UNIVERSIDADE D
COIMBRA

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SOLUÇÃO DE ARMAZENAMENTO PARA MINIMIZAR AS RECLAMAÇÕES DE QUALIDADE DOS CLIENTES EM PRODUTOS PERECÍVEIS

Dissertação no âmbito do Mestrado em Engenharia e Gestão Industrial orientada pela Professora Doutora Aldora Gabriela Gomes Fernandes, apresentada no Departamento de Engenharia Mecânica da Faculdade de Ciências e Tecnologia da Universidade de Coimbra.

Fevereiro de 2023

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FACULDADE DE CIÊNCIAS E TECNOLOGIA
UNIVERSIDADE D COIMBRA

Storage solution to reduce customer quality complaints in perishable products

Submitted in Partial Fulfilment of the Requirements for the Degree of Master in Industrial Engineering and Management

Solução de armazenamento para minimizar as reclamações de qualidade dos clientes em produtos perecíveis

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Institutional Collaboration

PICNIC

Picnic Technologies

Coimbra, Fevereiro 2023

“Stay hungry. Stay foolish.”

Steve Jobs

ACKNOWLEDGEMENTS

The present dissertation marks the end of the most memorable chapter of my life. Thus, I would like to express my gratitude to the people who have crossed my path, without whom this journey would not be so remarkable.

To my advisor Professor Gabriela Fernandes, I truly thank you for all the help and support throughout the development of this work. All the guidance was essential to successfully concluding this chapter in my life.

To Picnic, for giving me this internship opportunity that developed and challenged me to my limits, and especially to Matteo and Marie for all their support and guidance throughout this project.

To my parents, for believing and encouraging me in all my decisions in life. And to all of my family for their wise words and advice.

To my Erasmus friends, for the best five months of my existence and for creating the best version of myself. Split will always be my second home.

To my dearest friend group, Cachopas, for all the crazy nights, late-night study sessions, academic dinners, gossip talks, and daily company throughout the last five years.

To my godmother Inês, my godfather Pedro, and my pseudo godmothers I thank you for showing me Coimbra, all its magic and traditions. My experience would not have been the same without you.

To Bernardo, for being my biggest inspiration and company in the last few years. *"O futuro sorri-te p'ro resto da vida!"*

To BEST Coimbra, for developing me into a person able to achieve any goal and surpass any challenge that has crossed my path. It was truly a pleasure to be part of this organization, and I am thankful to all of you.

To my home, Coimbra, for showing me the meaning of saudade. *"Quem te não viu, anda cego. Quem te não ama, não vive."*

Abstract

A significant barrier to online food retailing is the fact that customers cannot physically engage with the products before purchasing them. Customers are still reluctant to buy perishable products due to safety and quality concerns. Therefore, it is necessary to ensure product quality and *Customer Freshness Guarantee Days* to assure safe consumption and customer satisfaction.

This study is based on the assumption that *Different storage systems have influence on customer complaints related with Best-before date (BBD)-too-short in the freshness category*, leading to the research question: *What is the storage solution for critical perishable products that can improve First-Expired First-Out (FEFO) picking and reduce freshness issues?* A case study based on a company from the online grocery retailing market is used as the research strategy supported by document analysis, observation, unstructured interviews and focus groups to answer the research question.

Findings show that 16 perishable products can be considered critical for the company to focus on storage solutions to reduce the number of freshness complaints related with BBD-too-short. Results suggest that the storage of Bread should be done in Dolly system, Vegetable products in Roll Container (RC) and Eggs in RC or Pallet, all of them inside of plastic trays each one corresponding to a single BBD. In the case of low selling Milk products, Shelving is a good option, and for high selling it is suggested the use of a Pallet or RC storage systems, with a single unit in the location. Finally, in the case of Meat products the solution is the use of a Flow Rack system, consisting in two storage locations, each one referring to a single BBD. A new storage system that can be described as a Pallet Conveyor is suggested as an alternative storage of high-selling Milk products.

Contributions from this study confirm the influence of storage systems in the number of freshness-related issues regarding too short BBD, reported by customers. Also, it suggests storage solutions that lead to the improvement of Quality of Service and customer satisfaction.

Keywords Warehouse Storage Systems, FEFO, Best-before date, Perishables, Online Grocery Retailing.

Resumo

Uma barreira significativa à venda online de produtos de supermercado é que os clientes não têm contacto físico prévio com os produtos antes de os adquirirem. Os clientes ainda estão hesitantes em comprar produtos perecíveis, devido a questões de segurança e qualidade. Deste modo, é necessário assegurar a qualidade e *Dias de Garantia de Frescura ao Cliente* para garantir que o seu consumo é seguro e o cliente fica satisfeito.

Este estudo tem como pressuposto que os *Diferentes sistemas de armazenamento têm influência nas reclamações dos clientes relacionadas com Best-before date (BBD)-too-short na categoria de frescura*, conduzindo à questão de investigação: *Qual é a solução de armazenamento para produtos perecíveis críticos que pode melhorar o sistema First-Expired First-Out (FEFO) e reduzir os problemas de frescura?* Um estudo de caso baseado numa empresa de venda online de produtos de supermercado é utilizado como estratégia de investigação com o suporte de análise documental, observação, entrevistas não estruturadas e *focus groups* para responder à pergunta de investigação.

Os resultados mostram que 16 produtos perecíveis podem ser considerados críticos para a empresa se concentrar em soluções de armazenamento de modo a reduzir o número de queixas de frescura relacionadas com *BBD-too-short*. Os resultados sugerem que o armazenamento de Pão deve ser feito em sistemas *Dolly*, produtos Vegetais em Roller Container (RC) e Ovos em RC ou *Pallet*, todos eles dentro de tabuleiros de plástico, cada um correspondente a um único BBD. No caso de produtos de Leite de baixa venda, *Shelving* é uma boa opção, e para produtos com maiores vendas sugere-se a utilização de um sistema de armazenamento em *Pallet* ou RC, com uma única unidade no local. Finalmente, no caso da Carne a solução é a utilização de um sistema *Flow Rack*, consistindo em dois locais de armazenagem, cada um referindo-se a um único BBD. Um novo sistema de armazenamento que pode ser descrito como um *Pallet Conveyor* é sugerido como um armazenamento alternativo para o Leite com elevados valores de venda.

As contribuições deste estudo confirmam a influência dos sistemas de armazenamento no número de queixas reportadas pelos clientes relacionadas com a frescura no que diz respeito a BBD demasiado curtos. Além disso, sugere soluções de armazenamento que levam à melhoria do *Quality of Service* e satisfação do cliente.

Palavras-chave: Sistemas de armazenamento do armazém, FEFO, *Best-before date*, Perecíveis, Venda online de Produtos de Supermercado.

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ACRONYMS

BBD – Best-before Date

DT – Design Thinking

EPV – Electric Picnic Vehicle

FC – Fulfillment Center

FC2 – Fulfillment Center located in Langenfeld, Germany

FEFO – First-Expired First-Out

FIFO – First-In First-Out

LIFO – Last-In First-Out

OP – Order Picking

RC – Roll Container

RO – Research Objective

SKU – Stock Keeping Unit

WMS – Warehouse Management System

1. INTRODUCTION

1.1. Research Problem

The COVID-19 pandemic has increased online shopping due to government-imposed restrictions and consumer apprehension about the potential health risks associated with in-store shopping (Shaw et al., 2022). Online food retailers focus on price, selection, and convenience to ease the transition between online and offline food purchases (Charlebois et al., 2021).

Food waste can be defined as the discarding of products that do not meet quality standards, the waste generated during processing, surpluses during catering and consumption, and unsold volumes that expire because of a mismatch between supply and demand (Hertog et al., 2014). Studies show that strategic application of First-Expired First-Out (FEFO) significantly contributes to food waste reduction (Mercier et al., 2017). This concept applies a stock rotation strategy, in which products with the shortest remaining shelf life are sold first (Jedermann et al., 2014).

The inability of consumers to physically interact with products before making a purchase decision is a weakness of Internet-based retail (Citrin et al., 2003). The perceived risks associated with receiving online purchased perishable food items represent a significant barrier for online grocers. To overcome these obstacles, online grocers must ensure the quality of products and services offered to customers.

Unlike traditional brick-and-mortar grocery stores, consumers are unable to touch products when making purchase decisions in the online food retail market. Therefore, it is necessary to ensure product quality and sufficient shelf life to guarantee customer satisfaction and safe consumption of the items. Since this concern is common in the online food retailing market, a case study on the company Picnic was used in the present research.

Picnic is an online-only supermarket that delivers groceries to the customer's house. The company's focus is on product quality and customer satisfaction. Picnic was launched in 2015 in the Netherlands and expanded to Germany and France. Customers can make grocery purchases through the Picnic online app, which displays all products and the

Customer Freshness Guarantee Days of each item. The orders can be placed until 22h and expect the delivery of the items the next day at the client's house.

After the consumer receives the order, the client can file a complaint regarding the quality or safety issues encountered with the order. The company's app enables customers to submit complaints regarding damaged, missing, or freshness-related issues. The complaints analyzed in this dissertation comprise the freshness category, which occurs when a product has quality issues, such as being overripe, underripe, or not fresh. Specifically, complaints regarding products with insufficient Best-before dates (BBD), and not respecting the *Customer Freshness Guarantee Days* that are promised by the company will be considered in this research.

Observing the workflow on the warehouse floor and conducting unstructured interviews with supervisors and experienced employers led to the conclusion that the difficulty in maintaining the FEFO assortment in certain product-picking locations may be the cause of delivering products with insufficient BBD to the end consumer. It is assumed that factors such as improper storage system selection, unusual item shape, and human error contribute to FEFO stock management issues. In the present dissertation, the assumption that the choice of material storage system in certain products have influence on the number of freshness issues associated with too-short BBD will be analyzed.

1.2. Research Questions and Objectives

The research question of this project is: *What is the storage solution for critical perishable products that can improve FEFO picking and reduce freshness issues?*

To answer this research question, three research objectives (RO) were proposed:

- RO1: *Analyze data on freshness customer complaints related to BBD-too-short and determine the products that have a higher impact on the number of this type of complaints. (Critical products).*
- RO2: *Propose suitable storage systems used by the company for the critical product's categories, that reduces freshness complaints related to BBD-too-short.*
- RO3: *Propose a new storage system solution to reduce freshness complaints associated with BBD-too-short.*

Thus, this research assumes that *Different storage systems have influence on customer complaints related with BBD-too-short in the freshness category*. Then, proposing solutions on storage types in critical product category's locations to improve the application of the FEFO principle in the Fulfilment Center and diminish the number of freshness complaints.

To attain these three research objectives several research methods were applied as presented in Table 1.1.

Table 1.1 Research methods used in the Research Objectives

Research Objectives	Research Methods
RO 1	Document analysis Unstructured interviews
RO 2	Observation Focus group
RO 3	Observation Focus group

1.3. Dissertation Structure

The structure of this document consists of six chapters, the first of which provides the context for the current study and describes the research problem, research questions and objectives. The second chapter presents a literature review that provides an overview of the knowledge surrounding the topics investigated in this study. The third section discusses the study's research methodology. The Research Onion proposed by Saunders et al., (2019), serves as the framework for guiding the development of this research project. The case study used in this research is described in the subsequent section. Then, following chapter presents the study's results and discussion, while the final chapter discusses the project's conclusions, its limitations, and suggestions for future research.

2. LITERATURE REVIEW

The present chapter reviews the theoretical concepts that support this research, allowing the reader to acknowledge the topics addressed throughout the project and comprehend its development to achieve its main goals and answer the research questions. Firstly, a context for Online Food Retailing is presented to better understand the research problem. Warehouse Processes and Storage and Handling systems are then described and explained. Then, the concept of quality is defined to understand consumers' expectations regarding food consumption, followed by the definition of Shelf-life, Best-before and Used-by dates, and the FEFO principle.

Scopus and *Google Scholar* databases were consulted to search for relevant scientific articles to provide the researcher with the background knowledge necessary to develop the present research.

2.1. Online Grocery Retailing

E-grocers can be defined as a channel that has been developed to support the overall grocery industry that aims to sell perishables and non-perishable grocery items using the Internet for delivery and pick-up. The value proposition of e-grocers is to become a single-source solution for busy consumers in the present day (Berning et al., 2005; Farris II & Gabaldon, 2020; Geunes et al., 2005). According to a study conducted by McKinsey and Company, 82% of e-grocers consumers do it as a substitute for regular trips to the supermarket (Geunes et al., 2005).

In the 1990s, online grocery retailing was predicted to be a promising opportunity to increase revenue, however, contrary to expectations, this concept was not successful among regular grocery consumers (Farris II & Gabaldon, 2020). Start-up Webvan was the pioneer in online food retailing but failed to balance market potential due to high customer expectations about product quality and service, and their overboard investment in technology and business strategy (Berning et al., 2005). The operational costs of online food retailing are considered to be too high, mainly because of order picking, storage, and

transportation (Farris II & Gabaldon, 2020; Kämäräinen et al., 2001). Since 2003, this market has grown significantly and has increased exponentially since the start of the COVID-19 pandemic (Baarsma & Groenewegen, 2021).

According to Seitz et al., (2017), online consumers are mostly working mothers, young professionals, and people over 65 years of age. While working mothers and young professionals can take advantage of the e-grocers due to convenience and time-saving reasons, the elderly benefit from this service due to their reduced physical mobility and the lack of strength to carry heavy items. Although 50% of German consumers consider "convenience" as their motive for doing e-grocers, the majority are still reluctant to buy fresh and chilled products (Desai et al., 2017).

