including the largest stores, it only represents 15,5% of the PD stores. In the next chapter it will be discussed possible solutions and partnerships that could enhance the amount of organic waste collected and valorised.

4.6 Chapter Conclusions

In this chapter, it is provided a contextualization of the Group JM and the main motivation of the problem in question, which consists in the high volume of FLW in the organic SC, mainly in F&V products. The chapter describes the evolution of JM along the years and explains how food distribution, where Pingo Doce is integrated, is the main business strategy. Since PD has a significant role in the Group JM, and this insignia is one of those which most contributes to the generation of F&V FLW, it is analysed the F&V's SC that reaches PD stores, describing the different stages and entities involved. With this study, it is verified the complexity of the SC due to the number of stakeholders and the importance that each one has to reach a global efficient operation. To have a closer look to the FLW generated by the Group, it is analysed by type of product but also by stage of the SC, although JM has limited information of the FLW generated by its suppliers. Nevertheless, when it's analysed which operations are implemented by the suppliers and in the stores to minimize and valorise their FLW, it can be concluded that while in the stores most measures are focused in preventing FLW, the suppliers focus on valorising the FLW incurred in their operations. Therefore, it is important to search for new solutions that can enhance a more efficient operation by the PD stores when minimizing and valorising their FLW. At last, it was analysed today's reality about the valorisation operators that work with JM, sustained with data that has been provided. It has been concluded that despite JM has been making an effort to reduce the FLW in the SC, the one generated in the distribution phase is still high and capable of providing more promising results. With animal by-products, partnerships are present in most stores, while with organic waste, which is very significant and has been in constant increase, there is a lack of local solutions to deal with such waste. Therefore, it is concluded that more effort has to be put in dealing with the collection of organic waste. For that, it will be studied the possibility of new partnerships with present valorisation operators and/or new partnerships with new valorisation operators and/or the regional centralization of the organic waste, so that valorisation operators can include these stores that are left out with the current partnerships, leading to higher rates of valorisation of organic waste.

5 Partnerships with Valorisation Operators

The previous chapter allowed to conclude that JM has made an effort to contribute to the decrease of FLW generation, both through prevention and valorisation methods. Nevertheless, organic waste generated in the distribution phase, in the PD stores, has still the possibility to significantly improve. With the relative low quantity of stores separating the organic waste from the unsorted waste, JM should look for the different characteristics of each region to implement the best solution. In this chapter, different scenarios will be analysed considering factors such as the presence of valorisation operators nearby.

JM can establish partnerships with companies that are able to collect the organic waste from the stores that currently do not have such service (section 6.2). This solution may have to take into account the area of action of different operators so that these are able to reach the required stores. New partnerships are not the only solution to improve the rate of stores that seggregate and valorise the organic waste. There is also the possibility of including new stores in present partnerships, since there is already a relationship between both companies, which could ease the possibility of celebrating new contracts (Section 6.1). Centralization of the stores' organic waste that are near each other is also a solution discussed (Section 6.3). A combination of these scenarios is proposed, where present partnerships increase the number of stores that they are responsible for, while new partnerships are established to be responsible for stores where today's valorisation entities do not operate. It is also considered the possibility of centralizing the organic waste of multiple stores where no valorisation operators are present. The best scenario to implement depends on the characteristics of the region in which the store is inserted.

Considering that seggregation and collection of organic waste will be mandatory starting in 2024, JM can start focusing in (1) improving stores' infrastructures, allowing them to separate and store organic waste for the respective collection and (2) building relationships with valorisation operators and municipalities to efficiently improve the required process for the waste's collection.

5.1 Improvement of Today's Partnerships

With the partnerships that are in course, 33,8% of the PD stores separate its organic waste. Nevertheless, there are many stores that, despite being close to other stores that have the collection service, are not covered by such service.

According to the data provided by JM, it can be noticed that only 71,5% of the stores located in Lisbon have collection of organic waste. In Lisbon, JM works alongside with private operators and the local municipality. The main reason that justifies not having every PD store seggregating its organic waste is the lack of storage conditions to store the organic waste for medium/long periods of time (more than one day).

Nevertheless, such reality can be overpassed: (i) JM could implement a centralization strategy, where the organic waste is transhipped to a store where there is collection service. The transportation could be guaranteed by a municipality transportation company or JM could arrange a partnership with a private transportation company as will be explained below in a more detailed way. With the increase of the quantity sent to valorisation and being a short distance

transportation, the cost of the service could be lower than the transportation discount obtained by seggregating organic waste from the unsorted waste. This scenario can be studied by the company, with the complementary data that is missing (transportation cost, waste generation per store, cost reduction from valorising organic waste) or (ii) rearrange the contract's partnership to include certain stores in the organic waste collection's route.

As previously stated, most stores that have collection service are located in big city centres, such as Lisbon and Porto. Considering this, these two cases will be analysed in more detail, since it is where more stores are located and more population is served.

