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Master Thesis

Fresh Food Products Inventory Control Management: the challenges in avoiding perishability at the retailers' shelf.

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Abstract

Purpose

This study focuses on applicable methods used in the Inventory Management of Fresh Food Products and challenges encountered in their implementation. The area of concentration is the Fresh Food Retailers. Secondly, the challenges encountered in the implementation of fresh food products is also addressed.

Methodology

The study employs a qualitative research technique with the use of a semi-structured interview for five companies to gather data.

Theory

The theory section of this study first gives a brief explanation of fresh food retailers'. Secondly, it addresses the keywords of the research questions: Fresh Food Products Inventory Management, highlighting the management of the shelf-life and technological innovations in use in the inventory management of Fresh Food Products. It moves on to address the challenges encountered in the implementation of inventory management systems

Empirical

This represents the outcome of semi-structured qualitative interviews conducted with five companies. It started with a brief description of the company.

Analysis and Discussion

The analysis portrays the techniques and models used in the inventory management of shelflife and technological innovations and identification and discussion of implementation challenges or drawback of implementation.

Conclusion

This addresses my contribution and a futuristic approach to the topic.

Keyword:

expiry date, fresh food products, fresh food retailers' perishables, perishable inventory management, Shelf-life, technological innovations, tracing and tracking**.**

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Växjö. 2020/06/01.

Adaku Edith Adedeji

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1.0.Introduction

This chapter introduces the reader with the topic of this paper. The background section reveals the focus of the paper: fresh food products, fresh food products inventory management and challenges encountered in the implementation of existing inventory management systems. The problem discussion gives tips on why products expire on the retailers' shelf. Hence, research questions for this research have been derived at problem discussion.

1.1.Background

The increase of demand for fresh products and healthier food by customers has dragged retailers into a freshness era, where the management of inventories is challenging and it requires huge demands on the whole food supply chain partners (Ketzenberg, Gaukler and Salin, 2018; Bai and Kendall, 2008). According to Amorim, et al. (2013) fresh products are mainly food goods referred also as perishable products. Perishability indicates a decay, damage, pilferage, loss of utility or loss of marginal value of a product which leads to a decrease in the value of the product. (Ibid) Hence, according to Feng, Chan and Cárdenas-Barrón (2017), the main issues with fresh food products are their expiration or their deterioration (if not sold on time) and their loss of sales due to absence of stock (out-stock situations). This implies that retailers cannot store large quantities of fresh food products because of temperature requirements needed to maintain the freshness of such stock. Viewing the scenario from another angle, they also want full shelves to capture all their sales which serves as a unique sales proposition for retail outlets. Thus, retailers are always trying to reach a balance between *in-stock* and *out-stock* situations to achieve the desired inventory level (Tromp, et al., 2012). Estimates have shown that approximately 40% of the food produced worldwide is lost or wasted at some stage in the food supply Chain with the retail sector accountable for approximately 5% of the losses Erikkson et al. (2012). This higher demand by customers for fresh and healthier food requires more from all food supply chain (FSC) partners. Consequently, food supply chains (FSC) are chains that are characterized by very strict legislation, handling and transportation matters due to perishability nature of the goods (Pal and Kant, 2019). This era of freshness has brought in to highlight the role of Fresh Food Retailers (FFR). Fresh food retailers (FFR) as referred to in this thesis are the partners in the supply chain that process and sell perishable products to their customers (the green box in figure 1).

Figure 1. addresses the focus of this thesis and it shows how products flow in the Food chain reaching every partner to the customer (Aung and Chang, 2014). Furthermore, according to Bottani, et al. (2017), FFR to a high extent depend on

their on-shelf availability which is the product being available for sale to a buyer whenever and wherever they want to buy it. However, on-shelf availability is easier said than done, as it has been a real challenge for retailers and suppliers for a long time. In this sense when FFR try to maintain their on-shelf availability they often overstock (order more than they can sell). This persists to be a serious problem because perishable products impose an additional constraint on the shelf life, which implies the maximum useful life of a product (Chande, et al., 2005). If the product does not reach the customer within its shelf life time frame, it expires and is wasted (Feng, Chan and Cárdenas-Barrón, 2017).

Consequently, expiration of perishable products at the FFR shelf which eventually leads to food waste in the whole food supply chains (FSC) could arise due to various factors, however, two topics are discussed in this paper. The inventory management systems with technological innovations and the challenges in managing short life inventories (Kiil, et al., 2018) with the available management and control techniques and innovations. These themes below:

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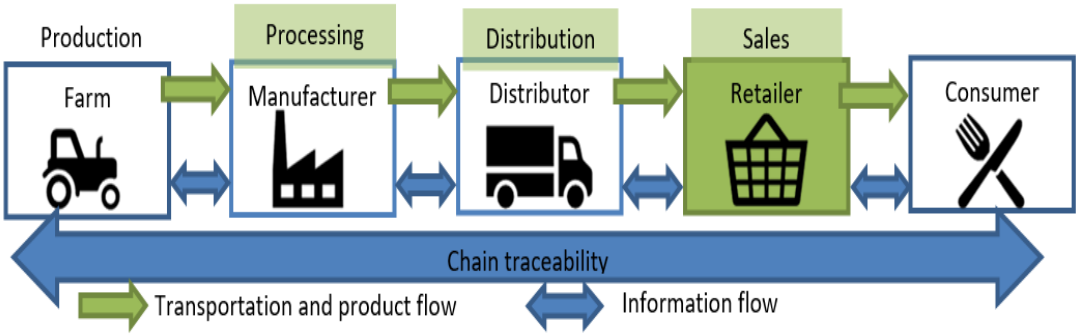

Figure 1: The fresh food Supply Chain and focus of the thesis (highlighted in the green box). – adopted from: Aung and Chang (2014).

Inventory management techniques of fresh food products on retailers' shelf

The greatest challenge experienced by most fresh food retailers is the management of inventories which is challenging due to the perishable nature of such products. Products that fall into these group are mostly agro-food industries like fresh fruits, ready to cook vegetables, dairy products etc. Inventories are most at times close to perishability on the retailers' self thereby causing loss of billions of dollars yearly and secondly causing food waste.

According to Chande, et al. (2005) inventory management refers to monitoring the availability of material, assigning it to demands that have arisen and placing orders

for replenishment of materials. Freshness is the main criteria to evaluate perishable products' quality and could dramatically affect their market demand. Reasonably, to obtain the most profitability outcome as possible from fresh food products, inventory management systems should be combined with maintenance conditions such as comfort temperatures and shelf management systems, shelf life space allocation etc (Bai and Kendall, 2008).