Business models used in online food retailing can be Store Pickup, where the consumer orders online and later pick it up at the store, or Home Delivery, where customers order online and receive groceries at their house (Farris II & Gabaldon, 2020). Home delivery services are preferred by e-grocer consumers (Saskia et al., 2016).

2.2. Warehouse

The warehouse plays a critical role in supporting a company's supply chain success, if the warehouse cannot process orders quickly, effectively, and accurately, then a company's supply chain optimization efforts will suffer (Tompkins et al., 2010).

Rushton et al., (2014) state that warehouses are involved from the handling of raw materials and work-in-progress products through to finished goods. According to Rushton et al., (2014), recent trends such as growing market volatility, increasing product ranges, and shortening customer lead times have an impact on the roles that warehouses must successfully play. Due to the nature of its facilities, staff, and equipment, warehouses are commonly the most costly elements of the supply chain and therefore, their successful management is critical in terms of both cost and service.

The capacity to build seamless and efficient logistic operations has become increasingly important due to the trend toward greater product diversity and rapid response times (Rouwenhorst et al., 1999). According to Richards (2018), the usage of a Warehouse Management System (WMS) is essential to improve speed, productivity, and accuracy in today's fast-moving environment. WMS is a complex software package that helps manage

inventory, storage locations, and workforce, to ensure that customer orders are picked quickly, packed, and shipped. A typical WMS knows about every item in the warehouse, its physical dimensions, how it is packed by the vendor, all storage locations in the warehouse, and their addresses and physical dimensions in real time (Richards, 2018). With this knowledge, the WMS orchestrates the flow of people, machines, and products (Bartholdi & Hackman, 2019).

2.2.1. Warehouse Processes

Each warehouse should be designed to satisfy the specific requirements of its supply chain (Rushton et al., 2014). Nevertheless, certain operations are common to most warehouses. The typical operations and flows in warehouses can be seen in Figure 2.1.

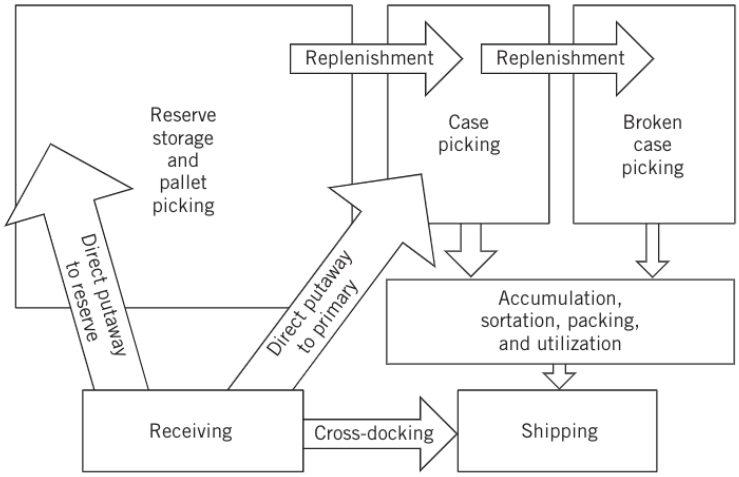

Figure 2.1 Typical warehouse functions and flows (Tompkins et al., 2010)

According to Tompkins et al., (2010), the main warehouse activities are:

- *Receiving* includes activities involved in the receipt of materials coming into the warehouse, assuring that the quantity and quality of such materials are as ordered, and moving materials to storage or to other organizational functions that need them.
- *Inspection and quality control* involve inspection and quality checks of the products and processes.

- *Put away* involves the transfer of product to storage locations and material handling and placement.
- *Storage can* be described as the physical containment of goods while they are waiting for demand. The size, quantity, and handling qualities of the inventory items as well as the nature of the product will determine the type of storage.
- *Order picking* involves the process of obtaining the right amount of the right product for a set of customer orders. This is the primary activity in most warehouses.
- *Postponement* involves the repackaging of individual items or assortments in boxes for more convenient use.
- *Sortation is* a necessary activity if the orders have been picked in batches. In such cases, the selected units must be grouped by customer order upon completion of the picking process.
- *Cross-docking is* performed when the received products are transferred directly to shipping docks.
- *Replenishment* involves primarily picking locations from reserve storage locations.
- *Shipping* involves dispatching products to the end customer on shipping docks.

2.2.1.1. Order Picking

Order Picking (OP) can be defined as the process of retrieving items from their storage locations in a warehouse to fulfill customer orders (Grosse & Glock, 2015). More than half of the costs associated with operating a warehouse are attributable to this operation, which is one of the most time-consuming and labor-intensive processes in warehousing due to the amount of manual labor required (Tompkins et al., 2010). According to De Koster et al., (2007), most warehouses (approximately 80%) are still manually operated, despite the various opportunities for automation. Usually, *picker-to-parts*-based order-picking systems are followed, where pickers move through the aisles of the warehouse, sometimes in

combination with an electric vehicle, to pick up the requested items from their storage locations (Masae et al., 2021).

Unlike robot-automated systems, human operators can respond rapidly to the demands of order diversity for products' various forms, weights, and volumes from their storage location, providing flexibility to the process thanks to their cognitive and physical skills (Grosse et al., 2015). As reported by Grosse et al., (2015), many planning models were created in an effort to increase order-picking productivity and effectiveness, but the researchers have neglected human factors from the workers. Manual operations are often combined with high levels of physical workload, psychological demands, long working hours, stress, and other factors that increase the possibility of human system errors (Setayesh et al., 2021). Order Picking by human operators includes the following tasks:

- *Setup*, including receiving orders, sorting, and prioritizing items.
- *Search* for and find the requested item
- *Travel*, moving to the requested item.
- *Pick and* select the requested items.

These tasks can lead to picking errors, such as the most frequent picking of the incorrect item, missing a pick of a product, picking under or over the requested amount of the correct item, damaged items during the material handling process, or the order picker failing to check the item’s integrity before picking (Setayesh et al., 2021). Picking mistakes made by human operators may also be a direct result of the system's format for picking information, complex routes, poor shelf layout, frequent changes in storage assignments, poor perception of item information, and the workforce's organizational structure and the nature of the job (Setayesh et al., 2021).

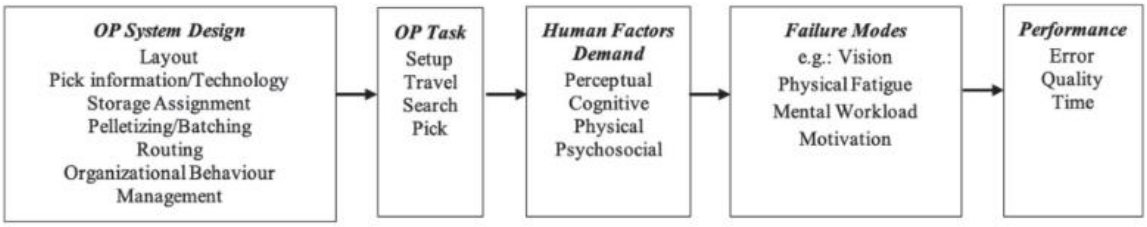

Figure 2.2 Framework based on OP system design, OP task, Human Factor demands, Failure Models, and Performance (Setayesh et al., 2021)

2.2.1.2. Receiving

The receiving process is an important phase in the supply chain, as it forms the basis for all subsequent warehouse activities. According to Ackerman (1990) and Rushton et al., (2014), the reception of goods in a warehouse requires detailed planning and a high degree of accuracy and control. During unloading, the products must be checked to ensure that the quantity and quality meet the expected requirements, some packages can require some form of processing, for example, applying barcode labels, palletizing, or re-palletizing, and placing them into tote bins. When the inbound is ready to be stored, the warehouse management system usually identifies the most appropriate location and issues put-away instructions to the operator (Rushton et al., 2014).

2.2.1.3. Replenishment

Storage replenishment corresponds to the transfer of products from reserved to forward storage (Çelik et al., 2022). Bahrami et al., (2019) state that the storage area should be divided into two areas: the reserve area (bulk area), where the products are stacked in high-density pallets, and the forward area (picking area), where products are stored in small quantities in accessible locations, commonly in shelves or flow racks, from which the items can be retrieved quickly. When the stock of a given Stock Keeping Unit (SKU) in the forward area is low, a replenishment operation is triggered. According to Rushton et al., (2014), the replenishment operation directly affects the efficiency and accuracy of the picking process because this operation aims to ensure that there are no stockouts and delays during order picking. While order picking constitutes most warehouse operating costs, efficient management of replenishment operations is important to ensure the availability of items for picking and to decrease the operating costs, which might be particularly high in warehouses with fast-moving items (Çelik et al., 2022).

2.2.1.4. Slotting

Slotting operations involve the allocation of SKUs to the proper location in the warehouse in such a way that the requested items can easily be picked during the picking process (Bahrami et al., 2019; Heragu et al., 2007). In accordance with Heragu et al., (2007)

and Viveros et al., (2021), the slotting process aims to improve the efficiency of order picking by searching for an intelligent arrangement of products within the warehouse while minimizing the total traveling time of the order pickers during the picking process.

The two main slotting strategies used are random and dedicated storage. Random storage means that any location within the warehouse can be selected to store an item (Heragu et al., 2007). Dedicated storage refers to the allocation of items to specific locations, usually based on the turnover rate or picking frequency of the SKU (Heragu et al., 2007). According to Rushton et al., (2014), the storage assignment in dedicated storage usually takes into consideration the most valuable picking area, often referred to as the "golden zone", usually corresponding to locations with ideal picking height or the area nearest the start or finish of the picking run or a combination of both.

2.2.2. Storage and Handling Systems

Storage and handling systems are responsible for receiving, storing, and moving goods within the warehouse, and are a key factor in determining the overall productivity and efficiency of the warehouse. Storage is the core activity of warehousing, and it identifies the location where goods are deposited and held until they are demanded usage (Gunasekaran et al., 1999). Effective storage systems can result in substantial cost savings owing to increased productivity and efficient space utilization (Shah & Khanzode, 2015). *Picker-to-goods* strategies remain the most utilized method in warehouse operations. However, *goods-to-picker* methods are gaining ground as automation becomes increasingly sophisticated and affordable (Richards, 2018).

Rushton et al., (2014) divide Warehouse Storage Systems into two categories: palletized and non-palletized systems. Pallets can be considered as the most significant unit load in warehouses (Rushton et al., 2014). Some products are not suitable for palletization because of their larger dimensions or shapes. Therefore, approximately half of the total items in a warehouse are stored in units other than the pallets. Regardless of the system, each SKU must have a specific location.

2.2.2.1. Palletized Systems

Pallet

The largest standardized material-handling unit is the pallet (Bartholdi & Hackman, 2019). A pallet consists of a raised flat platform often made of wood, where the product can be easily stored, lifted, and moved using truck forks inserted on the base (Ackerman, 1990). This type of storage is ideal for products with high inventory levels and scenarios in which strict First-In First-out (FIFO) is not required (Shah & Khanzode, 2015).

Block Stacking

This system is the simplest and most common method of pallet storage, with pallets placed on top of one another, without the need for any racking (Richards, 2018; Rushton et al., 2014). The products are packed in unit loads and stacked on the floor to their maximum safe height (Richards, 2018). This system follows the Last-In First-Out stock management since the pallets are extracted in reverse. Block stacking is commonly used for a few product lines with high inventory levels and has the advantage of quick access to inventory for rapid throughput operations and low capital cost (Rushton et al., 2014).

Drive-in and drive-through Rack

These systems offer a secure and effective substitute for block stacking for delicate or unstable loads that cannot be piled on top of one another. In place of the longitudinal beams that generally hold the pallet and load on conventional racking, each rack includes an L-shaped rail for the pallets to rest on, with enough room for forklift access (Richards, 2018). The pallets must be more robust than usual because they must support the weight of the load across the space between the rails, as seen in Figure 2.3.

In Drive-in racks, the unit loads are stored and retrieved on the same side, according to Last-In-First-Out (LIFO) strategy, whereas in Drive-through racks, the units are stored and retrieved on opposite sides (Hompel & Schmidt, 2007), as seen in Figure 2.3.

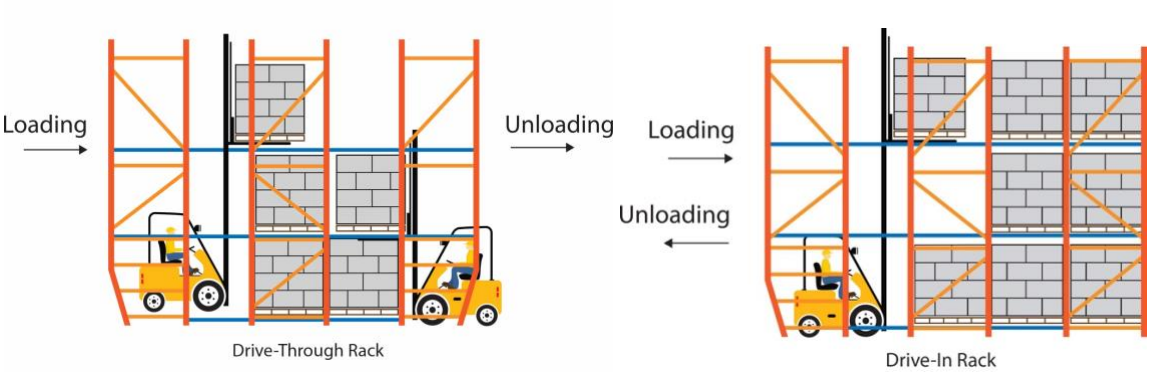

Figure 2.3 Drive-through and Drive-In Rack Systems (Source: https://rebstorage.com/our-products/rack-products/drive-in-and-drive-through-rack/ , consulted on 19/01/2023)

Push-back Rack

In Push-back systems, when a pallet is loaded from the front, it pushes the pallet behind it in one position. When unloading, the front pallet is removed, and the pallet behind it comes forward to the front, allowing for LIFO inventory management (Richards, 2018). The unit loads are moved using rollers with a slight incline. Loading and unloading are accessed in the same aisle, as it can be observed in Figure 2.4.