5.1.1 Partnerships in Lisbon

Lisbon is the city that has the greatest number of stores and yet, 16,7% of the stores does not segregate organic waste. Being Portugal's capital, it is the city with highest population, which leads to higher amounts of organic waste. Figure 19, in which are represented the locations of the PD stores in Lisbon region, indicated that, in this area, the stores that are not covered by the collection service are near stores that have such service. This means that, despite the problem the store might have to difficult the organic segregation and storage, these can be included in the partnership by sending the waste to another store or by including it in an adequate route. If neither solution is possible, a new partnership can be arranged and the mix of stores can also be modified to optimize routes and the quantities transported by all operators so that the collection process can be as efficient as possible. If every PD store located in Lisbon municipality is included in an organic waste collection agreement, JM would reach 35,4% of PD stores. The organic waste is transported to Valorsul. Despite the municipality being restricted to its area, private operators, that also collects organic waste from stores within the area of Lisbon, could also collect waste from some stores in the frontier and a bit further away, so that it could possibly consolidate transportation while increasing JM's valorisation rate.

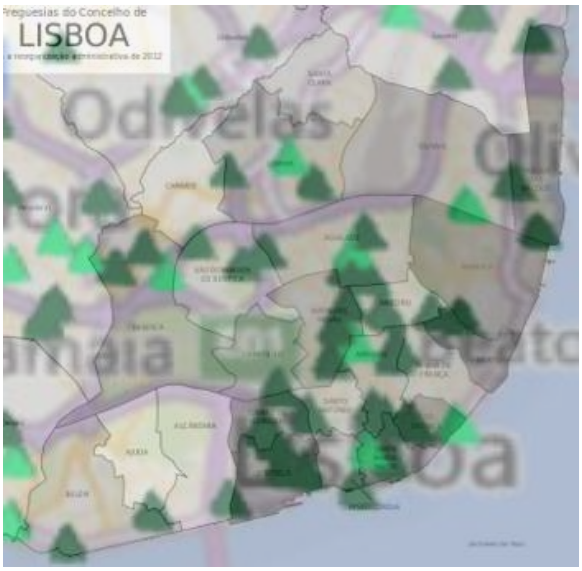

Figure 19 - Stores in Lisbon's city area

JM can also include Setúbal district in an agreement with private operators if the local municipality is not capable of providing such service. If every PD store located in Setúbal are included in a partnership, JM would have an overall increase of more than 7% of the PD stores segregating and valorising organic waste, reaching 42,3%. When such waste is collected, it can be delivered to Amarsul which is another subsidiary of EGF that operates in Setúbal.

5.1.2 Partnerships in Porto

In Porto's region, municipalities provide the service of collecting the organic waste to every PD store in the region. This might be justified by the higher capacity of the valorisation operators, and/or capacity/efficiency of the city hall's operation. After collecting the organic waste, Porto's city hall delivers it to Lipor, where the valorisation will take place. Since every PD store is already segregating and valorising its organic waste, no suggestions are provided.

5.1.3 Partnerships in Algarve

Focusing in Algarve, there is only one store, that is located in Portimão, that segregtes organic waste. The collection of such waste is provided by private operators that takes it to Algar. Algar is a subsidiary of EGF (Section 6.2.1) that has several facilities for waste valorisation of many types. To deal with organic waste, there are facilities that focus on producing compost (in Portimão, Tavira and São Brás) through green waste, which is mainly the waste generated from maintenance and cleaning of gardens and green public spaces. Considering that the characteristics of green waste and food waste are not the same, such as moisture, these should be valorised separately for better efficiency. However, Algar also has one facility in Parque Ambiental da Alfarrobeira called Central de Valorização Orgânica/ Unidade de Compostagem that receives unsorted waste, which is valorised through anaerobic digestion, which is one of the main valorisation destinations for FLW used by Jerónimo Martins. This facility can receive waste from São brás de Alportel, Tavira, Castro Marim and Vila Real de Santo António and it is able to valorise 22.500 tonnes/year of urban waste plus 10.000 tonnes/year of biodegradable urban waste. Therefore, it is verified that the stores located in Algarve have valorisation operators nearby with the capacity to valorise the organic waste generated. A partnership with Algar would lead to an increase of 5,9% of number of PD stores valorising its organic waste, reaching 48,1% if the previous partnerships are implemented.

5.1.4 Other Partnerships

A large number of stores that are located further away from the city centres are not in the perimeter that allows current independent valorisation operators to collect the stores' organic waste. Nevertheless, in the north area, there are some stores that have such service due to partnerships with the local municipality. Therefore, this strategy might be an efficient way to increase the number of stores that have its organic waste collected. City halls might be interested in contributing with such service as long as they are capable of sending the waste to valorisation, therefore there must be valorisation operators close to the respective municipality. Moreover, it is of the municipality's interest to collect the waste generated by the retailers, since it can improve its sustainability – increasing rate of valorisation leads to lower quantities sent to landfill. Sustainability is improved mainly in the environmental and social pillars by factors such as enhancing donations and keeping landfills with lower quantities, which leads to a decrease in air pollution. With municipalities receiving organic waste (and other kinds of waste), it can also be agreed to donate products that are not possible to sell, whether because they are reaching their

expiration date or due to labelling or packaging issues. Since municipalities have closer relationships with non-profit organizations, they can increase the number of institutions that JM and other retailers can donate their products to. Public organizations, such as schools and hospitals can also be considered.