According to (Dolgui, et al., 2018; Akkas, Gaur and Simchi-Levi., 2018) research has split fresh food products inventory management into two tiers, either fixed or random product lifetimes. The fixed product lifetime was proposed by Chare and Schrader (1963) as a deteriorating inventory model with a constant rate of decay. This implies the usability of a perishable unit up to a given period *n* after of which it will expire. According to this perspective, fresh food items have their expiry dates or used by dates printed on them, after these dates they become unusable Zsigmond, et al.,(2018). This tier has mainly focused on the fixed lifetime of the products and applied strategies for monitoring and replenishment (Ketzenberg, Gaukler and Salin, 2018). Hsu (2000) mentions deterioration rates being dependent on both stock's ages and production periods. Hence, Haijema (2013) explored optimal ordering and issuing policies for short fixed shelf-life products. Other authors include Kouki, et al. (2013) who suggested a system in which they created a variant of continuous review of inventory policy.

However, the fixed lifetime view according to Bai and Kendall (2008) does not match the freshness criteria that determines the value of a fresh food product. According to the above school of thought, assuming that fresh food products capture the same market demand as long as all the inventory is exposed in the shelf does not stand, mainly because the shelf life space for perishable products is limited due to the temperature requirements. This tier was developed by Nahmias (1982) by taking into consideration variable inventory deterioration over time rendering some of the units unusable as time progresses. Therefore, another tier of researchers on perishable inventory management (Chande, et al. 2005; Bai and Kendall 2008; Tromp, et al. 2012; Ketzenberg and Gaukler and Salin, 2018) focused on the random lifetime models under the assumption of continuous review and continuous decay. These sources state that there are uncertainties and variable characters such as temperature, transpiration conditions and bacteria levels throughout the supply chains that cannot be controlled. Therefore, the expiry date of a product is not always uniform decay, thus they suggested a dynamic expiry date instead of a fixed one. A dynamic expiry date should be applied in regards to the product condition measured after the product reaches the retail store (Tromp, et al., 2012; Ketzenberg and Gaukler and Salin, 2018).

Technological Interventions to avoid Perishability on the shelf of Fresh Food Retailers'

To be able to avoid product expiration on the shelve of FFR, a seamless flow of information and comprehensive traceability system needs to be implemented (Amorin, et al., 2011). According to Mishra, et al,. (2018) *products' traceability is defined as the ability to follow the product's data and information from its conception to destination in the supply chain*. Mishra, et al,. (2018) believes that having detailed data about product location, its processing history and its raw materials from concept to end is the key to success for any food supply chain. Every actor in the food supply chain would be able to add more value to each process they are involved in. According to Riad, et al,. (2018) tracing perishable products can give huge support to inventory management. This product category which in cooperation with a proper inventory policy can reduce expiration at FFR shelf and also out-of-stock situations. If FSCs use high accurate tracing devices, they will be able to solve the problem of expired products on a high scale. Zsigmond, et al. (2018) stated that traceability can also generate notifications when the shelf needs to be refilled or when products have expired on the shelf and need to be disposed of.

Furthermore, fruits of traceability are fully harvested at the retailers' phase when they sell these goods. Bottani and Rizzi (2008) and Bai and Kendall (2008) have worked on perishable inventory management and stated that traceability of perishable context helps FFR access a wider aspect of information, such as "due dates" and "shelf life span" to monitor the products close to expiration then promote, sell and finally replenish the stock. As shown in Figure 1 products flow forward in the Food supply chain and are either checked physically or scanned digitally then the information accessed is sent to the inventory management system for further process. Traceability can either be internal, (subject to one actor in the supply chain) or external, (as extended information throughout all the partners in the FSC). (Please see fig. 1).

1.1.1.Problem Discussion and Research Questions

There are several issues when trying to avoid product expiration at the retailers' shelf. Authors such (Bai and Kendall,2008; Tromp, et al. 2012; Ketzenberg, et al. 2018) stated that product expiration at the retailer's shelf has not been properly covered by research on inventory management. This is mainly due to focus on fixed inventory shelf-life and does not capture the ageing of the product on the shelf. Therefore, dynamic expiry dates should be applied regarding the product conditions (Tromp, et al., 2012; Ketzenberg, et al, 2018) but real-time data about product flows are required. This is easier said than done because there are challenges regarding fresh food inventory management.

Interventions available in the Inventory management of fresh food Products

According to Stanger, et al., (2011), good inventory management performance for perishables, entails carrying enough stock to generate high on-shelf availability and at the same time minimizing expiration time. Olsson,(2014) believes that for an efficient food supply chain with a focus on the Fresh food sector, the expiration date should be taken into account in the planning of inventory target level. The management of inventories to yield a seamless food supply chain has been challenging to the actors due to the short lifetime of these inventories as a result of the fast pace in which these inventories expire (Bai and Kendall, 2008). They retain some value until the day they expire, however they lose their utility, capturing shorter customer demand each day as they get closer to expiration (Bai and Kendall, 2008). Therefore, when managing fresh food products inventories, the whole food supply chain must perform effectively so the products reach the retailer and the customer as fresh as possible (Mishra, et al., 2018 and Kiil, et al., 2018). According to Stanger, et al. (2011), poor management of perishable inventories leads to increase in cost and increase in wastage due to deterioration of perishables. The use of Automated Store Order (ASO) which has mostly been in use have not given a fair picture of inventory management of perishables as it does not distinguish between perishable and non-perishables Stanger, et al., (2011). Another means of inventory management used in practice referencing Olsson, (2014) is inventory being controlled with simple ad-hoc rules or with standard procedures which are based more on assumptions. This has resulted in FFR incurring more cost due to outdating or deteriorating or small inventory holding leading to poor customer service. In my opinion, fresh food inventory acts as one of the key success factors for retailers as in a way, they serve as a determiner for the sale of other products in their outlets. This inventory management system has proven not to be accurate and cost-effective. The current day practice of Advance Planning System used in inventory management lacks shelf-life being adequately incorporated in the system Lútke Entrup, (2005). Also, the transportation and distribution of fresh food products throughout the FSC require the strict interplay of many processes to preserve the quality of the perishable products as they transit (Pal and Kant, 2019). Therefore, despite tremendous efforts by FSC to deliver their products as fresh as possible, some of the products may reach the FFR with a very short shelf life. This is very challenging for retailers to handle and sell and sometimes products might never reach their customer, consequently causing expirations at FFR shelves, (Hertog, et al., 2014).

Furthermore, rotation practices such as FEFO (first expired first out) normally secure close to expiry products leave the shelf before the fresher ones, helping in this way to avoid product expiration. However, this does not entirely solve the problem. Tromp, et al. (2012) had found that 55% of customers in a meat retail store pick a product that lies behind in the shelf hoping to have chosen a fresher product while

just 45% would pick the product closer to their hand, hindering, this way the (FIFO/FEFO) first in first out process of fresh food products. Hence, according to Akkas, et al., (2018) food retailers are subject to manufacturer's push up strategies that impact the uneven inventories in many cases leading to more product expiration at the retailers' phase. According to Zsigmond, et al. (2018) and Akkas, Gaur and Simchi-Levi (2018) perishable items are sometimes densely packed and "expiry dates" can be erased, as a consequence expired products are retained by error in the retailers' shelves taking up valuable storage space, hindering replenishment process and also being a risk of contamination for the store and the customers. Thus arising in:

RQ1: What Inventory management systems are used in avoiding perishability of fresh food products on the shelves of Fresh Food Retailers?