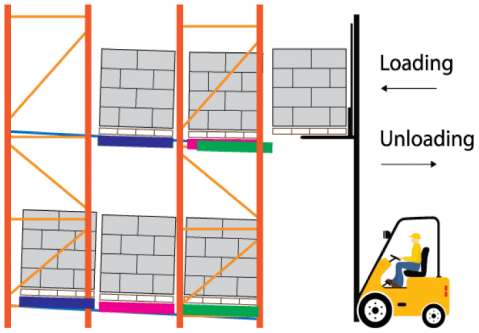

Figure 2.4 Push-back System (Source: https://rebstorage.com/our-products/push-back-rack/, consulted on 19/01/2023)

Pallet Flow Rack

The pallet Flow Rack consists of a deep lane rack with slanted shelves and lines with rollers (Bartholdi & Hackman, 2019). The pallets are loaded at the upper end of sloping lanes, and move down by gravity, allowing FIFO stock rotation (Richards, 2018). This enables pallets to be replenished on one side and picked from the other side, meaning that

the replenishment operation does not interfere with picking (Bartholdi & Hackman, 2019). This system can be seen in Figure 2.5.

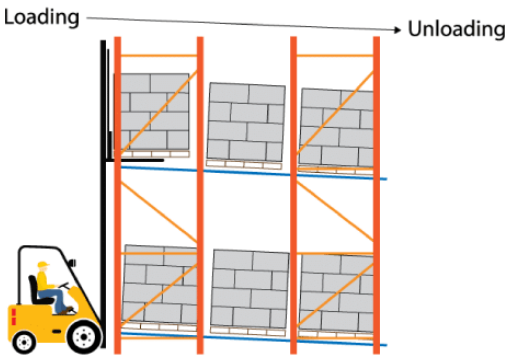

Figure 2.5 Pallet Flow Rack System (Source: https://rebstorage.com/our-products/rack-products/pallet-flow-rack/ , consulted on 19/01/2023)

2.2.2.2. Non-Palletized Systems

Shelving or Static Rack

Shelving is the most basic and least expensive storage mode (Bartholdi & Hackman, 2019), and is commonly used to store fewer products and items with smaller dimensions than a pallet storage system (Richards, 2018). Subdividers can be used so that several specific locations can be established to hold several different SKUs on one shelf. Similarly, drawer units or small plastic bins can be incorporated to store small items (Rushton et al., 2014). This type of storage is typically located in long rows that are accessible by aisles.

Carton Flow Rack

Flow racks have a slanted shelf that operates using gravity-fed rollers that move load carriers from the stocking aisle to the picking aisle of the system (Hompel & Schmidt, 2007; Richards, 2018). This type of storage is suitable for products in cartons or tote bins, as these have smooth bottoms that will run along the rollers (Rushton et al., 2014). Storage and retrieval are independent of one another since they occur in separated sides. In addition, such systems invariably operate in accordance with the FIFO principle because the first carton or tote inserted into the system is the first one to be removed (Rushton et al., 2014).

Flow racks are used for light as well as for heavy-piece goods (Hompel & Schmidt, 2007). This system can be observed in Figure 2.6

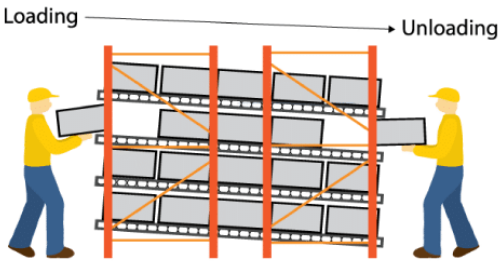

Figure 2.6 Push-back Systems (Source: https://rebstorage.com/our-products/carton-flow-rack/, consulted on 19/01/2023

Roll cages or Roll Containers

Roll-Cages are mobile storage units consisting of a metal frame and have a cage-like shape, with mesh bottoms and sides. Wheels are placed in each corner of the base to provide smooth travel and are often equipped with shelves (Rushton et al., 2014). This type of system allows for easy storage and transport of various goods around the warehouse.

Dolly

According to Rushton et al., (2014), this type of system consists of a platform with wheels that allow the movement of goods, typically plastic trays or containers. Dollies are commonly smaller than Roll-cages and provide easy transport and storage throughout the warehouse.

Freezer Island

A freezer island is a storage solution designed for the storage of perishable goods such as frozen or refrigerated food products. These consist of refrigerated areas surrounded by shelves or racking. This system allows for the storage of items under optimal temperature conditions to ensure their safe conservation (Bartholdi & Hackman, 2019).

Carousels

A Carousel is a rotatable shelving circuit that allows the storage location to travel to the order-picker instead of the opposite (Bartholdi & Hackman, 2019). They are normally computer controlled, bringing the appropriate shelf to an access point for the operator by the shortest possible route and at the ideal height for picking (Rushton et al., 2014). Products are directly placed onto shelves (with different SKUs normally separated by dividers), in tote bins resting on shelves, or in drawer units fitted into shelves (Rushton et al., 2014). Investment in carousel systems is paid back primarily by reducing travel time for picking and by reducing storage space (Ackerman, 1990).

Horizontal carousels work on a principle similar to that of the amusement ride carousel. It can be composed of shelves, bins, or garment holders that rotate and are controlled by an operator. These are ideal for storing and picking high numbers of SKUs, small individual items, and medium to large cartons (Richards, 2018)

Vertical lift modules are enclosures that have shelves that rotate in either direction similar to a large wheel at a fun fair, bringing a requested item to the operator at a suitable working height. They allow you to use the maximum height available within the building, providing the best use of space. Vertical carousels are ideal for small to medium-sized parts (Richards, 2018).

Conveyors

Conveyors are commonly used to move pallets, cartons, tote bins, and other loads between fixed points, and for holding goods and move goods to the operator workstations, allowing for *goods-to-picker* systems (Richards, 2018). Powered conveyors are usually used to transfer goods along long distances and utilize belts, chains, slats and rollers (Richards, 2018) On the other hand, gravity conveyors are commonly used to transfer loads along short distances and can have non-powered or powered rollers or belts (Richards, 2018). Conveyors can be suitable for situations with high throughput, fixed routes, and continuous movements (Richards, 2018).

Automated guided vehicles

Automated guided vehicles (AGVs) are battery-operated computer-controlled trucks that can automatically move pallets, or other unit loads, throughout the warehouse,

without the direct interference of humans (Hompel & Schmidt, 2007; Rushton et al., 2014), being highly flexible in different warehouse layouts (Ackerman, 1990). The advantages of the use of this system are the reduction of labor costs, transportation in dangerous areas to prevent labor incidents, accuracy or strictness and avoidance of floor installations in favor of rail-bound systems (Hompel & Schmidt, 2007).

2.3. Quality

Quality can be characterized as the absence of a defect or degree of excellence (Shewfelt, 1999). Quality in the food industry refers to the degree to which food products meet or exceed customer expectations and requirements with respect to safety, appearance, taste, aroma, texture, and other sensory attributes (Damodaran & Parkin, 2017). For German consumers, product quality is an important factor in purchasing decisions, especially in online shopping (Seitz et al., 2017).

When storing food items, the preservation temperature is crucial for maintaining quality standards. In the distribution center, proper preservation of the goods requires that there should be at least room, chilled and frozen temperature zones (Kämäräinen et al., 2001). Quality of Service in the supply chain context can be defined as the difference between the expectations and perceptions at each level within the supply chain (Seth et al., 2006).

2.3.1. FEFO principle

Efficient goods logistics in the food sector are an important factor in reducing product losses and waste and increasing product shelf life and customer satisfaction. Sazvar et al., (2016) state that according to the FEFO (First-Expired First-Out) principle products that are to expire soon should be removed from stock on a priority basis, meaning the products are dispatched from the warehouse in order of their expiration date regardless of the date of entry or acquisition. FIFO (First-In First-Out) principle implies that products that entered first in the warehouse are selected first to issue, while FEFO implies that the items that were manufactured earlier are first to be issued. This principle is most suitable for perishable products (Mendes et al., 2020).

2.3.2. Shelf-life

Although there is no established definition of the shelf life of a food product, it can generally be defined as the finite length of time after production a food retains a required level of organoleptic and safety qualities under stated conditions of storage (Valentas et al., 1997). In the food industry, this period is based on the extent of quality loss in food that the company will allow prior to its consumption (Fu & Labuza, 1993). Loss of a desirable food quality attribute can be measured using sensory, empirical, or analytical techniques (Valentas et al., 1997).

2.3.3. Best-before and used-by date

Best-before date can be considered as the last date on which food can be expected to retain all its quality attributes, provided it has been stored according to any stated storage conditions and the package is unopened (Newsome et al., 2014). Used-by date can be defined as the last date on which the food may be eaten safely, provided that it has been stored according to any stated storage conditions and the package is unopened, after which the food should not be eaten for health and safety reasons (Newsome et al., 2014).

2.3.4. Perishables

According to van Donselaar et al., (2006), perishable food products have a short shelf life of less than or equal to 30 days. A product is considered perishable if the high rate of deterioration under ambient storage conditions requires specific storage conditions, providing temperature reduction at the store and/or at the consumer facilities to slow their deterioration rate and deter spoilage. This usually excludes frozen food since the rate of deterioration is very low in the freezer. Perishable inventories commonly found in this industry include refrigerated products such as fruits, vegetables, meats, and bakery items (Valentas et al., 1997).

3. RESEARCH METHODOLOGY

This chapter explains the methodological approach used in this dissertation, following the Saunders et al., (2019)'s Research Onion. Then, the research steps that were followed throughout the development of the present study are described. Finally, the data collection and analysis methods are presented.

3.1. Methodology Overview

This section aims to illustrate the research decisions taken in the development of this research work, presented in the Saunders's Research Onion in Figure 3.1. The layers of the Saunders's Research Onion can be divided from the outer layer to the inner layer into Methodological Choice, Strategy(ies), Time Horizon, Techniques and Procedures.

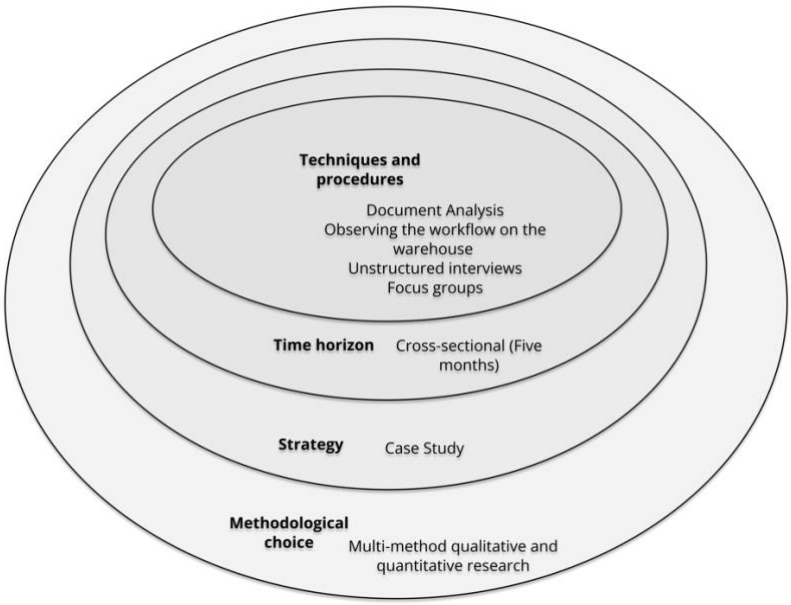

Figure 3.1 Research methodology

Methodological Choice

Regarding methodological choice, quantitative or qualitative methods can be used, with the first being used for numerical data and the second for non-numerical data (Saunders et al., 2019). In this study, multi-method qualitative and quantitative research was used. Using both dimensions allowed for detailed analysis of the data to obtain answers to the research questions.

Strategy

A research strategy can be defined as a plan of how a researcher will answer the research question(s) (Saunders et al., 2019). Considering the research project was done in a company context, a case study strategy was chosen. The case study focused on the online-only supermarket Picnic, specifically on its operations at the Langenfeld Fulfillment Center (FC2), located in Germany. This research strategy involves an empirical investigation within its real-life context using multiple sources of evidence (Saunders et al., 2019).

Time Horizon

This section describes the timeframe defined for the execution of a project. The research time horizon is considered cross-sectional when the study is limited to a particular time or longitudinal when the research is executed for an extended period, considering change and development (Saunders et al., 2019). The execution of the present project lasted five months, corresponding to the duration of the curricular internship, which was classified as cross-sectional due to its limited time frame.

Procedures and Techniques

This case study research strategy requires a full understanding of the specific case using, therefore, data gathered through different research methods, such as document analysis, observation, unstructured interviews, and focus groups.

3.2. Research Steps: Implementation of Design Thinking

In the present dissertation, Design Thinking (DT) was used as an approach to develop warehouse storage solutions to reduce customer quality complaints related to freshness issues.