5.2 New Partnerships

Considering the 66,2% (or 51,9%, if the previous partnerships are implemented) of PD stores that do not segregate organic waste, new partnerships could be established so that such reality becomes significantly less relevant. Today's reality might be justified by the inability of the valorisation operators to deal with such amount of waste or due to the stores' location that are not within the area in which the company operates. To deal with such obstacle, new valorisation operators were researched especially in areas where the stores present lower levels of segregation and valorisation.

There is a low number of entities that provide collection and valorisation services focused on organic waste. In this sense, it is important to understand that, since 40% of the total waste generated in Portugal is organic, the installed capacity to deal with such waste might not be sufficient when legislation about mandatory collection of organic waste take effect.

In this subsection, some partnerships are suggested according to the locations of the PD stores that require collection of organic waste and of the valorisation operators available.

5.2.1 EGF - Environment Global Facilities

EGF is a Portuguese company that operates in three continents – Europe, Africa and America. It provides strategic consultancy services in communication projects on environment education; strategic consultancy on waste management; and projects, constructs and operates owned facilities of waste valorisation.

Focusing in Portugal, EGF is present in 174 counties, with 167 facilities, reaching 6,2 million habitants. In 2020, it generated 447 Gwh/year of electricity, and treated 3.2 million tonnes of waste. It also produced more that 22 million tonnes of organic compost in its 13 facilities across Portugal. EGF started dealing with organic waste in 2005 and already has 19 operating facilities focused in organic waste valorisation. Depending on the facility, EGF provides mechanical or biological treatment, composting or anaerobic digestion. As can it be seen in Figure 20, EGF has 11 subsidiaries – Valorminho; Resulima; Resinorte; Suldouro; Resiestrela; Ersuc; Valorlis; Valnor; Valorsul; Amarsul; Algar – that cover a certain area of the country. EGF is the holding company responsible for the management and coordination of the concession companies of the multicounty systems for the treatment and valorisation of urban waste. Therefore, a partnership with JM can emerge directly with the holding or with separate

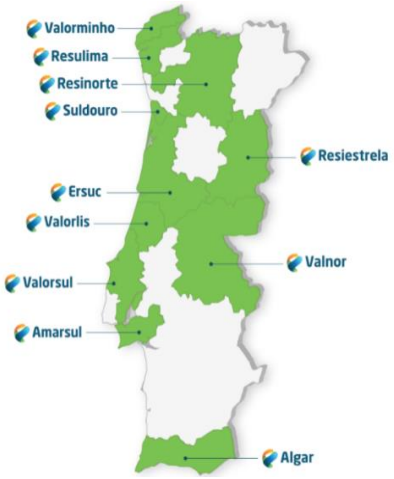

Figure 20 - EGF's subsidiaries and respective action area

agreements with the respective subsidiary of each store's county. In 2019, EGF handled 84 million tons in the bio waste flow, which shows a much higher capacity than the capacity required, when compared to the quantity registered in Figure 18.

If a partnership between JM and EGF is agreed upon, JM would significantly increase its number of stores that segregate and valorise its organic waste, while EGF would also increase the quantity of valorised matter and would guarantee a regular customer responsible for large amounts of waste in a daily basis. To have a closer look on the scenario improvement, Figure 21 shows an overlap of the PD stores' location with the areas covered by EGF subsidiaries. A scenario where every PD store within the area of EGF subsidiaries starts separating and valorising organic waste translates to an increase of 142% in the number of stores, which would mean that more than 76,5% of PD stores would separate and valorise organic waste. With the establishment of this partnership, it is possible to guarantee higher organic waste valorisation rates.

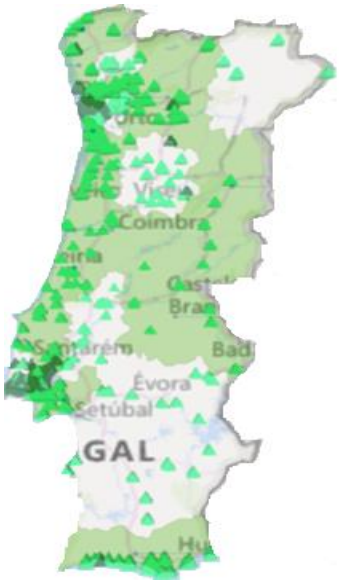

Figure 21 - Overlap of PD stores location and action area of EGF

With the lack of data available about the organic waste generated in PD stores that do not segregate organic waste or that have the collection provided by the local municipality, a direct proportion of the organic waste collected by private operators is considered. Since these are responsible for the collection of 15,5% of the PD stores, it means that, with 76,5% of PD stores segregating its organic waste, it would be verified an increase of 395% of organic waste collected and valorised. However, since it is not available the quantities collected by municipalities, it should be considered that each store generates the average quantity of organic waste. Thus, when considering that each store generates the average quantity of organic waste, it is verified that the increase of organic waste collected and valorised equals the increase of number of PD stores that starts segregating its organic waste, which is 142%.