Challenges in the management of fresh food products

Hence, according to Bottani and Rizzi (2008) and Bai and Kendall (2008) expiration of products can be avoided best if perishable inventory management can access in time information about the shelf life span of a product and take a decision to promote and sell sooner, products close to expiration. However, according to Tromp, et al. (2012) the problem with FFP is that there are often several production batches with several expiry dates in the same pallet or shelf. This hinders the ability to identify product data. Also, products' short life does not allow much time for slow traceability and inventory management decisions (Feng, et al., 2017). Therefore, avoiding perishable product expiration at retailers' shelf requires seamless and advanced tracing and tracking technologies that are still expensive to implement in FFP traceability. According to Bottani, et al. (2017) and Yiannas (2018) the cost of traceability technologies is high compared to perishable products value overall. Some of the methods known to track and trace products as they flow in the supply chain are the traditional manual methods or advanced methods such as; machine vision, barcoding technology and latest RFID technology (Bottani, et al., 2017).

Consequently, it takes immense time for FSCs to identify expiry dates manually. According to Yiannas (2018) in many cases, the paper data tracing method is still used to ensure up-to-date information. According to Riad, Elgammal and Elzanfaly (2018), only half of the small and medium enterprises track their inventory while the other half merely employ ordinary methods or do not track their inventory at all. Consequently, the inability to access in time product data regarding shelf life span can prevent inventory management to monitor the products close to expiration, contributing to higher product expiration at FFR shelves (Ketzenberg, Gaukler and Salin, 2018). Moreover, information between partners not accessed in the right format can also hinder the process of traceability and therefore lead to product expiration. Mishra, et al. (2018) stated that when tracing food products whole chain traceability is required. The actors need to act in collaboration to diminish the faults

in the traceability systems but there is always a dose of mistrust between the actors in the food supply chain. Secondly, every actor has their traceability systems. Yiannas (2018) states that because parties in the food supply chains record their data differently, this hinders their traceability capabilities and slow down the whole process. These, therefore, leads to:

RQ2: *What challenges are encountered by Fresh Food Retailers in the implementation of Inventory Control Management Systems to avoid perishability on their shelf?*

It is worth stating that this study focuses on the inventory management systems and traceability technologies to reduce expiration and deterioration which leads to waste of products. This also results in the loss of customers' trusts and increases the cost at the retailers'end. Given that the majority of food loss happens from the post-harvesting phase to the consuming phase (Pal and Kant, 2019). This study will investigate the Fresh food retailers' phase (please see fig. 1).

Hence, to find contemporary technology practices, the empirical scope of the study is the Swedish food supply chain with a focus on the Fresh Food Retailers (please follow the figure. 1) as it sums up the scope of this study.

1.2.Purpose of the Thesis

This study explores the challenges encountered by Fresh Food Retailers in the use of current Inventory Management Control systems.

Figure 2: The purpose of the thesis. (own work)

1.3.Scope and Delimitations

This study is delimited to the expiration of Fresh Food Products on the shelf of the retailers. This accounts for the high volume of inventories in the retailers' outlet with very limited shelf life, often less than two weeks and at most 2-3 days. It would explore if Fresh Food Retailers could be able to reduce to the minimal the rate of expiration of Fresh Food Products by use of better Inventory Management Methods and Technological Interventions. A geographical restriction of companies in Sweden is also applicable in this study. This study is mainly qualitative due to the intricacy of the topic.

1.4.Thesis Outline

The structure of this thesis goes thus:

Chapter 1 *Introduction*

This chapter presents the topic of this thesis. The reader will find preambles of foundations of this thesis such as Fresh Food Products, Fresh Food Retailers,

perishable inventory management, throughout the food supply chain. The problem discussion gives tips on why Fresh Food Products Inventory Management is challenging to be implemented. Consequently, research questions for this research have been derived.

Chapter 2 *Methodology*

Discusses methodological perspectives used to conduct the research reflecting research approach, research assumptions, the research process, data collection methods, and research validity.

Chapter 3 *Theoretical frame of reference*

The theory chapter constitutes the theoretical framework of the research. It explores valuable sources on supply chain within the fresh food retailers with a focus on perishables. Perishable inventory management and traceability solutions are discussed.

Chapter 4 *Empirical data*

The chapter summarizes empirical data collected per data collection methods and constructed validity chosen to guide the research.

Chapter 5 *Analysis and discussion of results*

This chapter summarizes the results of our data analysis.

Chapter 6 *Conclusion*

This chapter highlights my contribution to the study and brings the study to a conclusion.

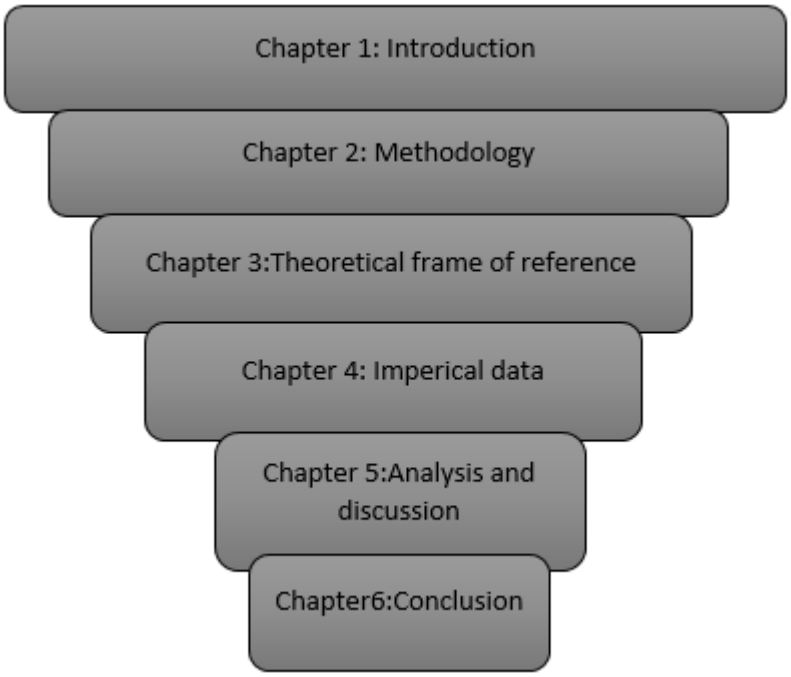

Figure 3: Thesis outline. (own work)

2.0.Methodology

This chapter introduces the outline of the method which is used to conduct the present research. The method is chosen per the research purpose and questions. The first phase defines the research philosophy and moves on to discuss the research approach, strategy, methodological choice, time horizon, techniques and procedures for data collection and analysis is presented. Furthermore, issues of data trustworthiness are addressed.

2.1.Research Philosophy

The most important step in the planning of research is the choice of research philosophy. According to Easterby-Smith et al, (2015), a well-grounded knowledge of philosophical assumptions could increase the quality of the research and contribute to the researchers' creativity. The philosophical content of research has an impact on the creation and outcome of the study. This implies the data collection and analysis are impacted by the research philosophy chosen. In the opinion of Easterby-Smith et al, (2015) research philosophy portrays the realism and clearness of the study object, the research design and highlights possible limitations to the research approach. Saunder et al, (2019) refer to research philosophy as all the techniques involved in the development of knowledge.