Brown and Funk (2012) define Design Thinking as a methodology that applies a human-centered design approach to the complete range of innovation activities. It uses the designer's sensibility and techniques to balance what is technologically possible with what is a workable business plan. It develops onto customer value and market opportunities. The principal characteristics of the application of this approach are:

- *User focus*: The development of solutions should take into consideration the user needs and points of view and has empathy as its core value. Users should be involved in ideation, prototyping, and testing, and feedback should be gathered and implemented during these phases (Carlgren et al., 2016).
- *Problem Framing:* The initial problem should be repeatedly questioned and reformulated to expand the problem and solution space (Carlgren et al., 2016).
- *Visualization:* Visual representations make ideas visual and tangible by means of representation of solutions in sketches, improvisation, or by making simple models with the use of physical materials (Carlgren et al., 2016).
- *Experimentation:* DT is characterized by trial and error, learning through iterative forms, prototyping, and trials that test a range of possible solutions (Beverland et al., 2015).
- *Diversity:* by the integration of diverse perspectives and backgrounds throughout the process (Carlgren et al., 2016; Meinel & Leifer, 2011).

DT process involves three steps: *inspiration*, *ideation*, and *implementation* (Brown, 2012; Brown & Wyatt, 2010). *Inspiration* involves a problem or opportunity that motivates a search for solutions. Observing people's needs in the field and conducting research are part of this stage. *Ideation* is the process of generating, developing, and testing

ideas, which can lead to potential solutions. Lastly, *Implementation* is the path that leads from the project stage to a fully concrete action plan. This involves prototyping and turning ideas into actual products and services, which are then tested and refined.

Firstly, in the *inspiration* step, the company's processes were observed and executed in detail in the Fulfillment Center (FC) located in Langenfeld, Germany, for a duration of three weeks. Additionally, Picnic's documents were analyzed to further understand the processes and the company guidelines and requirements. After this period, ten unstructured meetings were held with experienced employees from different fields to gain insights into potential issues and concerns that would lead to the research's main objective. These meetings allow to establish the project assumption that *different storage systems have influence on customer complaints related with BBD-too-short in the freshness category.* To determine the project's scope, objectives, and questions, it was also deemed necessary to hold two meetings with the project advisors from Picnic, the FC Lead and Quality of Service Lead from FC2, to align the research objectives with the needs of the institution and the company.

Secondly, the *ideation* step involved validation of the data analysis and the search for potential improvements in the storage systems used by the company to reduce the number of freshness issues related to BBD. For this purpose, recurring meetings were held with Picnic's project advisors and the institution's supervisor to provide guidance during the research and development of potential solutions. Then, two focus groups were conducted to gather feedback and input from experienced employees from different backgrounds regarding the proposed storage solutions. Finally, the outputs of the focus groups were taken into consideration, to produce the results of this work.

In the Implementation involved the prototyping and transforming the solution into a sketch. Due to time constrains the physical prototype wasn't created, however, the company validated the outputs of the present work and has the knowledge needed to implement the suggestions in the Fulfillment Center to reduce customer quality complaints related to freshness issues.

3.3. Data Collection and Analysis

Documentary analysis, observations, unstructured interviews, and two focus groups were used in this dissertation. The data collected and analyzed refers only to the Fulfilment Center located in Langenfeld, Germany, from January 1st to September 31st, 2022. This timeframe was chosen to simplify the data gathering of qualitative information from the employers because they are less likely to remember useful information if the timeframe chosen was more extensive.

For quantitative data collection, information was taken from an internal database stored in Tableau and exported to Excel sheets. The data gathered included the following parameters:

- Fulfillment Center (FC)
- Date of the complaint
- Article ID
- Article Name
- Article Category L1
- Article Category L2
- Complaint Issue L0
- Complaint Issue L1
- Complaints Issue Total Quantity

The dataset was then filtered to obtain relevant information. From this dataset, it was filtered the Fulfilment Center located in Langenfeld, FC2, Complaint Issue L0 considered was Freshness and Complaint Issue L1 was BBD-too-short. This dataset was relevant for analyzing the number of customer complaints each product had as well as the product category and subcategory. An extract of this *Complaints Dataset* can be seen in Appendix A.

In addition, a supplementary dataset containing the following information was needed:

- Fulfillment Center (FC)
- Date of picked items
- Article ID
- Pick Location
- Storage type
- Pick quantity

From this dataset, it was selected the Fulfilment Center FC2. This dataset was relevant for gathering information regarding the storage system used to store the SKUs throughout the defined time frame. In addition, it was possible to obtain the sales of the products, as they corresponded to the total picked quantity in the period chosen. A frame of this *Storage Type Dataset* Excel Sheet can be seen in Appendix B.

Through the analysis, qualitative information was gathered through observation of the FC and frequent unstructured interviews with the project advisors from the company, which allowed for a better understanding of the products and special cases that should be taken into consideration.

ABC analysis

According to Richards (2018), before laying out a warehouse, deciding on the most suitable handling equipment, installing storage systems, and deciding on the type of picking system to implement, a detailed ABC analysis of the products in stock should be conducted.

ABC analysis was primarily used for data analysis. To classify SKUs, ABC analysis is frequently used in the stock management decision-making process because of its simplicity and versatility (Rushton et al., 2014). This analysis is based on the Pareto Principle, which states that 80% of the effects originate from 20% of the causes (Richards, 2018). Through this analysis, products can be divided into three groups: A, B, or C, according to one specific criteria. A category of products accounts for approximately 20% of the total items and can be considered the most relevant. Followed by group B, with medium relevance and corresponding to about 15% of the total products. Finally, C products encounter the least relevant items, corresponding to approximately 5%. Therefore, it allows the classification of products according to their relevance to the company.

This type of analysis was conducted on the *Complaints Dataset* to determine the products that were having a higher impact in the number of customers complaints related with BBD-too-short for the company.

Focus Groups

To gather qualitative data and gather feedback on the research done regarding the storage system solutions and proposals, two focus groups were conducted.

The first focus group had a duration of 45 minutes and had present the interviewer, a Fulfillment Analyst, a Fulfillment Launch Lead, and a Quality of Service Supervisor. The following topics were covered:

- Discuss the ideal storage solution for the critical product categories from the storage types that are already used in Picnic.
- Discuss the storage proposal for the Milk product category from the suggested storage system that isn't used by Picnic.

The second focus group had present the interviewer, a Quality of Service Lead, a Slotting Lead, a Fulfillment Analyst, and the Fulfillment Center Lead from FC2 which lasted for 45 minutes. The topic covered in this focus group was:

- Defining improvement requirements to be implemented on a storage system for the Meat category of products.

The data collected on the focus groups was implemented in the decision-making process as well as in the development of solutions in storage systems. The presentations used in the focus group can be consulted in Appendix C.

4. CASE STUDY DESCRIPTION

4.1. The Company: Picnic Technologies

Picnic Technologies is an online-only supermarket founded in 2015 in the Netherlands in response to the growth of online grocery shopping. Founded in 2015, the company was quickly established as one of the fastest-growing companies in the Netherlands in 2019, with hundreds of thousands of customers and monthly expansion into new cities. With a focus on providing high-quality products at affordable prices, Picnic differentiates itself from other online grocery retailers by offering a unique shopping experience that is fast, convenient, and easy to use. The company's innovative business model and commitment to customer satisfaction have helped it to grow rapidly and build a loyal customer base.

Some of the company's distinct features are:

- Orders via the online app: Picnic is an online supermarket, therefore, it does not have any physical brick-and-mortar stores.
- Next-day efficient delivery: The customer can place an order until 22h of the same day and expect to receive it the next day in a selected fixed time slot chosen by the consumer.
- Low price and free delivery: the company does not charge for delivery, and the orders can be placed from a minimum price of 35 euros.
- Sustainable delivery: deliveries are made using 100% electric cars that do not emit CO2 and cause less noise pollution than conventional trucks.

Picnic is currently based in the Netherlands, Germany, and France. The company has Automated and Manual Fulfilment Centers, however this research focuses on the Manual Fulfilment Center located in Langenfeld, Germany (FC2).

4.1.1. Supply Chain Process and Operations

As part of Picnic's Supply Chain, Fulfillment Centers are used to handle the entire order process, from receiving to storage and handling to delivery of products to customers, similarly to a warehouse. In the FC, inbound is received from various suppliers that provide high-quality products, including fresh produce, dairy, and other groceries. The products are then stored in temperature-controlled conditions. Then, the workers pick the orders into totes, that later get shipped to the Hub in frames. In this location, the orders are delivered to the customer's home in Electric Picnic Vehicles (EPV). Picnic Warehouse Management System (WMS) runs in all its FCs and Hubs, keeping track of stock levels and supporting internal flows from inbound to outbound. The company Supply Chain is shown in Figure 4.1.

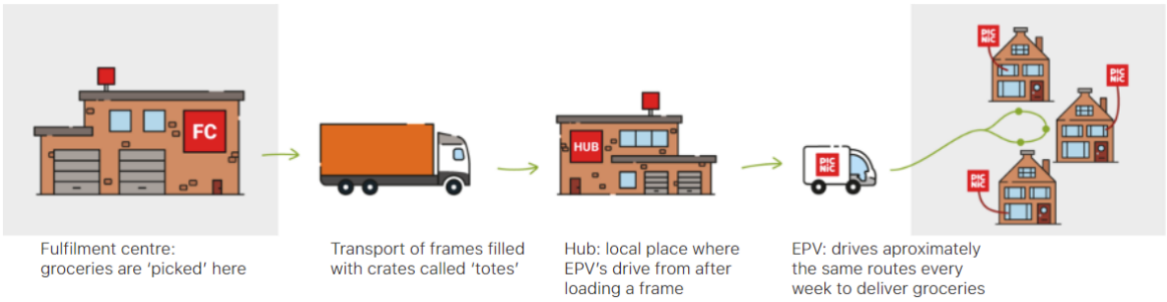

Figure 4.1 Supply Chain simplified (Picnic)

Regarding operations, Picnic follows a typical warehouse operation system inside the Fulfilment Centers, similar to what can be seen in Figure 4.2. The focus of the present research will be on Order Picking, Receiving and Replenishment and Slotting Operations, what will be described in detail.

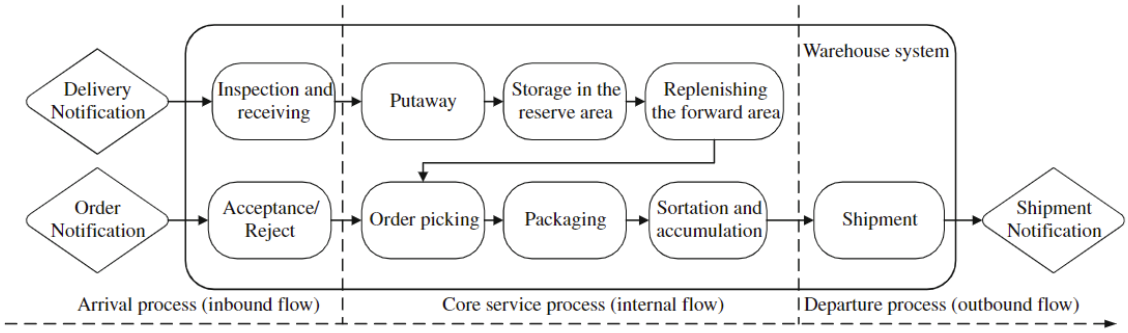

Figure 4.2 Typical warehouse operations from a stochastic process view **(Gong & de Koster, 2011)**

Order Picking

At Picnic, order picking involves retrieving an item from a pick location and placing it in an order tote. It is performed manually by shoppers based on a *picker-to-parts* system. During a picking round, a shopper moves through the picking circuit with a set of customer totes on a pick cart containing 21 totes, each of which corresponds to a specific customer order. The Warehouse Management System (WMS) directs the shopper from pick location to pick location to complete all planned picks for customer totes during that pick round. There are three distinct zones in Picnic FCs: ambient, chilled, and frozen. In accordance with the product storage recommendations, the products are placed in the zone where they are best preserved. Two types of totes are used: plastic totes for ambient-temperature storage and Styrofoam isolation totes for chilled and frozen items to maintain their cold temperatures.

Receiving and Replenishment

Receiving is the process of moving products upon the arrival of carriers to a location in the warehouse. It is done in the morning and evening with the inbound coming from various suppliers, based on the First-Expired First-Out (FEFO) principle. FEFO suggests that items with the earliest expiration dates should be sold, used, or discarded first. To speed up the picking process and manage stock efficiently, the company separates the bulk stock in the buffer area (or reserved area) and the picking stock in the forward area. The inbound can be received directly at the forward area, or, if the location is already full, the products are received and stored in the buffer area.

Regular internal replenishment is done from the reserve to the forward area when stock levels on the pick locations fall below a predetermined quantity. In this operation, the shoppers replenish the products' picking location with buffer stock according to the FEFO principle. So that the receiving and replenishment operations do not interfere with the order-picking process and FEFO can be easily implemented, these operations have a designated aisle distinct from the picking aisle.

Slotting

Slotting can be defined as the process of organizing inventory, in which an item is assigned or removed from a location. This method improves the overall storage capacity of the FC and maximizes the efficiency of order picking. Slotting also includes changes in the storage system type used.

In this operation, the company follows *Slotting requirements* that allow to optimize the storage of products, minimize waste, and improve the efficiency of the Fulfilment Center. *Slotting requirements* can include factors such as product size, weight, and fragility, as well as the volume of products stored in the storage system, to ensure that the products are stored in the appropriate conditions to maintain their quality and freshness. In addition, establishing specific guidelines for the placement of products can also influence the safety of the workers handling the products. For example, products that are heavy or bulky may need to be stored in specific locations to reduce the risk of injury to workers.