Besides providing valorisation services for organic waste, EGF also offers other services. Such services include screening of recyclable materials, energy recovery, scobs valorisation, production of waste-based fuels and landfill services. This means that PD stores can turn to EGF not only to deal with organic waste generated in store, but also inorganic waste that also has a significant impact in the waste generation and consequent impact on the environment. As previously stated, starting in 2024, the segregation and collection of organic waste will be mandatory. Therefore, JM should start analysing how the stores that currently do not segregate their organic waste due to operational issues (e.g., no space available) are going to comply with the legislation. An investment can be made to improve the infrastructure of PD stores so the available space to store the waste generated is extended. Daily collection of the organic waste so that large quantities are never reached can also be a solution that mitigates the infrastructural issue. On the other hand, in case daily collections are not possible, organic waste can be transhipped to stores that have such service.

EGF subsidiaries, such as Suldouro, Resiestrela, Ersuc, Valnor, Valorlis, Valorsul, Amarsul and Algar provide biological and mechanic treatment to urban waste. This method aims to segregate organic waste from the other types of residues such as plastic and paper amongst others. Despite JM not being obligated to segregate organic waste from the unsorted waste before sending its waste for these facilities, it will be in 2024. Therefore, JM can start planning and implementing measures to assure that organic waste is separated so that when it is mandatory to do so, JM already has the processes required efficiently implemented.

South of Tejo river, in Setúbal, there are 35 PD stores that do not separate organic waste. However, Amarsul operates in this area and has facilities destined to valorise organic waste, which means that most of these stores could start segregating and valorising such waste. Nevertheless, Valorsul, which operates in the northern side of the Tejo river and has the largest valorisation facility destined to organic waste, is already dealing with the waste generated in PD stores in Lisbon. Accordingly, JM could contract with Setúbal's municipality to collect and transport the organic waste to Amarsul or negotiate with private operators, if Valorsul is the chosen facility to valorise the respective waste.

Considering Valorsul, there are still a large number of stores that are within its operating area that are not using such service, especially in the area above Lisbon. Thus, it is important to contact the local municipalities of the respective PD stores to arrange a contract that enables these stores to start segregating and sending the organic waste to valorisation. Otherwise, private transportation companies can be analysed as a possibility to collect and transport the waste to the valorisation facility.

On the other hand, ERSUC is the subsidiary that operates in the centre of Portugal, where there are 39 PD stores that do not separate its organic waste, being that more than 92% of the stores are within ERSUC's operating area. It is therefore important to mobilize a partnership with the local city hall of each store, or contact ERSUC directly so that its organic waste collection and valorisation is enhanced.

5.2.2 Associação de Municípios da Região do Planalto Beirão (AMRPB)

This association was founded in 1991 with the goal of finding and implementing innovative and sustainable solutions for the urban waste generated in some counties of Viseu, Guarda and Coimbra districts. This association is responsible for the collection, transportation and valorisation of such waste. With this initiative, the municipal landfills present in these districts were closed and waste are now being sent to facilities that valorise them. There are nineteen counties that are part of this association, ten of which have PD stores.

This association is responsible for the operation of the Central de Valorização Orgânica do Planalto Beirão that has a capacity of 130.000 tonnes of solid urban residues per year. This facility does the pre-treatment and screening of the waste received to separate the biodegradable parcel. Afterwards, this waste is submitted to anaerobic digestion to produce biogas. Such biogas is then sent to a generator with a production capacity of 3 MW. Composting is another valorisation method available in this association.

Since this association operates in an area where EGF is not present, PD stores can find another solution for its waste. With Figure 22 that is composed by an overlap between part of Figure 21 and the counties that are part of this association, it can be verified that these counties are the ones missing in the operation area of EGF. Therefore, it can be concluded that a partnership with this association can be beneficial for JM. For instance, both in Coimbra and Guarda one more store can segregate and valorise its organic waste, while in Viseu, which is a district where EGF is not present at all, as can be seen in Figure 22, allows ten new stores to send its organic waste to valorisation. With a partnership with both valorisation operators, JM would increase 2,8% of PD stores valorising its organic waste, which means that it would reach a total of 79,3% of the PD stores segregating and valorising organic waste.

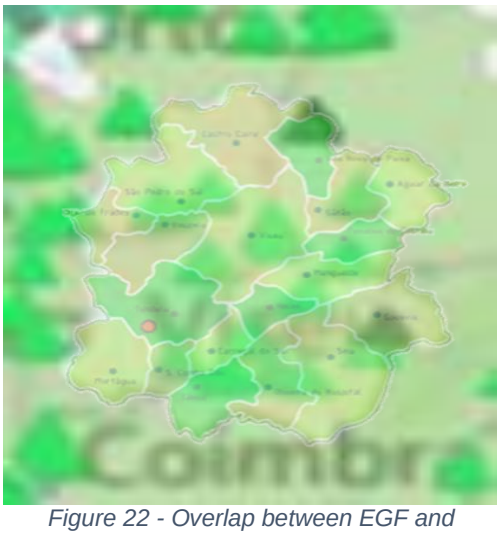

Figure 22 - Overlap between EGF and AMRPB operation area

Another strategy that would enhance organic waste valorisation is by facilitating nearby municipalities to utilise the valorisation facility.