The research philosophy used depends to a large extent the nature of the study undertaken. According to Saunders et al, (2019), there exist five management philosophies: *positivism, critical realism, interpretivism, postmodernism and pragmatism.*

Positivism is the study according to Saunder et al, (2019) is a social reality within nature science applications which yields law-like generalization. **Realism**: this philosophy is made up of two types, *critical* realism and the *more extreme form* of realism. The more extreme form which is referred to as direct or native empirical scientific realism portrays what is perceived as the outcome of the study. Critical realism explains what is perceived and experienced in terms of the underlying structures of reality that shapes the observable event. The difference in the two forms of realism is: critical realism view reality as external and independent highlighting how human sense deceive us. Direct realism explains the first step is enough. **Interpretivism**: According to saunders et al, (2019), interpretivism portrays the interpretation of the content is assigned by the players with its meanings assigned to them. The purpose of the study is creating richer understandings and interpretations of the social world and its contexts. Thereby, data which is meaningful to the participants are collected. **Postmodernism**: This portrays the findings of a study used as the overall determinate and not the collected data. The outcome is interpreted from

the angle in which it is viewed, which thereby implies there exist no wrong or right results. **Pragmatism**: Referencing Saunders, et al, (2019) concepts are only relevant where they support actions. In pragmatism, research starts with a problem and contributes a practical solution that informs for future practice.

2.3.Research Strategy, Design and Method

A research strategy is used in the creation of the design of the research while research design is the context within which the collection and analysis of data take place Bryman (2016).

The research design chosen depends on the nature of questions the proposed research would be answering. There exist four major types of research design.

Explanatory Design - this comprises of a cause and effect relationship between variables and answers 'how' or 'what' questions.

Exploratory Design – uses the current situation to scrutinize and arrive at an outcome. An exploratory design is mostly used together with a descriptive design.

Descriptive Design - as implied by its name describes accurately and systematically a population, situation or happenings and answers 'how, what, when, where, and who' questions.

Evaluative - reviews the domain of studies and provides answers to' how, what, when, where or who'.

The research method is the technique in which research design is carried out. These techniques could be through surveys, experiments, grounded theory, case studies semi-interviews. There exist two main techniques available for researchers to pick from in the design of research. It could be **Deductive** which is linked to the quantitative method or **Inductive** linked to the qualitative method. The quantitative research method is a numerical survey and experiment while qualitative research methods are worded – like case studies surveys. A combination of both could also be used.

In this thesis, I have chosen the ***case study research approach (qualitative study)*** because the case study is aligned with the explanatory research design. Baxter and Jack (2008) mentioned correctly, that this strategy allows the authors to see the phenomena from a different perspective in a real-life context and develop an in-depth conclusion.

As per the description of Yin (2003), this thesis used a multiple and holistic case study strategy. A multiple case study allows the authors to compare and explore the research topic within the different cases and replicate the findings across cases. A holistic case study provides the platform to have a research conclusion on a global

scale. In this paper, the relevance of holistic research is magnified as there is a global concern on continuous temperature control for the fresh food supply chain. Thus, this thesis is a multiple case study of the inventory management control systems and challenges encountered by the fresh food retailers' in Sweden.

2.4.Research Approach

According to Saunder et al., (2019) the approach being used in research depends to a large extent on the acquired theory. The two most used strategy is, inductive and deductive Bryman, (2018). In referencing Saunders et al, (2012), the *deductive approach* starts with a developed theory through academic literature to the data. It starts with the theory of knowledge and stretches to the empirical. The *inductive approach* is the reverse whereby the empirical start the study and stretches to the theory. (Bryman and Bell, 2017, Saunders et al,2019). Bryman and Bell (2017); Saunders et al (2016) adds a third approach which has become popular within business research, the abductive approach. The abductive approach is a combination of both the deductive and inductive, which is an alternation between deductive and inductive approach. Bryman and Bell, (2017), Saunders et al (2016).

A deductive approach was used in this study. This is due to the use of a theoretical framework on FSC used in the development of the theoretical concept of this study. This was used as a guide in empirical data collection.

2.5.Population Sampling

According to Saunders et al, (2019), the population being studied in the research process needs to be precise and clear. A population can be referred to as the universal set of units (Continents, countries, nations, firms) while sampling is the portion of the population hand-picked for investigation Bell et al,(2018). The population is the full set of the case from which a sample is taken. Sampling is a means to reduce the volume of data collected for the survey. Sampling techniques could be grouped into **probability sampling** (representative sampling**)** which according to Saunders et al,(2007), is associated with survey-based research. Inferences from samples about a population provides answers to research questions to meet objectives. This implies the use of statistical estimate which is associated with survey and experiment studies. The second technique is a **non-probability sampling** (non-random sampling) which is a qualitatively based method. It implies selecting samples based on the subjective judgement of the researcher. This is vitally used in case studies. A non-probability sample was used in the population sample for this thesis.

It is worth noting studying a population is a challenging task as every aspect of a population could be inaccessible. Narrowing of a population makes it easier to

manage the study. The Food Supply Chain stands as the Population of this study while fresh food retailers which is the study focus as the sample of the study.

The main focus of this study is the fresh food retailers and the challenges encountered in the effective inventory control management of perishable products. FFR is the go-between the producers (farmers) and the consumers (fork). They break the bulk quantity to smaller portions, thereby making it more convenient for the consumers to acquire.

The cases studied are a combination of hypermarket, convenience store, discounts store and start-up store all retailers of fresh food products. According to Amorim, et al. (2013) fresh food products are mainly food goods referred also as perishable products. The main issues with fresh food products are their expiration or their deterioration (if not sold on time) and their loss of sales due to absence of stock (out-of-stock situations) in referencing Feng, Chan and Cárdenas-Barrón, (2017). Products in this category comprise of fruits (oranges, banana, plums, honeydew, water melons, Galia melon. pears etc) and vegetables (parsley, lettuce, spinach, Basil, coriander, broccoli, cauliflower etc). The stores vary in sizes ranging from 700 square meters to 13,000 square meters. These firms have different means of inventory control of their fresh food products and encounter different challenges.