The process ends when all orders scheduled for shipment have been fulfilled, the truck has been loaded with the frames containing the order totes and has departed for the Hub. Here, frames are loaded into EPVs which then deliver the orders to the customer's home. Picnic's delivery model is unique since it operates using electric vehicles and a dynamic routing algorithm to optimize delivery times and reduce emissions. The company’s EPVs are equipped with smart refrigeration units to keep food products at the right temperature during transit.

Picnic's Supply Chain is designed to provide a seamless and sustainable online grocery experience for customers, while also minimizing waste and reducing the carbon footprint of the company.

4.1.2. Warehouse Storage Systems

To manage and store inventory in Picnic Fulfilment Centers, different warehouse storage systems are used. The goal of a warehouse storage system is to optimize space utilization, improve order accuracy and speed, and increase overall operational efficiency. These systems can be designed and customized based on the specific needs and requirements of each warehouse and the products they store, as per product type and dimensions. There

are six types of Storage Systems used in Picnic's Fulfillment Centers, them being: Dolly, Flow Rack, Freezer Island, Pallet, Roll Container, and Shelving.

Dolly

Commonly, Dollies are described as storage units consisting of a wheeled base on which plastic trays and tote bins can be stacked. At Picnic, the base is immobile and lacks wheels, and products are stacked in various plastic trays above it. This system is primarily used for bread and is located at the end of the picking circuit. An example can be seen in Figure 4.3.

Figure 4.3 Dolly Storage System in FC2

Flow Rack

In Flow Rack storage systems, products are placed on plastic trays on slanted rollers that roll forward until they reach the lower end due to the force of gravity, ensuring that the FEFO principle is followed, as it can be seen in Figure 4.4. This type of system is used mainly for meat, fish, and veggie products inside the chilled area.

Figure 4.4 Flow Rack Storage System in FC2

Freezer Island

A Freezer Island is defined as a refrigerator with a door that opens from the top. It is generally located in the chilled zone and is used for products that require colder storage conditions than the chilled environment. This system is also located in the frozen zone to store frozen products. According to German law, ground beef and sausages must be kept on freezer islands, inside the chilled area. An example of this storage system can be seen in Figure 4.5.

Figure 4.5 Freezer Island Storage System in FC2

Pallet

A Pallet storage system consists of a raised, flat platform, typically made of wood, on which products can be easily stored, lifted, and moved using truck forks inserted into the platform's base. It is typically used to store heavy loads and large quantities of units, typically beverages, as it can be seen in Figure 4.6.

Figure 4.6 Pallet Storage System in FC2

Roll Container

Roll Containers allow the storage of materials in horizontal rows on multiple levels due to the presence of shelves. This system is constructed of steel with a mesh bottom and has wheels in the bottom corners, allowing it to be easily moved around the FC. Typically, products are placed in plastic trays and stacked in this storage system, allowing for a large variety of products to be stored. They are primarily utilized for vegetables, beverages, eggs, cereals, and numerous other items in ambient and chilled areas. An example of a RC can be seen in Figure 4.7.

Figure 4.7 Roll Container Storage System in FC2

Shelving

Shelving is the most common type of material handling storage solutions system in Picnic. They are in chilled and ambient zones in long aisles throughout the FC. They are commonly used for individual items of a multitude of sizes and dimensions. One shelf can be subdivided so that it can hold a variety of SKUs, as it can be observed in Figure 4.8.

Figure 4.8 Shelving Storage System in FC2

4.1.3. Quality of Service

In traditional supermarkets with brick-and-mortar stores, the customer does their shopping by picking the articles from the shelves and seeing and selecting the desirable quality of the products they are buying, unlike online supermarkets where the customer has no contact with the products until they receive them. Since Picnic is a fully online retailer, the company needs to ensure the maximum quality of all the products, from the FC to the customer's home.

Quality of Service is critical for Picnic. A certain product can be qualified as a bad quality product for the customer if it meets the following sentence*: "If the most critical customer would complain about this product, we don't want to sell it to him"*.

Once the products are delivered to customers, Picnic offers a customer support service to address any issues that may occur with their order. The customer can report complaints related to the overall order and the quality of the products received. Customer complaints can be divided into three categories: Damaged, Missing, and Freshness.

Damaged issues

Damaged issues can be reported by the customer when the article received is broken, has a packaging issue, or the product is not delivered at the right temperature or in the right conditions.

These complaints can be categorized into those different sub-categories:

- Chilled product is frozen
- Heavy on top
- Product damaged
- Product dirty because of other product
- Product eaten before delivery
- Product leaking/packaging open
- Product melted/defrosted
- Product wet at delivery (e.g., rain)

Missing issues

These types of issues are a result of failing to deliver a complete order, without the customer being informed of this fact prior. If the customer is notified that he's getting a substitute product, it it's expected that the customer fills the missing complaint.

The missing issues can be subcategorized in:

- Product missing
- Product missing (automatic)
- Product not complete
- Wrong quantity (extra)

Freshness issues

Freshness issues can be reported by the customer when the article they received is not proper for consumption. Some reasons can be that the product has quality issues, being that it is too ripe or not ripe enough or is not fresh. Also, the Best-before date can be too short, leading to the product not meeting the *Customer Freshness Guarantee Days*, as promised by the company.

Customer Freshness Guarantee Days correspond to the number of days of freshness promised to customers in each product. These are the minimum number of days of freshness from the delivery date until the item reaches their BBD, implying that when the final consumer receives their order, they are expected to have a few days to consume the products, without compromising on quality and safety. For example, if a product has a freshness guarantee of 10 days and it is delivered on September 1st, it should have a BBD of at least September 11th (according to Germany food safety requirements). Depending on the product category, the number of "freshness days" varies. The *Customer Freshness Guarantee* of each article can be consulted in the Picnic App. If the product doesn't meet this concern, the consumer can report this issue as BBD-too-short, inside the Freshness category.

To ensure *Customer Freshness Guarantee Days*, the supplier also needs to follow *Supplier Freshness Guarantee* towards Picnic. These correspond to a minimum number of days of freshness on the day of inbound before expiring.

The freshness issues can be subcategorized in:

- BBD is too short

- Product is not ripe enough
- Product too ripe
- Product spoiled / not fresh
- Unhappy with freshness guarantee

4.2. Problem Description

After conducting multiple interviews with experienced employers from Picnic to better understand potential issues in the process, a recurrent concern was the number of customer complaints regarding freshness issues, specifically related to customers receiving products with too short best-before dates. In these cases, the company wasn't respecting the *Customer Freshness Guarantee Days* that are described for each product while the consumer is making their order online. This factor was leading to multiple dissatisfied customers, food waste, and increased costs.

Observing the workflow on the warehouse floor and conducting unstructured interviews with supervisors and employers, it was possible to identify some of the possible root causes for the Freshness issues related to BBD-too-short, as shown in the Cause-and-Effect diagram in Figure 4.9.

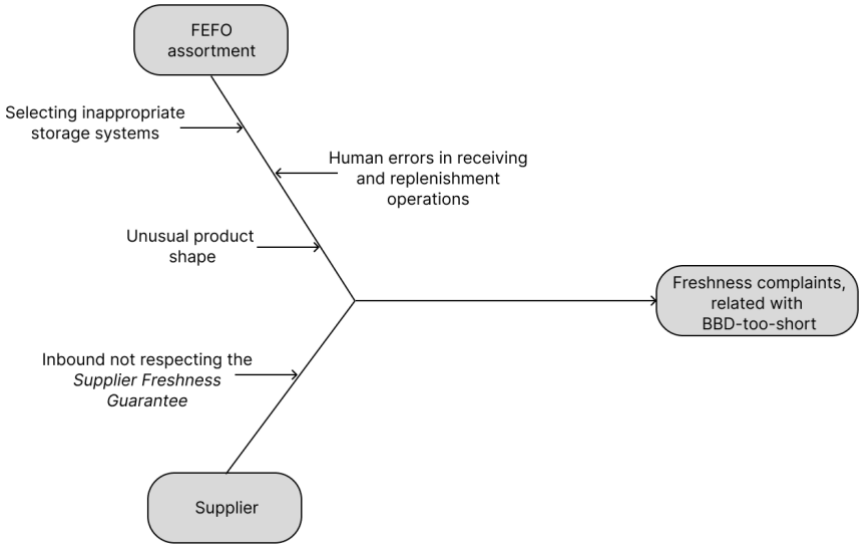

Figure 4.9 Cause-and-Effect diagram for Freshness issues related with BBD-too-short

One of the potential causes originates directly from the Supplier, as the inbound received at the Fulfillment Center may already have insufficient BBD upon arrival, not respecting the *Supplier Freshness Guarantee Days*. The other potential cause is the difficulty in maintaining the FEFO assortment in some picking locations. The present study will focus on the analysis of the FEFO assortment related causes, as this is a factor that can be controlled and improved by the company and is not influenced by external entities.

As the replenishment of products is executed, the products are placed in the picking location following the First-Expired First-Out (FEFO) principle. In other words, the new inbound is placed behind the old inbound, to ensure that during the manual picking process, the product with the closest expiration date is picked and delivered to the customer first. However, the FEFO assortment is not always followed in some locations. It is assumed that one or more of the following factors contributes to FEFO issues:

1. Unusual shape of some items – the lack of structure on some items can result in non-stack ability at the location and disrupt FEFO assortment.
2. Human errors – employers often make receiving and replenishment mistakes, not respecting the FEFO principle.
3. Selecting inappropriate storage systems – different products require different storage systems, and in some storage types, the FEFO assortment can be harder to maintain.

The first reason (unusual shape of some items) is the most challenging to address, given that the company does not manufacture the products but rather acquires them from a variety of suppliers. To change the shape of a product, it would be necessary to approach the suppliers for this purpose, but since this Fulfillment Center has few orders, the suppliers would most likely deny this request.

Regarding the second reason, despite shoppers being instructed in the proper application of the FEFO principle in receiving and replenishment operations, human errors are a constant problem since workers do not adhere to the standard work. The company has a hard time taking measures for this concern since shopper retention is very low—about 50 percent of employees leave after 8 weeks—and the company doesn't have enough human resources to control and instruct repeatedly on the proper way to execute this task.

Lastly, the selection of inappropriate storage systems in some product categories can lead to FEFO issues. The optimal choice of the right storage system for each product category is controlled by the company taking into consideration the product's shape, size, number of sales and specific *Slotting Requirements* that should be taken into consideration in each case. The correct choice of the storage system used in each category might improve the FEFO stock management in the location, and consequently reduce costumer's freshness complaints related to BBD-too-short.

The present dissertation will analyze the following assumption:

Different storage and handling systems have influence on customer complaints related with BBD-too-short in the freshness category.

This research will follow a Design Thinking approach to develop improvements and solutions for the storage and handling systems that can be implemented in the FC2 in the future to improve the Quality of Service provided by the company.

5. RESULTS AND DISCUSSION

To analyze the present situation the period from January 1st to September 31st 2022 was considered. The examined products have at least one customer complaint regarding BBD-related freshness issues. In total 547 SKUs were taken into consideration, corresponding to a total of 1461 customer complaints in this period from the orders placed in the Fulfilment Center located in Langenfeld, Germany (FC2).

Firstly, an ABC analysis was performed to determine the critical products that had the highest relevance for the company in terms of the number of freshness complaints related to BBD being too short. Secondly, the material storage systems of the relevant items were analyzed, focusing on the SKUs that had storage changes in the time frame selected (January 1st to September 31st 2022). This analysis allowed to conclude what would be the most suitable storage systems used by the company to diminish the issues in the product categories analyzed.

In addition, two focus groups were conducted to discuss the research done and to define requirements to be applied to new storage systems taking into consideration the inputs of experienced employees of the company and applying their feedback to the outcomes of the research.

5.1. Critical Products: ABC Analysis

This analysis enables to recognize the critical products that are more relevant for the company to tackle and therefore, have a bigger impact on the number of customer complaints. Focusing on these key items will allow Picnic to diminish consumer complaints significantly and reduce waste and costs. ABC analysis was conducted on the 547 products that had customer complaints regarding Freshness issues related to BBD-too-short in FC2 in the time frame selected.

This analysis allowed for the products to be divided into A, B, and C categories, as can be seen in Table 5.1. These results indicate that the 80/20 ratio of the Pareto Principle cannot be confirmed. However, it can be concluded that 24.3% of the products account for 60% of the complaints. These SKUs belong to the A category and are the most relevant for the company to focus on reducing their issues and customer complaints. Therefore, only this category of products will be further researched.

Table 5.1 ABC Analysis Results

Product Category	Percentage of complaints	Quantity of SKUs	Percentage of SKUs
A	60%	133	24.3%
B	25%	194	35.5%
C	15%	220	40.2%
Total	100%	547	100%

To determine if the storage type used to store the SKUs in the Fulfillment Center has any impact on the number of customer complaints, the A category of products was analyzed by their type of storage throughout the time frame selected. From the 133 SKUs analyzed, 113 maintained the same storage method throughout the selected period. However, 20 SKUs had storage system changes during this period, which may have contributed to an increase or decrease in the number of complaints, depending on the storage type used.

To confirm the assumption that *Different storage systems have influence on customer complaints related with BBD-too-short in the freshness category*, the 20 SKUs with storage modifications throughout the period were analyzed. Different storage types can impact the FEFO principle during picking, thereby increasing the probability of BBD-too-short issues once the customer receives the product. The same product can maintain better FEFO assortment in the location when stored in a certain storage system than when is stored in another type of system. To further analyze the 20 SKUs, a meeting was held with the Fulfillment Center Lead to determine which type of products should be considered in the analysis and special cases that should be taken into consideration.