5.2.3 Ambitrevo

In 2010, this company built its facility that is responsible for the valorisation of organic waste, Centro Integrado de Valorização Orgânica (CIVO), located in Coruche. This facility receives waste from the agri-food industry, waste from processing of food products and organic products unfit for consumption or processing. The valorisation processes available include composting and anaerobic digestion. Collection and transportation of the organic waste are also services guaranteed by Ambitrevo. The installed capacity is an information that is not publicly available, although it is known that such installation has an area of 20.900 m^2, and it is stated that the facility is in an ampliation phase, both in terms of reception of organic waste and production of compost.

Despite the different solutions provided in the previous subsections, there are still PD stores that do not have the possibility to valorise its organic waste. The scenario that is going to be developed is for some of the stores that are not within the operation area of neither of the valorisation operators mentioned previously.

As it can be seen in the Figure 20, the area of Santarém is not covered by any EGF subsidiary nor by AMRPB. Thus, there is the need to find a new valorisation operator – Ambitrevo – has a facility located in Coruche that valorises organic waste.

Considering that every PD store located in Santarém would have its organic waste collected, transported and valorised by Ambitrevo, JM could have an increase of 3,7% of PD stores segregating and valorising organic waste. This increase is considering that the partnerships mentioned previously are kept in place, which would result in having 83,1% of PD stores segregating and valorising organic waste.

With a partnership considering these valorisation operators, JM would significantly increase the number of stores separating and valorising its organic waste. As can be seen below, JM could have partnerships that cover most of Portugal, essentially where more PD stores are located. The table presented can also provide information about how each operator contributes to have a more sustainable supply chain.

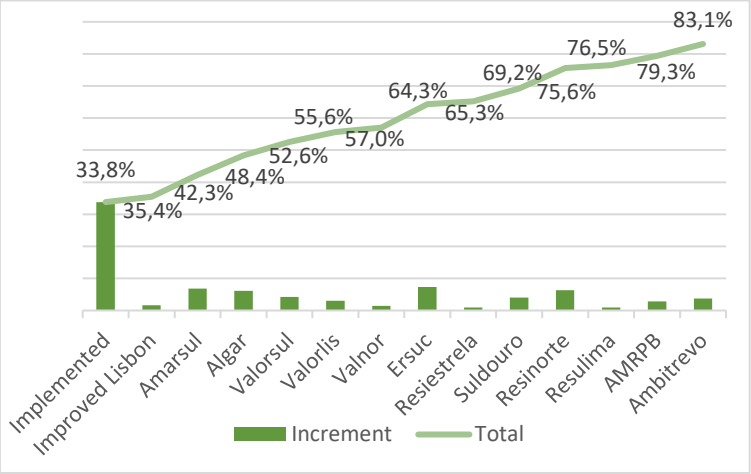

Figure 23 - Increment of PD stores valorising organic waste by partnership

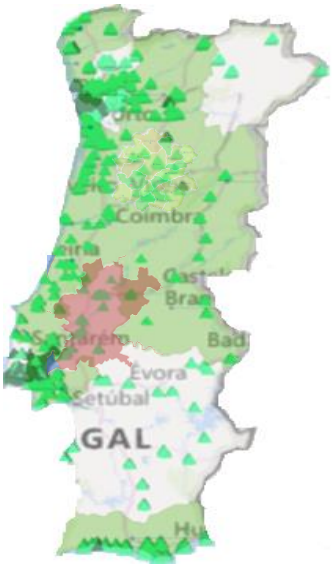

Figure 24 - map of new partnerships

It can be verified that the red and green area partly overlap, although the stores accounted for the red area are only the ones not covered by the green area. As can be seen in the Figures 23 and 24, there is a significant improvement on the initial scenario. It is verified a relevant increase of PD stores separating organic waste with the possibility of sending it to valorisation. Nevertheless, there are still regions on the map there are not covered by the partnerships suggested, since no valorisation operators were found. For that case, it is suggested a centralization strategy that is explained in the subsection 6.3.

5.3 Centralization Strategy

Despite the efforts for finding valorisation operators nearby every PD store, there are still a significant number of stores (16,9%) that are not within any operating area. The stores that are not able of sending their organic waste for valorisation generally are not located in big city centres, and therefore generate lower amounts of waste – due to the dimension of the store, sales volume or product mix available. As stated in the literature review, centralization allows companies to reduce distances travelled, as well as being more capable of reducing transportation rates by achieving full truck loads.

In such case, centralizing the organic waste generated in some stores located nearby each other in a location where the closest valorisation operator operates can not only improve the number of PD stores separating and valorising organic waste, but also decrease the cost of transportation if each store made it individually, due to transportation rates. Considering the centralization strategy, Figure 25 represents three scenarios have been considered to improve the number of stores that do not have nearby valorisation operators.