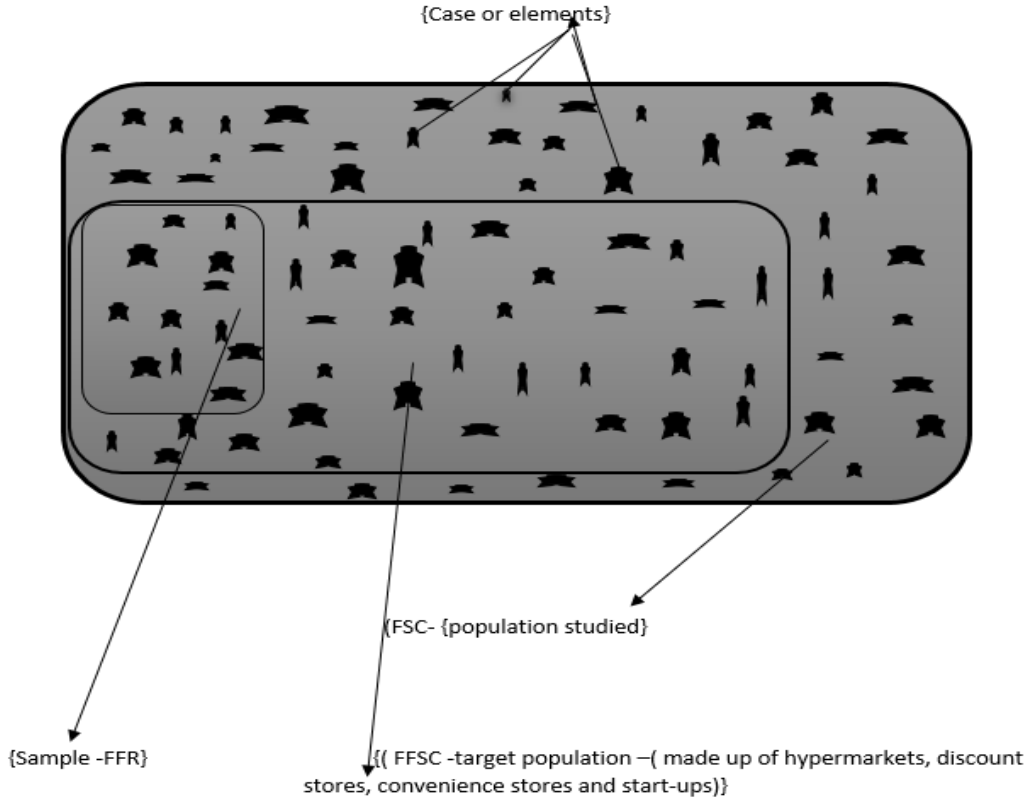

Figure 4: Population sampling. (own work)

2.6.Data Collection Methods and Analysis

Data Collection

According to Bryman and Bell, (2015), the unstructured nature of data collected from interviews and observations in a qualitative study makes analysis challenging. There exist three types of interview – structured, semi-structured and unstructured techniques used in primary data collection. The major difference that exists in these techniques are *structured* interviews are more controlled. The responses are straight to the point. The *semi-structured or unstructured* are flexible. Data collected in qualitative research is unstructured and flexible, which implies the use of either semi-structured or unstructured techniques Saunders, et al. (2012). The semi-structured nature of the interview creates room for the composition of more questions based on the initial response gotten. This results in acquiring more detailed data.

Data could either be primary data gotten from interviews and observations and are semi-structured while secondary data are borrowed from previous pieces of literature according to Hox and Boeije, (2005). The use of multiple data enhances its credibility Yin, (2003). This type of data collection depicts the researcher crisscrossing between data and theory to ensure the data collected meets the concept being studied Bryman and Bell, (2015).

According to Saunders, et al. (2012), there exist three ways to conduct semi-structured or unstructured interviews: face to face, telephone conversation and internet mediation. The three methods were applied in the current research. This study made use of the Semi-structured interviews which provided the avenue to compose more questions related to the topic. Interview questions used in data collection are attached in the appendix of this study.

Due to the knowledge base nature of this study, a short presentation portraying an overview of the company.

The companies studied are retailers within the Hypermarkets, convenience stores, discount stores and start-up. Their sizes range approximately 680 sq metres to 13, 200 sq metres. These stores are grocery stores, with one being a bulk sale one. Apart from trading in grocery, stores A -E are also retailers of FFP like bananas, apple, lettuce, melon, spinach, cauliflower, tomatoes, potatoes, carrots, pepper etc

Company Name	Respondent	Reference code	Date	Duration of Interview	Data Nature
Company A	Store Manager	A-SM	2019/09/13	00:35:00	Phone call
	Inventory Manager	A-IM	2020/01/08	01:43:00	Interview
Company B	Store Supervisor	I-SS	2019/09/18	01:23:00	Interview
Company C	Store Manager	C-SM	2019/09/19	01:58:00	Phone call
Company D	Purchasing Officer	L-PO	2019/10/03	01:45:00	Interview
Company E	Store Manager	LL-SM	2019/09/20	01:18:00	Phone call

Table 1: Data collection (source: own work)

Data Analysis

According to Bryman (2016), there is no clear lied down rules on how a qualitative study data should be analysed due to the volume of unstructured data. Referencing Yin(2014) in terms of case studies, there are five techniques for data analysis methods: **Pattern matching** is predicting of outcomes-based on a theoretical proposition to explain the researchers' expectation Yin, (2014). **Time-series analysis**: responses to how and why questions about relationships of events over time. **Explanation building**: as its name implies, builds an explanation in the data collection and analyzes process rather than testing a predicted explanation Yin, (2014). **Cross-case synthesis**: is used in multiple case studies. In this technique, every case is treated as a separate study with the view of finding cross-case conclusions. This analyzes its similarities and differences. **Logic models**: studies changes by operationalizing a complex chain of events over time.

2.7.Validity and Reliability

Most schools of thought have challenged the relevance of validity and reliability in a qualitative study. Bryman and Bell (2015) believe these terms could still be viewed relevant provided they do not interfere with the measurement aspect of the concept.

Validity: In referencing Bryman and Bell (2015), validity is the integrity of the conclusion generated from a piece of research. This ensures whether the research explored the intended study through its techniques. This implies the findings of the

study reflecting what they appear actually to be Saunder, (2007). It can also be defined as a study that has interpreted its data thereby depicting the object of study in its conclusion (Yin,2015). According to Kumar (1999), validity should be addressed in every step of a research study as it refers to the quality of the research. The strength of qualitative research is covered by the semi-structured interviews which serve as a guide for the questions prepared. Validity could be*:*

Internal validity research seeks to explain how and why an event leads to another. It explains the causal relationship between variables. It implies how a variable affects the variation of another variable in a study Bell et al,(2018).

External Validity implies if the findings of a study could be applied to other research settings. Bell et al,(2018). It means findings not generalizable to other settings. This poses challenges especially if the case study should be applied to an organization of different structure and sizes. This study does not make use of external validity due to the findings not applicable to other structures because all organization are not faced with the same circumstances. This could be as a result of size, setup and exposure.

Construct Validity implies identifying and making use of the right operational measures for the concept used in the research. This study made use of the construct validity due to the operationalization of all important concepts (shelf-life management, technological innovation and implementation challenges) used in this study.

Reliability: According to Collins and Hussey (2009), reliability refers to the absence of differences in the outcomes of a research work repeated. In referencing, Yin, (2014) reliability is a reduction in error or biases in the study. According to Yin (2019), this implies, the same study hypothetically done by a different researcher and still arriving at the same conclusion.

2.8.Ethics

An explanation of the motive of study and opportunity for participants to freely ask questions should be officially communicated to the participants before the collection of the empirical data and the research conducted (Saunders et al, (2016). The techniques to be used for data collection, the confidentiality of data collected and time to decide if participants would want to be partakers in the research study are points of ethical considerations to be noted.