Firstly, storage changes were only considered when a product has been stored in a particular storage type for over 20% of the total period selected. A product that had a storage type for less than 20% of the total period was likely a result of operator error and should therefore be excluded from the analysis. The time frame percentages can be calculated by adding the number of days an SKU had a picking action at a specific storage location and dividing by the total number of days actions occurred for this SKU. A certain SKU might not have daily picking actions if there isn't any customer order for this product on some days of the week or on Sundays since the company doesn't operate on this day of the week.

After applying this criteria, 4 SKUs didn't verify relevant storage changes in this period, due to the small time frame of some storage solutions (less than 20% of the total time), therefore, will not be considered in this analysis.

The 16 SKUs analyzed can be considered the critical products for the company to focus. The critical product's name, categories L1, L2, number of issues and complaints and storage system changes can be seen on Table 5.2. Since all the products have a different number of sales, the number of complaints made by the customers were calculated for each 10.000 sales, for the products to be comparable to one another. The formula (1) was used to determine the number of complaints per 10 000 sales.

$$Complaints\ per\ 10\ 000\ sales = \frac{Total\ issues \times 10\ 000}{Total\ Sales} \qquad (1)$$

Table 5.2. Critical Products in detail

			Issues		Sales		Storage type 1			Storage type 2			Storage type 3 (Current)		
Article Name	Category L1	Category L2	Total Issues	Issues in 10000 sales	Max sales in a day	Total Sales	Storage type	Issues in 10000 sales	Percentage of time stored	Storage type	Issues in 10000 sales	Percentage of time stored	Storage type	Issues in 10000 sales	Percentage of time stored
BÃ¼sch Mandelstuten geschnitten 340g	Bread, Cereals and Spreads	Sweet rolls & Waffles	10	21	55	4746				Shelving	35	35%	Dolly	13	65%
Gut&GÃ¼nstig Feiner Stuten 400g	Bread, Cereals and Spreads	Sweet rolls & Waffles	22	17	167	13127				Shelving	22	72%	Dolly	3	28%
Vriesen-Hof Eier Freilandhal 10er Pack Gr. M-L	Eggs & Milk	Eggs	4	2	295	23488				Roll Container	1	55%	Pallet	2	45%
Arla Bio Frische Weidemilch 1,5% 1L	Eggs & Milk	Milk	83	64	354	12906				Pallet	33	22%	Roll Container	78	78%
Arla LactoFREE Laktosefreie Milch 1,5% 1L	Eggs & Milk	Milk	10	18	173	5613				Shelving	0	61%	Roll Container	65	39%
Landliebe Frische Landmilch 3,8% 1L	Eggs & Milk	Milk	12	8	140	14329				Roll Container	11	74%	Shelving	0	26%
Edeka Bio Bio Frische Vollmilch 3,8% 1L	Eggs & Milk	Milk	6	1	854	67184				Pallet	0	24%	Roll Container	1	76%
Rasting Ganzes HÃ¤hnchen 1,1kg	Meat, Fish & Veggie Products	Poultry	9	42	37	2120				Roll Container	40	66%	Shelving	47	34%
Rasting HÃ¤hnchen-InnenfiletspieÃ¥e Curry T 300g	Meat, Fish & Veggie Products	Poultry	6	23	181	2625				Flow Rack	10	59%	Shelving	56	41%
Rasting HÃ¤hnchen Minutenschnitzel 400g	Meat, Fish & Veggie Products	Poultry	6	14	213	4412				Flow Rack	25	20%	Shelving	4	80%
Rasting HÃ¤hnchenflÃ¼gel gewÃ¼rzt 400g	Meat, Fish & Veggie Products	Poultry	3	7	188	4141				Flow Rack	0	65%	Shelving	18	35%
Rasting HÃ¤hnchen Filetstreifen 400g	Meat, Fish & Veggie Products	Poultry	7	6	432	12086	Flow Rack	0,0	35,3%	Roll Container	3	38%	Shelving	16	27%
Vion SchlemmerrÃ¶llchen Schinken KÃ¤se 3 x 100g	Meat, Fish & Veggie Products	Pig	12	72	45	1667				Shelving	102	68%	Flow Rack	17	32%
Rasting Cordon Bleu 500g	Meat, Fish & Veggie Products	Pig	4	17	202	2318				Shelving	25	80%	Flow Rack	0	20%
Rasting Nackensteaks gewÃ¼rzt 500g	Meat, Fish & Veggie Products	Pig	4	12	209	3274				Flow Rack	13	71%	Shelving	10	29%
Heemskerk Asiatische GemÃ¼sepfanne 400g	Vegetables	Ready-to-cook & Mixed Vegetables	3	11	153	2830				Roll Container	6	35%	Shelving	17	65%

These products belong to one of the L1 categories listed below:

1. Bread, Cereals, and Spreads.
2. Vegetables.
3. Meat, Fish, and Veggie Products.
4. Eggs and Milk.

All these products are perishable products since they are more likely to spoil or deteriorate rapidly if they are not stored and handled properly, since their shelf life is short, around less than 30 days.

The realization of this analysis allows to accomplish the first research objective (RO1): *Analyze data on freshness customer complaints related to BBD-too-short and determine the products that have a higher impact on the number of this type of complaints. (Critical products),* since it was possible to determine the 16 SKUs that are considered the critical products for the company to focus on.

5.2. Proposed Storage Systems Solutions

Taking into consideration the data analysis and the insights gathered in the two focus groups, the results of the research on storage systems solutions and proposals for the company are presented. In this chapter the categories of the 16 SKUs that had storage system changes are analyzed and solutions are proposed, taking in consideration the storage systems already used by the company.

5.2.1. Bread, Cereals and Spreads Category

In this category, two SKUs were analyzed, both corresponding to types of sliced bread, similar to the product that can be seen in Figure 5.1 Their subcategory, the number of complaints, and the sales can be seen in Table 5.3.

Figure 5.1 Example of product of Bread, Cereals and Spreads Category

Table 5.3 Product Complaints and Sales: Bread, Cereals and Spreads Category

Product name	SubCategory L1	Total Complaints	Sales	
			Total	Max Sales reported in a day
Gut&Günstig Feiner Stuten 400g	Sweet rolls & Waffles	10	4746	55
Büsch Mandelstuten geschnitten 340g	Sweet rolls & Waffles	22	13127	167

The number of issues per 10.000 sales in each of the Storage types used to store the two SKUs of the Bread category can be seen in Table 5.4.

Table 5.4 Complaints per 10 000 sales: Bread, Cereals and Spreads Category

Product name	**Complaints per 10 000 sales in each Storage System**	
	Shelving	**Dolly**
Gut&Günstig Feiner Stuten 400g	22	3
Büsch Mandelstuten geschnitten 340g	35	13

Both products were stored in Shelving and then were changed to Dolly storage. When stored in Shelving, the number of issues in 10 000 units sold was 22 for Gut&Günstig Feiner Stuten 400g and 35 for Büsch Mandelstuten geschnitten 340g, and after switching to Dolly it reduced to 3 and 13, respectively. The Shelving storage increased the number of complaints by 733% and 269%, respectively.

This type of product has a better performance when stored in the Dolly storage system since fewer issues regarding freshness and BBD-too-short occur. This can happen because this product is very malleable and soft, it is difficult to stack this product on the shelf, leading to the struggle to maintain FEFO assortment on the shelf. Also, if the shelf is too full and the product is stacked on top of each other, there is a risk of damaging the shape of the product, due to its soft texture. This issue can be seen in Figure 5.2.

Figure 5.2 Lack of FEFO assortment in Shelving storage system on a Bread product location

Products stored in Dolly have a more controlled FEFO assortment since the items are stored inside plastic trays, each corresponding to one BBD. Another reason in favor to use Dolly is that this system is located at the end of the picking circuit, meaning is less likely that its product is damaged due to stacking other products on top of the picking tote. An example of bread stored in Dolly can be seen in Figure 5.3. This conclusion was confirmed by focus group participants.

Figure 5.3 Bread stored in Dolly storage system

5.2.2. Vegetables Category

Next, the product from the Vegetables Category was analyzed, as it can be seen in Figure 5.4 and Table 5.5.

Figure 5.4 Example of product of Vegetables Category

Table 5.5 Product Complaints and Sales: Vegetables Category

Product name	SubCategory L1	Total Complaints	Sales	
			Total	Max Sales reported in a day
Heemskerk Asiatische Gemüsepfanne 400g	Ready-to-cook & Mixed Vegetables	3	2830	153

The number of issues per 10 000 sales in each of the Storage types used to store the Heemskerk Asiatische Gemüsepfanne 400g can be seen in Table 5.6.

Table 5.6 Complaints per 10 000 sales: Vegetables Category

Product name	Complaints per 10 000 sales in each Storage type	
	Roll Container	Shelving
Heemskerk Asiatische Gemüsepfanne 400g	6	17

This product was stored in a Roll Container, accounting for 6 issues in every 10 000 items sold, and then stored in a Pallet and had an increase of 283% of complaints, accounting for 17 issues in 10 000 sales. During the *focus group* it was mentioned by the Quality of Service Supervisor that: *"There is a common issue that these types of products have FEFO issues due to their lack of structure on stacking them on the shelf*". Similarly to the Bread products, this product also lacks structure, therefore, it can be hard to stack on a shelf, making it difficult to maintain the FEFO assortment, as can be seen in Figure 5.5.

Figure 5.5 Lack of FEFO assortment in Shelving storage system on a Vegetable product location

The item can maintain the FEFO arrangement effectively if it is stored in a Roller Container (RC) with plastic trays with each tray can corresponding to one expiration date. This outcome was also validated in the focus group.

5.2.3. Meat, Fish and Veggie Products Category

For the products corresponding to Meat, Fish and Veggie Products category were analyzed according to their storage handling method. These eight products correspond only to Meat products and the number of complaints and sales can be seen in Table 5.7 and an example can be seen in Figure 5.6.

Figure 5.6 Example of the product of Meat Subcategory

Table 5.7 Product Complaints and Sales: Meat, Fish and Veggie Products Category

Product name	SubCategory L1	Total Complaints	Sales	
			Total	Max Sales reported in a day
Rasting Cordon Bleu 500g	Pig	4	2318	2029
Rasting Nackensteaks gewürzt 500g	Pig	4	3274	209
Vion Schlemmerrüllchen Schinken Küse 3 x 100g	Pig	12	1667	45
Rasting Ganzes Hähnchen 1,1kg	Poultry	9	2120	37
Rasting Hähnchen Filetstreifen 400g	Poultry	7	12086	432

Product name	SubCategory L1	Total Complaints	Sales	
			Total	Max Sales reported in a day
Rasting Hähnchen Minutenschnitzel 400g	Poultry	6	4412	213
Rasting Hähnchenfügel gewürzt 400g	Poultry	3	4141	188
Rasting Hähnchen-Innenfilet Spieße Curry T 300g	Poultry	6	2625	181

All these products are usually packed in plastic containers, and placed into plastic totes, if they are stored in Roll Containers and Flow Racks, allowing for better FEFO control in the location. The number of issues per 10 000 sales in each Storage type used for the storage of these products can be observed in Table 5.8.

Table 5.8 Complaints per 10 000 sales: Meat, Fish and Veggie Products Category

Product name	Complaints per 10 000 sales in each Storage type		
	Flow Rack	Roll Container	Shelving
Rasting Cordon Bleu 500g	0	Not used	25
Rasting Nackensteaks gewürzt 500g	13	Not used	10
Vion Schlemmerrüllchen Schinken Küse 3 x 100g	17	Not used	102
Rasting Ganzes Hähnchen 1,1kg	Not used	40	47
Rasting Hähnchen Filetstreifen 400g	0	3	16
Rasting Hähnchen Minutenschnitzel 400g	25	Not used	4
Rasting Hähnchenfügel gewürzt 400g	0	Not used	18
Rasting Hähnchen-Innenfilet Spieße Curry T 300g	10	Not used	56

The Meat case was analyzed in detail in a second focus group since the results from the analysis were very inconclusive. From these three storage types, Flow Racks show the least number of complaints regarding freshness is the storage system that provides the best conditions for FEFO stock management.

The current procedure used on Flow Racks was analyzed in detail in the focus group: The supplier brings meat in Plastic Trays, and in each tray, a different BBD is placed. The supplier can bring the products in normal-sized trays or big trays (around double the size of normal trays), however, the amount of consumer units placed on the bigger tray is the same as in the smaller tray. Then, these Plastic Trays are placed on the back side of the Flow Rack and retrieved from the picking side, according to FEFO stock management. Some issues regarding the Flow Rack storage were identified that were potentially disrupting the FEFO assortment:

- Workers place units from the front tray in the tray behind it, to empty the front tray to be able to replenish more quantity of products in a single time, mixing different BBDs on the same tray.
- Some suppliers send the meat products in big trays, but not filled up to their full capacity. To optimize space, workers place more units on the bigger tray, but don’t take into consideration the BBD of the product they are placing, mixing different BBDs in the same tray.
- In the receiving and replenishment operation, to be able to fit more trays in the Flow Rack slot, the normal-sized trays are stacked on top of each other. This can lead to trays with longer BBD being placed over trays with closer BBD, causing issues in the FEFO assortment. A diagram of this situation can be seen in Fig 5.7.