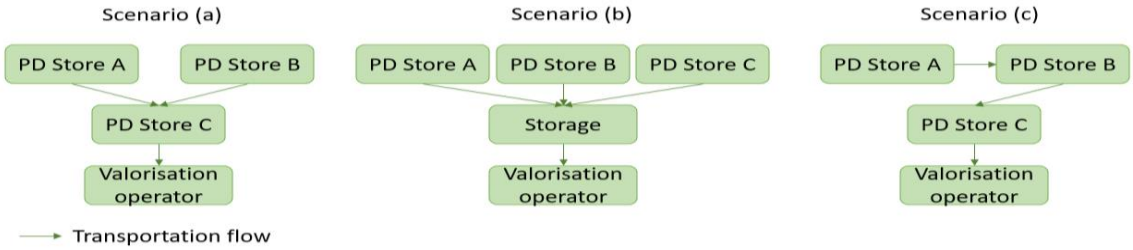

Figure 24 - Scenarios of centralization strategy

Thus, (a) JM can plan the transportation of the organic waste generated in multiple stores so that it is transported to a store with higher storage capacity. With the centralization of organic waste in a single store, a private transportation company can collect it and leave it in the closest valorisation operator. If this scenario is to be implemented, it is preferred to centralize in a PD store that already separates organic waste and has it collected for valorisation.

On the other hand, (b) the collection of the waste can be contracted with local city halls so that it is transported to a small facility that stores the waste. Afterwards, the valorisation operator or a contracted transportation company, such as Blue Otter, can collect it and transport it to the valorisation facility.

Nevertheless, (c) it can also be considered a scenario where a private transportation company collects the waste of multiple stores and transports it to the closest valorisation operator directly.

The assessment of these multiple scenarios has to consider the quantitative values that allows a comparative analysis between the scenarios, studying which one is more feasible, efficient and less costly.

However, it needs to be considered that scenario (a) is most likely not feasible, since the centralization of organic waste between stores can jeopardize the food security of the receiving store and it can hinder the organic waste characteristics for valorisation methods.

In every scenario, it is considered to have a private transportation company that takes the organic waste to the valorisation operator, since its location is outside of every county considered.

This scenario can be applied for the stores located in Évora and Beja, as well as Bragança. This solution can also be considered if any of the partnerships mentioned before is not possible to achieve, such as in Viseu, Santarém; in locations where the installed capacity of any EGF subsidiary does not guarantee the full treatment of the organic waste generated; or if any subsidiary does not provide the services for organic waste valorisation, such as Valorminho, Resulima and Resinorte.

This strategy can have costs associated that the previously recommended do not have, such as the use of a facility for storage of waste if the centralized storage cannot be done in a store. Transportation costs can also increase, depending on the partnerships and scenario agreed, e.g., for scenario (b), transportation is divided in two phases – from the store to the waste “warehouse”, and from the “warehouse” to the valorisation facility. Nevertheless, it is a strategy that enables PD stores to valorise organic waste where there are no valorisation operators.

Partnerships with other retailers or with establishments in the HORECA channel is another alternative that can increase occupation rate of transportation. These partnerships have to occur

with private transportation companies, since it is required to transport the organic waste across different city halls.

5.4 Chapter Conclusions

In this chapter, it is considered the case study on Jerónimo Martins about collection and valorisation of organic waste. JM has relative low rate of stores that separate organic waste and send it to valorisation, and the stores that use such service are located in the city centres of Porto and Lisbon.

In 2024, it is going to be mandatory to separate the organic waste generated, therefore JM will have to provide the required conditions for every store to be able to separate organic waste. Investment in infrastructures might be required for some PD stores to have sufficient space to store the waste until its collection. Considering the obligation of separating organic waste, JM can enhance its valorisation rate by promoting partnerships with companies that provide such service. Focusing on the valorisation of organic waste, it is analysed the possibility of improving partnerships that are already in place to increase the number of stores that have collection service for organic waste. On the other hand, it is located different companies that operate in other regions than Lisbon and Porto to establish new partnerships. Companies such as EGF, AMRPB and Ambigroup were found. These companies operate in regions where no partnerships are in place and each one of these companies operate in different regions between them. Partnerships with these three companies simultaneously would result in having more than 83% of PD stores separating and valorising its organic waste.

At last, it is suggested three different scenarios that implement a centralization strategy for locations where there are no valorisation operators nearby. With the aggregation of the organic waste generated in multiple stores and a combination of partnerships with the local city halls and private transportation companies, PD stores that are located where no valorisation company operates can still take advantage of such service.

Figure 26 represents the different scenarios suggested in this study. Depending on the PD store location, different strategies are proposed. It is also relevant to analyse whether there are valorisation operators available to receive the waste. Depending on these factors, a strategy emerges as being the better fit for the store.