In referencing Bryman and Bell (2015), it is important for the identification of the respondent and company if it causes harm in any way so it could be avoided. This

has led to omitting the company names and exclusion of the company webpage also used in information gathering due to the anonymity of the company.

Research Method	Research Technique Used	Reason for use of the technique
Research Philosophy	Pragmatism	This study started by addressing a problem and the solution was provided by the empirical study.
Research Strategy	Case-study approach that was multiple and holistic (Qualitative study)	The research aligns with the explanatory design, explored and compared the research topic with different cases.
Research Approach, Design and Method	Deductive, Cross-sectional explanatory, exploratory, evaluative and descriptive	Theoretical framework on FSC was used in developing the theoretical concept of this study. It also served as a guide for the empirical data collection.
Population Sampling	Non-probability sampling	This research is case-study based.
Data Collection, Methods and Analysis	Semi-structured interviews and use of web sites and annual reports	The semi-structured interviews created room for more question composition.
Validity and Reliability	Construct validity	This study operationalized all important concepts like shelf-life management, Technological Innovation.
Ethics	Anonymous and informed	The identity of participants are protected and they were not obliged to participate.

Table 2: Summary of research method used (own work).

3.0.Theory

This section of the paper provides a deeper theoretical understanding of fresh food inventory management tools currently been used in the control of deterioration in the retailers' shelf. It also provides a framework of the challenges related to the use of these inventory management methods or technologies.

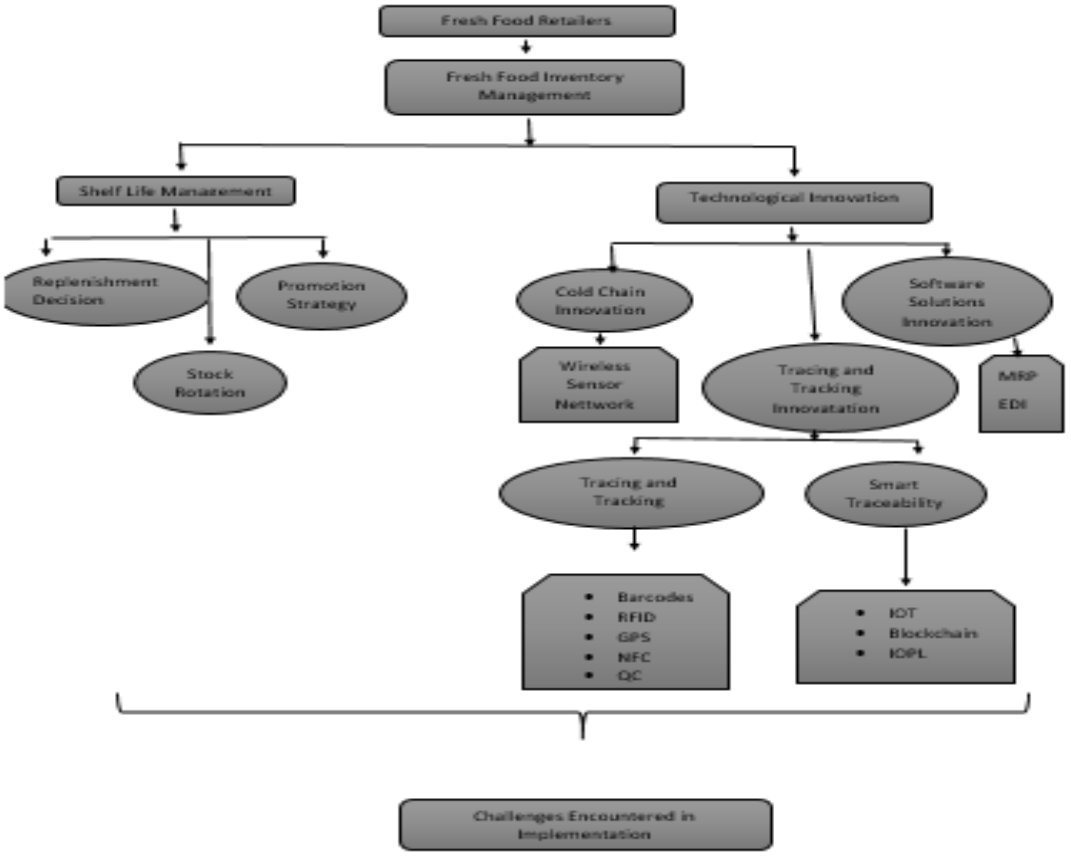

Figure 5: Overview of Chapter 3. (own work)

3.1.Fresh Food Retailers

Retailers act as a go-between the suppliers and consumers in the food supply chain. In referencing Gellynck et al. (2015), retailers are held responsible for the action of other actors in the food supply chain. They are the creators of product assortments, bulk breaking and also offering a range of services Esbjerg et al, (2016). They can be viewed as been able to change practices within the food chain. According to Li et al, (2016), most fresh food products though having a short lifetime, generate a substantial amount of revenue as well as drive store traffic in the retail outlets. Customer's choice of retail outlet is based on the fresh food products displayed on the retailers' shelves. Fresh food products are highly perishable food items. They have a very short life span as they begin to deteriorate fast such as fresh fruits and vegetables. Their useful life span on the average is between two days to a week. For this study, Fresh food Retailers are those outlets selling perishable food items to their customers.

3.2.Fresh Food Inventory Management

According to Li et al, (2016), the inventory control management of fresh food products referred mostly as perishables could be challenging due to its short life span. These food products require proper handling and storage and the use of the right technological innovations throughout the entire food supply chain. These interventions are strategies employed by retailers in the control of inventory of fresh food products. Previously, in referencing Duong and Wood (2019), inventory control management was done by monitoring inventory levels at fixed intervals – a system whereby a store person counts the inventory once per week and use the outcome to estimate what quantity of inventory would be required to re-order. This was used and still used by most retailers due to its simplicity.

According to Slack, Chamber and Johnston (2010), inventory or stock is the stored material in a transformation system supporting the business due to uncertain supply or demand. Inventory is referred to in various names such as safety stock, buffer inventory etc. Hence, when Slack, Chamber and Johnston (2010) attempted to describe inventory management they mentioned three merited points: *how much should be ordered*; *when should the order be made* and *how to control the overall procedure*. Alike, older sources, such as Quinn (1997) and Silver, Pyke and Peterson (1998) defined inventory management as a collection of tools and strategies of an organization that help to control inventory levels within the supply chains. Other valuable sources like, Chande, et al., (2005) described inventory management as a

tool that monitors the availability of material, considering the demands that have arrived and place orders for a refill of stock.