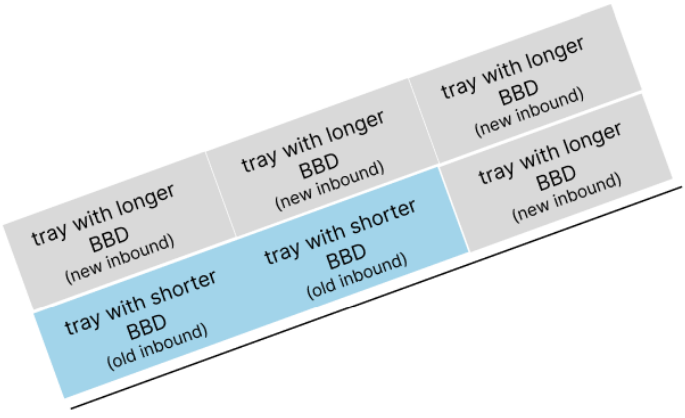

Figure 5.7 FEFO assortment issue with the replenishment of trays in Meat Flow Racks.

A proposal for a storage solution on the current Flow Racks used by the company discussed in the focus group would be to have two locations with the same product, but each location referred to a different BBD. The worker would be guided to the location via WMS with the closest BBD, and when the stock on this location would be finished, and it would be guided to the other location with a longer BBD, and so on. Therefore, a single SKU would need two locations to best perform FEFO stock management. This solution would most likely diminish the problems stated above, without the need of implementing a new storage system.

5.2.4. Eggs and Milk

Lastly, five products that belong to the Eggs and Milk category can be seen in detail in Table 5.9.

Table 5.9 Product Complaints and Sales: Eggs and Milk Category

Product name	SubCategory L1	Total Complaints	Sales	
			Total	Max Sales reported in a day
Vriesen-Hof Eier Freilandhal 10er Pack Gr. M-L	Egg	4	23488	295
Arla Bio Frische Weidemilch 1,5% 1L	Milk	83	12906	354
Arla LactoFREE Laktosefreie Milch 1,5% 1L	Milk	10	5613	173
Edeka Bio Bio Frische Vollmilch 3,8% 1L	Milk	6	67184	854
Landliebe Frische Landmilch 3,8% 1L	Milk	12	14329	140

In this category, the Eggs and Milk will be analyzed separately since their packaging is very distinct. First, eggs will be analyzed, an example of the shape of the product can be seen in Figure 5.8.

Figure 5.8 Example of product of Egg Subcategory

The number of issues per 10 000 sales in each of the Storage types used to store the Vriesen-Hof Eier Freilandhal 10er Pack Gr. M-L can be seen in Table 5.10.

Table 5.10 Complaints per 10 000 sales: Egg Subcategory

Product name	**Complaints per 10 000 sales in each Storage type**	
	Roll Container	**Pallet**
Vriesen-Hof Eier Freilandhal 10er Pack Gr. M-L	1	2

This product was stored in Roll Container and then changed to a Pallet. It accounts for 1 issue in 10 000 sales in RC storage and 2 in Pallets. In both storage systems, the product had a similar number of complaints. Observing more closely how the eggs were stored in FC2, it was possible to conclude that this type of item is stored on plastic trays and then placed either on Roll Container or Pallet, as can be seen in Figure 5.9. Since the product is stored in trays, the FEFO assortment is easier to maintain in receiving and replenishment operations since the workers can easily place the new inbound under the old inbound simply by lifting the totes.

While analyzing this product on the focus group, the Fulfillment Analyst mentioned that "*Since the workers do quality checks on the eggs to ensure that this product was not damaged, the expiration dates can be mixed up in the location, disrupting the FEFO assortment*". Also, it was mentioned that this type of item, due to its fragility, should be stored near the end of the picking circuit, to not have other products stacked on top of the picking tote, potentially damaging it. Considered the option of storing this product in Dolly storage, but since this product has a lot of sales per day, it wouldn't be a viable option. Therefore, the best way to store this item is on the Roll Container or Pallet, in combination with plastic trays, each corresponding to a single BBD and the workers should be advised to not disrupt the FEFO assortment when checking the quality of this type of product.

Figure 5.9 Eggs stored in Roll Container storage system

From the Eggs and Milk category, four of the products correspond to Milk items. Due to their identical packaging, these products are easily comparable, an example of a milk product can be observed in Figure 5.10.

Figure 5.10 Example of product of Milk Subcategory

The number of issues per 10 000 sales in each of the Storage types used to store the Milk products can be observed in Table 5.11.

Table 5.11 Complaints per 10 000 sales: Milk Subcategory

Product name	**Complaints per 10 000 sales in each Storage type**		
	Pallet	**Roll Container**	**Shelving**
Arla Bio Frische Weidemilch 1,5% 1L	33	78	Not used
Arla LactoFREE Laktosefreie Milch 1,5% 1L	Not used	65	0
Edeka Bio Bio Frische Vollmilch 3,8% 1L	0	1	Not used
Landliebe Frische Landmilch 3,8% 1L	Not used	11	0

This analysis shows that Shelving can be a good option for Milk products, being it's downside the fact that it doesn't allow for a high volume of products, due to the shelf size constraints in FC2, leading to the need for multiple replenishments during the day, which requires more operations, and more travel time spent on this activity.

In the focus group, the current storage situation for these types of products was analyzed, to understand the current issues and what could be improved and how. The standard procedure for the storage of Milk products in RC and Pallets is to have two units of storage in the location, one in the front and the other behind it. When the front storage is empty, that unit should be removed, and the unit from behind comes forward. The issues with the current procedure are:

- The main issue that is disrupting the FEFO stock assortment is that when there are two Pallets or RC on the location workers place loose units from the front system to the back system, to be able to free the storage to be able to replenish the location faster.
- To remove an empty Pallet from the forward face a Forklift is required, and the picking process needs to be stopped in this area, leading to potential delays in order picking.
- Often the front Pallet is not immediately removed, leading to workers stepping on the empty pallet, which shouldn't be done due to safety reasons.

Taking in consideration the storage systems already in use by the company, one solution discussed was changing the procedure and only having one Pallet/RC on the location. This would eliminate the issues stated above but would require replenishing the location more often, and faster so there are no stock shortages. An alternative solution involving the creation of a new storage system is described in the following chapter.

5.2.5. Summary

This chapter allowed to achieve the second research objective (RO2): *Propose suitable storage systems used by the company for the critical product's categories, that reduces freshness complaints related to BBD-too-short.*

It was possible to determine for the 16 SKUs and their respective category, the optimal storage solution that would minimize the amount of customer complaints regarding

BBD-too-short, using suggestions on the systems already used by the company. The storage solutions proposed can be converted into *Slotting Requirements* that should be implemented to minimize customer's freshness complaints, reduce food waste, and improve the efficiency in FC2. A resume of the Slotting Requirements suggested are presented in Table 5.12

Table 5.12. Slotting Requirements suggestions

Category L1	Category L2	Slotting Requirement
Bread, Cereals and Spreads	**Sweet rolls & Waffles**	*Sweet rolls & Waffles must be stored in Dolly storage system in combination with plastic trays, each corresponding to a single BBD*
Vegetables	**Ready-to-cook & Mixed Vegetables**	*Ready-to-cook & Mixed Vegetables must be stored in Roll Container storage system in combination with plastic trays, each corresponding to a single BBD*
Meat, Fish and Veggie Products	**Meat (Pig; Poultry)**	*Meat products (Pig, Poultry and other types of meat products packaged in plastic containers) must be stored in Flow Rack system, consisting in two storage locations, each one referred to a single BBD*
Eggs and Milk	**Eggs**	*Eggs must be stored in Pallet or Roll Container storage system in combination with plastic trays, each corresponding to a single BBD*
		Eggs must be stored near the end of the picking circuit
	Milk	*Low selling Milk products must be stored in Shelving storage system*
		High selling Milk products must be stored in Pallet or Roll Container storage system, with only one storage unit on the location

5.3. New Storage System Solution

In the focus group, an alternative storage solution for high-volume milk products was discussed. The storage proposal was the Pallet Flow Rack (see Figure 5.11). This system consists in deep lane racks in which the shelving is slanted. The pallets are loaded at the upper end of sloping lanes and move down by gravity. The first pallet to be loaded in a lane is the first pallet available at the picking face on the retrieval side, allowing for FEFO stock management.

Figure 5.11 Pallet Flow Rack (Source: https://blog.unex.com/solution-spotlight-pallet-flow consulted in 10/01/2023

However, in the focus group issues with this system were also pointed out:

- Due to the heavy weight of a pack of Milk products, consisting in 8 units, when the Pallet would be placed in the top part of the Flow Rack, it could gain a lot of velocity due to the slant of the system and could lead to the risk of the pallet to tilt over and cause an incident. "*When I look into the practical side, pallets of Milk, for example weigh around 1.000 kilos. If you put a pallet at the back/high side of the Pallet Flow Rack it can gain a lot of velocity before it arrives at the pick location, and it can be a risk to replenish that kind of locations*", quoted by the Fulfillment Launch Lead.

- To remove the empty pallet from the forward face would require the use of a Forklift, meaning the picking operation would have to be stopped, causing delays.

Concluding that this Pallet Flow Rack storage solution is not ideal for the storage of Milk products in the company.

Taking in consideration the feedback from the focus group and implementing a Design Thinking approach it was possible to develop a new storage system that would fit the needs of the company. The DT characteristics were taken in consideration:

- *User focus*: the development of the storage solution took in consideration the needs of the company and the points of view of its employers gathered through observation in the work floor and the feedback collected in unstructured interviews and in the focus groups.
- *Diversity:* diverse perspectives and backgrounds from experienced employees from different fields were gathered in unstructured interviews and in the focus group.
- *Visualization:* The storage system prototype was design in *SolidWorks* to better visualize the solution, as it can be seen in Figure 5.12 e 5.13.

In DT's *Inspiration* phase the problem that motivates the search for solution is based on the third research objective (RO3): *Propose a new storage system solution to reduce freshness complaints associated with BBD-too-short*. In the *Ideation* phase the ideas and discussion gathered in unstructured meeting and focus groups were used to develop the storage solution prototype. In the focus group, it was discussed the possibility of a moving platform to move the pallet from the picking to the receiving aisle. Taking in consideration this input and the research done in storage systems, a new storage system adapted on the already existing storage systems was elaborated. Finally, in the *Implementation* phase a sketch of the prototype was done, as it can be seen in Figure 5.12. The operation of this system can be seen on Figure 5.13. Due to time constrains the physical prototype wasn't created.

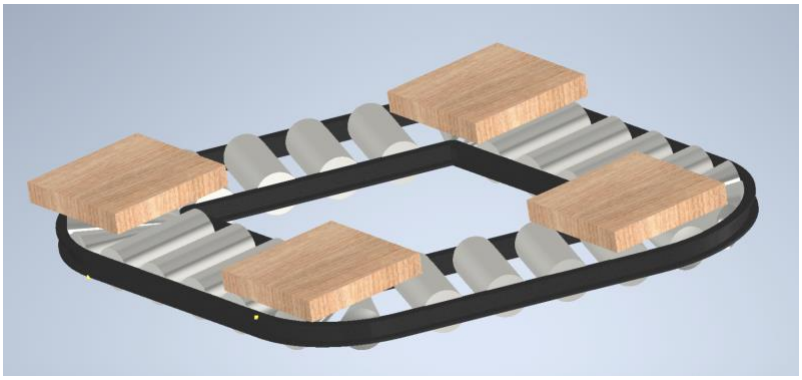

Figure 5.12 Pallet Conveyor Prototype

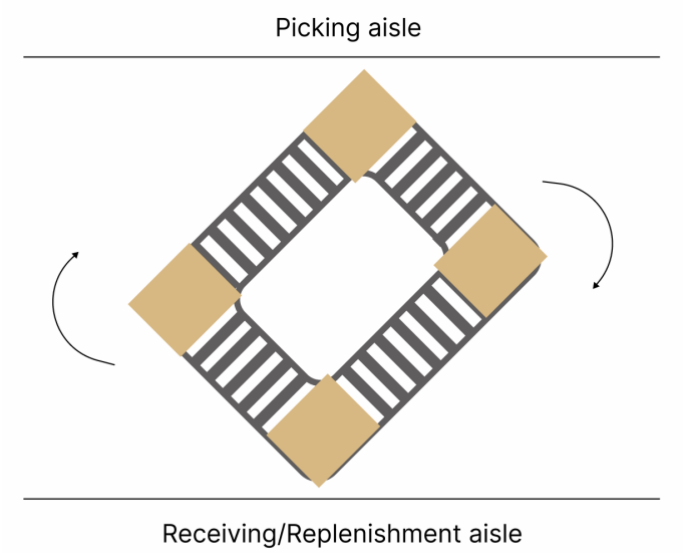

Figure 5.13 Pallet Conveyor Prototype Operation

The solution proposed would be the implementation of a new storage system that can be described as a Pallet Conveyor shaped in a rectangle that would allow for four Pallets to move in a rotative way where the pallet would be transported to the picking aisle, while the pallet located in the picking aisle would be moved towards the back, to the receiving aisle. This system would allow to solve the issues raised with the previous system, the Pallet Flow Rack. This conveyor could be manual, using a push to move the pallets, or automatic. The final prototype was discussed in a meeting with the FC2 Lead and Quality of Service Lead that occur after the focus group and seen as a viable solution.

6. CONCLUSIONS

The present dissertation considered the assumption that *Different storage systems have influence on customer complaints related with BBD-too-short in the freshness category*. Thus, considering the topic under research the dissertation was developed in the form of a case study, in the company Picnic.