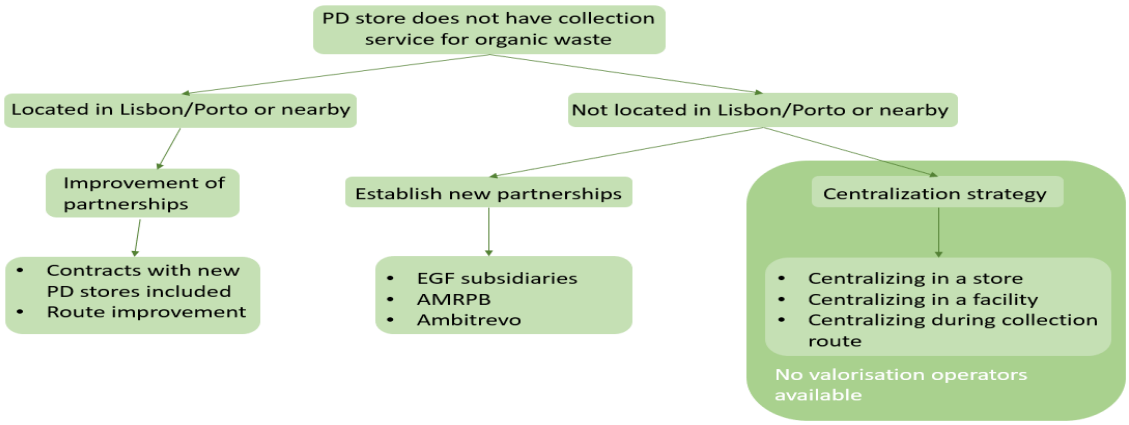

Figure 25 - Summary of valorisation strategies for PD stores

6. Conclusions

Companies, as part of the society, are responsible for guaranteeing a future for the upcoming generations. Thus, all TBL pillars should be considered in the companies' activities, instead of focusing only on economic results, such as cost minimization and profit margins.

This work was developed alongside with Jerónimo Martins after a professional internship took place and emerged from the need to improve JM's reality on the generation of FLW, mainly in the distribution phase. Considering that FLW valorisation was the main issue to address, it was decided to focus on the PD stores, where it was identified that is where the organic waste is mostly generated. The goal was to screen today's reality on how JM is addressing this issue and provide suggestions on how it can be improved. The study focussed on searching for valorisation operators where PD stores could turn to for treatment of the organic waste generated and, if this solution cannot be implemented, provide other solutions, such as centralizing this waste. Despite the limitations that are going to be named after, it is considered that the goal of this study is reached and can be better sustained with real monetary values that JM has. Nevertheless, it is considered that the work developed can serve as basis for future work.

This dissertation was an opportunity to learn more about: (1) the Group JM, but also the food retail industry and about the biggest AFSCs in the world; (2) the reality of FLW across the world and supply chain and respective impact; (3) the main causes that lead to FLW and strategies implemented to prevent and mitigate such generation; (4) the complexity about the functioning process of AFSCs and interactions of the different stakeholders and respective balance; (5) which strategies the biggest AFSCs in the world are implementing on this issue; and also (6) which valorisation methods are most prevalent in Portugal and which operators are present in the market.

In this dissertation, it was firstly developed a literature review to have a close comprehension on the urgency to address and solve the problem of FLW and how it can be accomplished in AFSCs. It is concluded that it is required to see the AFSC as a whole, since the FLW generated in a determined stage of the SC can be caused by actions in the upstream or downstream stages. It is also verified the importance of the interactions between stakeholders and the relation between them, in terms of power balance. Thus, it is concluded that collaboration between stakeholders is crucial to enhance the overall sustainability of the SC.

Afterwards, it was developed a case study where the biggest AFSCs in the world, according to Gartner, are analysed on how they are addressing the issue of FLW. It were analysed the goals that each company has established to reach, the respective progress and the measures implemented.

After having a closer understanding on the urgency of tackling the issue of FLW and how the biggest AFSCs are addressing the issue, it was presented the Group JM, the stakeholders present across the SC, which measures PD stores and suppliers have implemented to prevent and mitigate the generation of FLW and the role of valorisation operators.

At last, since FLW is most present in the PD stores, the study was focussed in this stage of the SC. After concluding that most stores do not separate or valorise organic waste, valorisation

operators were researched to provide new possible destinations for the organic waste generated. It is also suggested that infrastructural issues that hinder the storage of organic waste should be overpassed, since organic waste separation and collection will be mandatory in 2024. New valorisation operators were found, depending on the location desired. It was also concluded that such strategy can better be implemented if local city halls collaborate with JM. Whenever no valorisation operators are available, centralizing the organic waste in a capable nearby store or facility is suggested.

With this work, it is suggested different complementary scenarios, depending on the location. The different valorisation operators are present in different parts of Portugal, which means that partnerships with all of them can be negotiated so that more PD stores are covered by this strategy.

Although considering the detailed work developed, some limitations can also be identified, which can influence the decision of implementing the identified strategies. These limitations will be described (section 7.1) as well as suggestions for future work will be identified (section 7.2).