In referencing Riad, Elgammal and Elzanfaly (2018) inventories are classified into three categories: 1. *Perishable inventory*, products that are sensitive to time, storage and environment conditions (fresh food products fall within this category). 2. *Non-perishable inventories*, the category that is solid and has a fixed lifetime such as home appliances, clothes etc. and 3. *Service inventory*, that are intangible resources such as hotel rooms, flight tickets etc. Consequently, fresh food products (perishables) are seen to capture more demand nowadays and are being adopted by considerable Supply Chains (Siawsolit, Gaukler and Seepun, 2018). In the competitive markets, determining price and order quantity to better manage perishable product inventories is known as an essential way to increase profitability and competitiveness in the Supply Chain (Feng, Chan and Cárdenas-Barrón, 2017). According to the same authors, the main issues with this product category are their expiration (when the product cannot be sold anymore) and the loss of sales (due to the absence in the stock). As mentioned earlier in referencing Chande, et al. (2005) *"Perishability refers to the decrease in value or usability of the product over time due to the inherent characteristics of the product.*".

In respect to fresh food products, freshness is the main criteria to evaluate their quality and could dramatically affect their market demand. To obtain the most profitability outcome as possible from fresh food products, inventory management models should be combined with proper storage, aided by the use of the right technological innovations such as comfort temperatures, shelf life space allocation etc (Bai and Kendall, 2008). Inventory management has many purposes however in perishable context the focus is extended to accessing a wider aspect of information such as "due dates" and "shelf life span" to monitor the products close to expiration then promote, sell and finally replenish the stock. Authors that have come up with models in this perspective are Chande, et al. (2005); Bai and Kendall (2008); Tromp, et al. (2012). Furthermore, because of the sensitivity that short-life products have in the sustainability of FSCs, many authors have worked in this field and have offered solutions. Table 3. Sums up the summary of sources used to preamble the theoretical framework in this chapter.

Source	Focus	Scope	Support
Kiil, et al., 2018	Automatic replenishment Program (ARP)	Reducing food waste at grocery stores	Share of information between partner., Seamless traceability with new technologies.
Pal and Kant, 2019, 2018	Automation of fresh food logistics	Reducing food waste throughout the supply chain	High advanced traceability systems
Siawsolit, Gaukler and Seepun (2018)	Managing fresh food inventories	Increase profitability, reducing the impact of lost sales	RFID, Purchases through mobile phones.
Feng, Chan and Cárdenas-Barrón (2017)	Inventory model that stipulates the customer demand for fresh food products.	Increase profitability thought to sell at discount and having better control of inventories.	Promotion through: Price, Freshness and displayed space.
Ketzenberg, Gaukler and Salin (2018).	The rate of decay is random to a variety of products.	To determine accurate expiry dates. Some can expire earlier and some later.	Markov decision process to determine expiration. A variable model for expiry dates is suggested
Akkas, Gaur and Simchi-Levi (2018)	Inventory management in avoiding unsaleables (loss of value due to expiration)	Unsaleables (wastes) due to packing failure, manufacturer's sales incentives, replenishment workload, and min. order rule	Data integration from manufacturer and retailer to diminish expiry of products

Dolgui, et al., (2018)	Perishable inventory management model	Three-stage supply chain producer- inventory-retailer Optimise fleet sizes.	Optimising the order policy by integrated production, distribution and inventory (PID) models
Hu, Toriello and Dessouky (2018)	Fresh food products inventory management with a fixed lifetime.	logistics, inventory routing, freight consolidation	Use of transportation assets by intelligently routing a fleet to serve multiple customers
Riad, Elgammal and Elzanfaly (2018)	Efficient Perishable inventory management	Inventory management models, IoT to seamlessly monitor the perishable products for full inventory visibility.	Connect the supply chain seamlessly to make full inventory visibility, through IoT.
Yang., Xiao and Kuo (2017)	A sustainable food supply chain	Pricing and discount strategy, shelf space allocation, and replenishment policy	Price and shelf space promotion as a solution to increase customer demand for perishables

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Table 3: Sources of fresh food inventory Management

3.2a. Shelf Life Management

Kiil, et al. (2018) state that 10-20% of the waste in the food supply chain occurs at the retailer phase due to expiration on their shelf. In referencing Olsson (2014), to operate an effective Food Supply Chain with a focus on the fresh food sector, the expiration date of fresh products should be taken into account in the planning of inventory target levels. Inventory Management of Fresh Food Products to avoid expiration of products could be achieved by first addressing shelf-life management and inventory policies. Inventory policy is an inventory management tool and comprises the guidelines and accounting policies to ensure that inventory is properly controlled, cost allocated, and *waste* or *out of stock* situations are prevented Dolgui

et al., (2018). Hence, the inventory policy addresses the decision of replenishment, promotion strategies stock rotations. Replenishment is a focal point for the performance of FFR as it must maintain product availability while avoiding excessive food waste due to expiration on the other side (Ketzenberg, Gaukler and Salin, 2018). In referencing Teller et al, (2018) shelf-life visibility serves as a unique sales point that attracts customers to other products the retail outlet offers. For effective shelflife management, right temperature setting, the right shelf space allocation and the right assortment of products are required

3.2ai. Replenishment Decisions

Replenishment decision is a very important tool in the inventory management of fresh food products, which in the long run affects the performance of the whole FSC. According to Ketzenberg et al. 2018, replenishment aims to make products available on an appropriate level and avoid excessive inventories at the backroom(stockroom) that increases the number of expired products at the retailers' phase. Maintaining a high functioning replenishment decision impacts on the satisfaction level gained by the customer. Sarimueiset al. 2008. An effective replenishment decision is the use of the pull-based inventory management technique (referred mostly as Just in Time JIT technique). This is an inventory reducing system that attempts to reach a zero-inventory level in an organization.

In referencing Feng et al. (2017), the inventory level is monitored manually and when it gets below its surplus level, then it is replenished. (Chande et al. 2017; Bai and Kendel, 2018 and Tromp et al. 2012) are of the opinion inventory expiration date are monitored and then sold when closed to the expiry date and automatically replenished.

Just in time works as a pull system using the Kanban technique where products remain out of the organization until demanded. Sarimveis et al. 2008. The number of products out of the system are readily available when requested for as if they are in the shelf. It is a system which easily meets demand size and can be sold within the shelflife time. Riad et al. 2018. This technique reduces the challenges of overstocking or understocking as retailers can order the required quantities of products.

Replenishment method according to Chande et al. (2005) introduced an algorithm which maintains inventory level via monitoring the age of the product automatically. This they did by proposing a strategy of monitoring the First In products by increasing the demand for products close to expiration through dynamic pricing and other sales strategies and at the same time place an order for stock replenishment.

Tromp et al. (2012) also supported a similar approach of replenishment but took into consideration uncertainties and variable characters such as temperature, transportation conditions and bacteria levels throughout the food supply chain which cannot be controlled. This results in fixed expiry dates not been accurate thereby

suggested the use of a dynamic expiry date instead of a fixed one during replenishment. A dynamic expiry date could be defined as an expiry date fixed based on the quality of the product. Dolgui et al (2018) supported the idea of product expiration depending on the weather conditions, transportation and bacteria level. These models have resulted to be highly accurate but require advanced traceability methods thereby making implementation more expensive.