In order to answer to the main research question *What is the storage solution for critical perishable products that can improve FEFO picking and reduce freshness issues*?, three research objectives were defined:

- RO1: *Analyze data on freshness customer complaints related to BBD-too-short and determine the products that have a higher impact on the number of this type of complaints. (Critical products).*
- RO2: *Propose suitable storage systems used by the company for the critical product's categories, that reduces freshness complaints related to BBD-too-short.*
- RO3: *Propose a new storage system solution to reduce freshness complaints associated with BBD-too-short.*

To start this research work, document analysis, observation and unstructured interviews were used to determine the project's scope, research objectives, and question. Design Thinking approach was used in the development of warehouse storage solutions to reduce customer quality complaints related to freshness issues.

To accomplish the first research objective (RO1), a data collection and analysis on freshness complaints related to BBD-too-short was performed on 547 SKUs, from January to September 2022, on the products from the Fulfilment Center located in Langenfeld, Germany (FC2). Then, through ABC analysis, it was possible to determine which products had a higher impact on the number of this type of customer complaints, corresponding to 16 critical products for the company. For the critical products it was possible to analyze the storage system changes during this period, verifying that certain storage type systems lead to more customer complaints regarding BBD-too-short when compared with the use of other storage systems on the same exact product (see Tables 5.2),

confirming the assumption: *Different storage systems have influence on customer complaints related with BBD-too-short in the freshness category.*

From the first analysis, it was possible to search solutions for the critical products' categories that would minimize the amount of customer complaints regarding BBD-too-short, using the systems already used by the company, taking in consideration the feedback of two focus groups performed with experienced employers from the company. The storage of Bread and Vegetable products should be done inside plastic trays each one corresponding to one BBD, and then placed in Dolly storage, in the case of the Bread, and in Roll Container, in the case of the Vegetables. This type of storage can provide a better FEFO assortment to this type of product since they lack stability and shape when stored in shelving. For the Egg subcategory, the optimal solution was storage in Roll Container or Pallet, inside plastic trays, each corresponding to a single BBD, and located near the end of the picking circuit, due to the fragility of this product. In the case of low selling Milk products, Shelving is a good alternative for this type of product. On the other hand, for high selling Milk products, it is suggested the use of a single unit of Pallet or RC storage systems. This solution diminishes issues pointed out with both Pallets and Roll Container storage in the focus group. Lastly, in the case of Meat products the solution is the use of Flow Rack system, consisting in two storage locations, each one referred to a single BBD. The storage solutions proposed were then converted into *Slotting Requirements* that should be implemented in the company to minimize customer's freshness complaints regarding BBD-too-short (see Table 5.12). From these outcomes it was possible to fulfill the second research objective RO2: *Propose suitable storage systems used by the company for the critical product's categories, that reduces freshness complaints related to BBD-too-short.*

Lastly, the third research objective (RO3) was achieved: *Propose a new storage system solution to reduce freshness complaints associated with BBD-too-short*. A new storage solution was developed for the Milk category of products, as it can be seen in Figure 5.12 and 5.13. The solution proposed can be described as a Pallet Conveyor shaped in a rectangle, that provides a rotational movement from the receiving/replenishment aisle to the picking aisle, and again to the receiving/replenishment side and so on. This system allows to solve issues with the currently used systems in the Fulfilment Center.

The main limitation of this study was the time restriction to physically implement the Slotting Requirements proposed in FC2. This research was limited to study

the different storage systems, however, as recognized other factors might cause freshness issues related to BBD-too-short, namely, the cases there inbound doesn't respect the *Supplier Freshness Guarantee* and human errors that occur during picking.

Regarding future work, it is advised for the company to implement the suggested *Slotting Requirements* and the new storage system to the critical products and analyze if the freshness complaints regarding BBD-too-short decrease. In deep research of the other possible causes and potential solutions for freshness issues related in BBD-too-short should also take place, namely on human errors caused by the workers during the receiving and replenishment operations to reduce the number of these type of freshness complaints.

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APPENDIX A

WAREHOUSE_ID	DATE	ARTICLE_ID	ART_SUPPLY_CHAIN_NAME	TEMPERATURE_ZONE	ART_P_CAT_LEV_1	ART_P_CAT_LEV_2	FRESHNESS_COMPLAINTS
FC2	2/17/22	11404577	BÃ¼sch Niederrheinisches Schwarzbrot 250g	ambient	Brot, Cerealien & Aufstriche	Brot	1
FC2	7/12/22	11947866	Vion SchlemmerrÃ¶llchen Schinken KÃ¤se 3 x 100g	chilled	Fleisch, Fisch & Veggie	Schwein	1
FC2	6/1/22	11947866	Vion SchlemmerrÃ¶llchen Schinken KÃ¤se 3 x 100g	chilled	Fleisch, Fisch & Veggie	Schwein	1
FC2	7/13/22	11850707	Gut&GÃ¼nstig HÃ¤hnchen Innenfilet 400g	chilled	Fleisch, Fisch & Veggie	GeflÃ¼gel	1
FC2	9/29/22	11933161	BÃ¼sch Rosinenschnecke 1st	ambient	Brot, Cerealien & Aufstriche	SÃ¼ÃŸe BrÃ¶tchen & Waffeln	2
FC2	3/15/22	11959119	Bauernliebe Schinkenwurst 80g	chilled	Fleisch, Fisch & Veggie	Wurstaufschnitt	1
FC2	6/29/22	10020306	Gut&GÃ¼nstig GrieÃŸ Pudding Zimt 175g	chilled	Eier & Milch	Milchsnack & Dessert	2
FC2	5/4/22	10018967	Gut&GÃ¼nstig Sahne Kefir Erdbeere 250g	chilled	Eier & Milch	Frucht- & Sahnejoghurt	1
FC2	7/12/22	11094241	Rasting HÃ¤hnchen Filetstreifen 400g	chilled	Fleisch, Fisch & Veggie	GeflÃ¼gel	2
FC2	6/14/22	11974470	Bauer Funken Salatbowl Oriental vegan 425g	chilled	GemÃ¼se	Salate & Sprossen	1
FC2	2/3/22	10020930	Gut&GÃ¼nstig Roggenvollkornbrot geschnitte 500g	ambient	Brot, Cerealien & Aufstriche	Brot	2

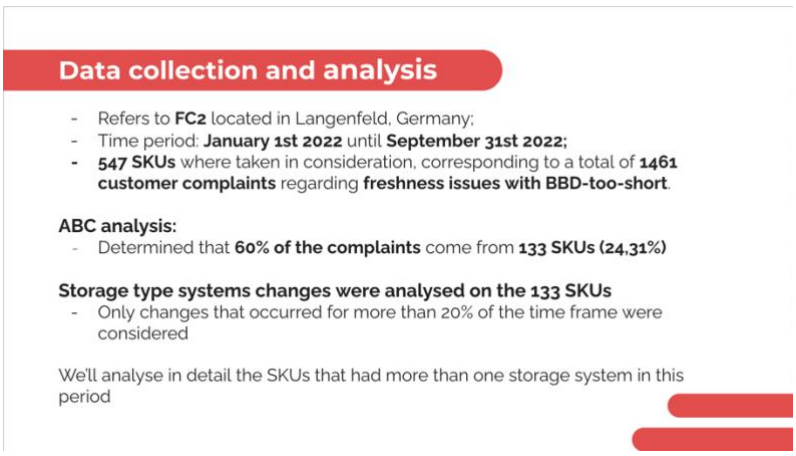
APPENDIX B

SITE_ID	KEY_DATE	ARTICLE_ID	HANDLING_UNIT_ID	STORAGE_AREA_TYPE	PICK_QTY
FC2	20220928	12141079	FC2-CH-B-056-06-3	Shelving	2
FC2	20220929	12141079	FC2-CH-B-056-06-3	Shelving	3
FC2	20220927	12141079	FC2-CH-B-056-06-3	Shelving	4
FC2	20220930	12141079	FC2-CH-B-056-06-3	Shelving	11
FC2	20220929	12141051	FC2-AM-D-071-14-1	Shelving	30
FC2	20220927	12141051	FC2-AM-D-071-14-1	Shelving	12
FC2	20220921	12141051	FC2-AM-D-071-14-1	Shelving	11
FC2	20220924	12141051	FC2-AM-D-071-14-1	Shelving	2
FC2	20220930	12141051	FC2-AM-D-071-14-1	Shelving	28
FC2	20220928	12141051	FC2-AM-D-071-14-1	Shelving	25
FC2	20220929	12139677	FC2-CH-C-024-09-1	Shelving	1
FC2	20220926	12139670	FC2-CH-C-045-10-4	Shelving	5

APPENDIX C


Focus groups presentation
Storage solution to reduce customer quality complaints in perishable products
Master Thesis - Industrial Engineering and Management
January 2023
PIC NIC


Focus group 1 objectives:
1. Discuss the ideal storage solution for the critical product categories from the storage types that are already used in Picnic;
2. Discuss the storage proposal for the Milk product category from the suggested storage system that isn't used by Picnic.
PIC NIC


Data collection and analysis
- Refers to **FC2** located in Langenfeld, Germany;
- Time period: **January 1st 2022** until **September 31st 2022;**
- **547 SKUs** where taken in consideration, corresponding to a total of **1461 customer complaints** regarding **freshness issues with BBD-too-short**.
ABC analysis:
- Determined that **60% of the complaints** come from **133 SKUs (24,31%)**
Storage type systems changes were analysed on the 133 SKUs
- Only changes that occurred for more than 20% of the time frame were considered
We'll analyse in detail the SKUs that had more than one storage system in this period

Bread, Cereals and Spreads

Product name	Issues per 10.000 sales in each Storage type	
	Shelving	Dolly
Gut&Günstig Feiner Stuten 400g	22	3
Büsch Mandelstuten geschnitten 340g	35	13

- Malleable/soft product (lacks structure)
  → Hard to product to stack - also it can lead to damages
  → Difficult to maintain FEFO on the Shelf

Outcomes

- Best stored in **Dolly**
  → Inside of in plastic trays (each corresponding to one bbd)
  → Also Dollys are located in the end of the picking aisles, meaning is less likely that is product is damaged due to stacking other products on top

Vegetables

Product name	Issues per 10.000 sales in each Storage type	
	Roll Container	Shelving
Heemskerk Asiatische Gemüsepfanne 400g	6	17

- Malleable product (lacks structure)
  → Hard to stack product
  → Difficult to maintain FEFO on the Shelf

Outcomes

- Best stored in Roll Container
  → Inside of in plastic trays (each corresponding to one bbd)

Eggs

Product name	Issues per 10.000 sales in each Storage type	
	Roll Container	Pallet
Wiesen-Hof Eier Freilandhal 10er Pack Gr. M-L	1	2

- Fragile product

Outcomes

- Should be stored in plastic totes (each corresponding to one bbd)
  → in Roll Container or Pallet
- Another alternative could be Dolly
  → Since it is a fragile product, Dollys can be a good option since they are located in the end of the picking aisles, meaning is less likely that is product is damaged due to stacking other products on top

Milk

Product name	Issues per 10.000 sales in each Storage type		
	Pallet	Roll Container	Shelving
Edeka Bio Bio Frische Vollmilch 3,8% 1L	0	1	Not used
Landliebe Frische Landmilch 3,8% 1L	Not used	11	0,0
Arla Bio Frische Weidemilch 1,5% 1L	33	78	Not used
Arla LactoFREE Laktosefreie Milch 1,5% 1L	Not used	65	0,0

- Heavy product
  → it can be difficult to maintain FEFO assortment in RC and Pallet in receiving and replenishment operations

Outcomes

- Shelving is a good option for Milk with low volume of sales

Alternative for Milk products with high volume of sales

Pallet Flow Rack

Pallet Flow Rack is a deep lane rack in which the shelving is slanted. The pallets **are loaded at the upper end of sloping lanes, and move down by gravity**. The first pallet to be loaded in a lane is the first pallet available at the picking face on the retrieval side, allowing for **FIFO stock management**.

Advantages:

- **Reduces labor** – workers can spend more time on productive movements instead of carrying items back and forth or wandering around a shelf trying to locate items;
- Ideal for fast-moving products;
- Ideal for products with **best-before date (FIFO/FEFO complaint)** ;
- Low maintenance;
- No energy consumption;
- Fast handling and picking: goods are always available at the picking place;

Disadvantages:

- **Investment** on new storage system;
- Pallet quality and consistency is important to ensure the loads convey properly;
- Requires additional training to operate on top of more conventional safety requirements and usage;

Meat, Fish and Veggie Products

Product name	Issues per 10.000 sales in each Storage type		
	Flow Rack	Roll Container	Shelving
Rasting Hähnchen Filetstreifen 400g	0	4	16
Rasting Hähnchen Minutenschnitzel 400g	25	Not used	4
Rasting Hähnchenflügel gewürzt 400g	0	Not used	18
Rasting Hähnchen-Innenfilet Spieße Curry T 300g	10	Not used	57

Product name	Issues per 10.000 sales in each Storage type		
	Flow Rack	Roll Container	Shelving
Rasting Ganzes Hähnchen 1,1kg	Not used	40	47
Rasting Nackensteaks gewürzt 500g	13	Not used	10
Rasting Cordon Bleu 500g	0	Not used	25
Vion Schlemmerröllchen Schinken Käse 3 x 100g	17	Not used	102

Meat, Fish and Veggie Products

- Commonly stored inside of plastic trays
  → already come in trays from the supplier

Issues:

- All of the storages systems used to store meat seem to have FEFO issues
- Most of the FEFO issues are likely to come from shopper's placing some units in other trays, mixing the BBDs;

Brainstorm: Defining Requirements

- Out of the 3 storage systems used, Flow Rack seems to have the best FEFO performance

What are some requirements/characteristics That could be implemented in this type of issue to improve the FEFO assortment?