6.1 Limitations

The main objective of this dissertation is the implementation of measures that enhance the number of stores that separate and valorise its organic waste. Nevertheless, there are limitations in this study that difficult the full analysis of the recommendations given:

1. Different sources of information – Despite the information gathered about Group JM is provided from primary sources, the information about the companies of the case study on the worldwide and of the valorisation operators is from secondary sources. This differentiation leads to higher detail in describing JM operation about prevention and mitigation of FLW.
2. Lack of information on FLW generated in PD stores – Despite having the information about the organic waste collected by Blue Otter, the organic waste collected by local city halls is not available. This information is important to have a more justified urgency on the separation and valorisation of the organic waste. Furthermore, the organic waste generated in stores not located in city centres is not available and is useful to analyse the feasibility of establishing partnerships for these stores.
3. Lack of information about valorisation operators – Despite the development of the case study on JM, this work is focused on the valorisation of organic waste generated in PD stores, which means that the detailed information on the capacity of collection and reception of this waste is not within JM operation. Thus, the required information on the possibility of agreeing on a partnership depends also on the availability of the valorisation operators, which is an information that is not available. On the other hand, it was researched a limited number of valorisation operators, which means that other companies might be available and with more beneficial agreements.
4. Lack of information on costs and duration – It is not specified the costs of implementing this strategy. The costs of improving PD stores' infrastructure and establishing the

partnerships suggested might be more costly than what JM is available to spend. Time is also a factor not considered. Nevertheless, these two factors are relevant for the analysis.

6.2 Suggestions for future work

The priority for the future work is to consolidate the strategy suggested with the relevant economic values. JM has to analyse the different scenarios considering the economic values, without ignoring the social and environmental impacts, to conclude its feasibility.

According to the obligation of separating organic waste, JM has to better understand the need for infrastructural investments. The quantities of organic waste generated by the PD stores that do not separate it have to be analysed. Depending on the amount, JM has to decide whether the stores need a storage upgrade or not.

On the other hand, the availability of the city halls and valorisation centres have to be considered, as well as new valorisation operators and transporters can be researched to have a larger spectrum of options to achieve the optimal solution. Without the economic information required to compare different companies, it is only suggested one solution per region, however, with all the information needed to analyse different scenarios, different companies should also be researched.

7. Acknowledgement

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9 Annexes

Annex A - FLW

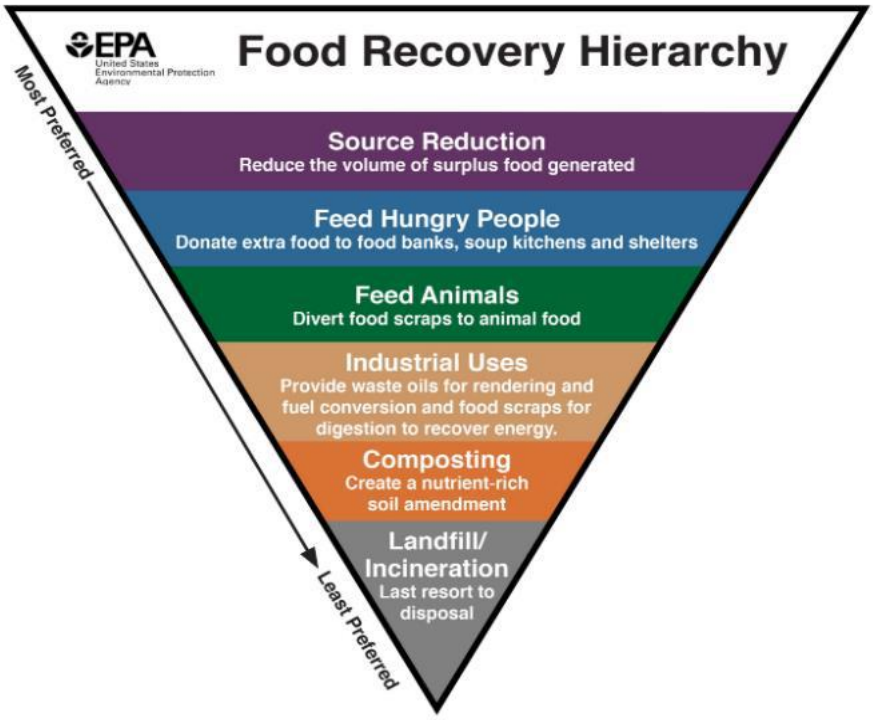

Figure A 1 - FLW valorisation hierarchy

Annex B - Distribution Centres

Região	Centro de Distribuição	Armazém	Operação	Refrigeração
Norte	Alfena	Secos	JIT/Stock	Ambiente
		F&V	JIT	6 a 12 °C
		Peixe	JIT	0 a 2 °C
		Logística Inversa	Stock	Ambiente
	Vila Conde	Frescos	JIT	0 a 4 °C
		Congelados	JIT	Abaixo de -20 °C
Centro	Azambuja	Secos	Stock	Ambiente
		Frescos	JIT	0 a 4 °C
		F&V	JIT	6 a 12 °C
		Peixe	JIT	0 a 2 °C
		Logística inversa	Stock	Ambiente
		PD&Go	Stock	Ambiente
	Vila Nova	Secos	JIT	Ambiente
	Alcochete	Secos	Stock	Ambiente
		Bacalhau	Stock	6 a 12 °C
	MARL	Congelados	Outsourcing	Abaixo de -20 °C
	DECOPHARMA	Parafarmácia	Outsourcing	Vários tipos
Sul	Algoz	Todos os fluxos	JIT	Vários tipos

Figure B 1 - Operation of JM's DCs in Portugal (Fialho, 2020)