3.2aii. Stock Rotation (FIFO, FEFO*)*

It has been mentioned in the introduction that fresh food products impose an additional constraint. Shelf life is the prediction to know how long a product can stay in the shelf before it expires (Chande, et al., 2005). In the physical control of perishable inventory, the clearance of stocks that have come in first is crucial. Therefore, stores that sell perishable products use stock rotation or the practice of putting fresher products to the back of the shelf and pulling older ones to the front (Akkas, Gaur and Simchi-Levi, 2018).

Moreover, FIFO is a shelf filing system for fresh food products that are subject to deterioration (Ferguson, & Ketzenberg, 2008). When replenishing a shelf based on FIFO, the products that have entered the store first (first in) are displayed to the front closer to the customers' hand while the freshest ones (last in) sit at the bottom of the pallet or behind the first in stock. This will make the pull-based inventory more functional because customers are supposed to pull the thread all the way to the sourcing. FIFO requires that each partner in the supply chain deliver first the products that have sat most in the warehouse irrespective of their shelf life left (Hertog, et al, 2014). This policy will reduce the number of products wasted throughout the food supply chain, while clients are served better by receiving products that meet their requirements. However, in reference to Pal and Kant (2019) last in products do not always have the longest shelf life bringing the FIFO system sometimes in question. Yet, technology nowadays has made it possible to access detailed product information and due to this (FEFO) strategy is made possible Hertog et al. (2014). (FEFO) is "First expired First out" and it is designed especially for the fresh food sector Kaipia et al, (2013). FEFO is smarter than FIFO and allows first expired to be shipped out first by estimating the accurate shelf life granted by online sensing infrastructure (Kiil, et al., 2018). FEFO makes it possible to ship products depending on their shelf life potential in relation to their end destination. Of course, in order to be shipped expiry date of goods is known, thus ensuring only high-quality products are sent to retailers and eliminating product loss during transport (Hertog, et al, 2014).

3.2aiii. Promotion Strategy (Dynamic Price, shelf location)

According to Yang, et al. (2017) due to the deterioration of quality in fresh food products, customer demand slows down for these products after a period of time, therefore resulting in retailers using promotion strategies to improve the efficiency in the food supply chain. Referring to Riad et al. (2018), in fresh food inventory

management, it is essential to have shelf life estimation to enable products to be sold with an optimum price before deterioration. Products with short lifetimes can be subject to different promotion strategies. According to Bai and Kendall (2008), there exist three main strategies to increase customer demand for fresh food products at their close to deteriorate stage. These are dynamic pricing, shelf allocation and differentiation strategy.

Dynamic pricing assumes that perishable products are highly-priced products. Prices in this promotion strategy are placed based on the quality of the product. Introduction of price discounts will increase the consumption rate when the quality of products begins to deteriorate. According to Riad et al., (2018) in perishable inventory management it is essential to have shelf life estimation so the business can sell the products with an optimum price before they deteriorate. Moreover, knowing the exact remaining lifetime can enhance inventory management by checking alternative options to promote the products. Being able to access product data regarding time and temperature would enable the retailer to set dynamic expiration dates for the product.

The second promotion strategy is known as shelf space and shelf allocation. According to (Yang et al, (2017; Feng et al, 2017) having a more visible and larger shelf result in higher sales which yield higher profits for the retail outlet. Bai and Kendall (2008) are of the opinion that shelf space is very important to boost perishable products sales but in most cases, shelf space is limited due to temperature control requirement and the cost associated with it. Therefore, the retailer will offer a discount and relocate them from the original shelves to a discount rack imposing demand increase for the same products

The third strategy is the shelf differentiation. It is a product classification based on fresh vs non-fresh products. Fresh products are separated from non-fresh products and sold separately in different shelf with different prices allocated to them. (Bai and Kendall, 2008).

3.2b.Technological Innovations

3.2bi. Cold Chain

In referencing Tromp et al. (2012), characters such as temperature, transportation conditions and bacterial levels are uncertainties and variables that cannot be controlled. Due to these factors, fresh food products require efficient modes of transportation and storage to prolong their shelf life. Pal and Kent (2019) defined three main factors which increase the rate of deterioration of Fresh Food Products. These are temperature, humidity and vibration. According to Luo et al. (2016), the

cold chain is a perfect balance between science, technology and process. Bharti (2014) is of the belief cold chain is a form of the supply chain (food) which ensures a longer lifetime for perishable products (in this context Fresh Food Products) and its quality through the control of temperature and humidity while transiting through the value chain. The main objective of a cold chain in Food Supply Chain is the preservation of products especially Fresh Food Products through all phases until it reaches its end consumers Luo et al. (2016).

In reference to Pal and Kent (2019), Fresh food products not refrigerated at the right temperature results in their deterioration by 50% leading to expiration at the Fresh food retailers' shelves. (Pal and Kent, 2019: Tromp et al 2012) believe protective packaging and ambient control sensors are necessary to be able to control the humidity level of fresh food products. Humidity should be maintained at a level that minimizes water vapour pressure deficit between the environment and the product. For instance, a 20% higher scale in humidity causes product deterioration 7% more within four days period Pal and Kent. (2019). According to Pal and Kent, there are other variables like oxygen control and vibration during transportation which have little impact on the overall shelf life of fresh food products.

3.2bii. Wireless Sensor Network (WSN)

In reference to Luo, et al. (2016), the most frequent use of tracking tools is in the transportation of perishables through the cold chain as it requires constant monitoring of real-time temperature, humidity the physical position of products. The authors came up with the structure and information platform design to monitor perishable goods in the cold chain within less cost. This tracking system uses a wireless sensor network (WSN) built on Zigbee which can collect and transmit live data instantly and efficiently. WSN is used for sending high-profit perishable products like- food, flowers, chemicals etc.from supplier point to the receiver's place Li, (2014). WSN is a collection of sensors that monitor and record the physical or environmental conditions and then store these data to a central server. The pieces of information measured are environmental conditions such as temperature, sound, bacteria levels, humidity, wind etc (Aung and Chang, 2014). Decisions taken through the help of WSN are intended to improve the delivery of perishable products, thus it is particularly intended for monitoring and forecasting the shelf life span of fresh food products.

WSN is very helpful in perishable inventory management (in this context fresh food products) and delivery of products in its fresh stage, but it cannot function as an independent tool because it is not intended for single item identification but rather for a full batch identification (Aung and Chang, 2014). However, if used in cooperation with RFID and Quality Control (QC) sensors this tool is incomparable in the perishable food traceability context.

3.2biii. Software Solutions (MRP, EDI)

In referencing Amorim et al, (2013), accessing real-time information about product lifetime helps fresh food retailers to reduce the number of products expiring at their shelves. Software products in the food supply chain can generate notifications about products close to expiration, shelf replenishment and expired products and the need to dispose of them. Products and information flow forward and backwards in food supply chains from the farm to the customer's hand. Hence the forward information flow examples are manufacturing schedules and purchase orders while the reverse would be production reports and purchased product receiving reports (Toomey, 2012). In the context of this paper, information flow are harvest dates, packaging, movements and storage information. According to Ilie-Zudor, et al. (2011), the systems used in planning and controlling the flow of products were previously paper-based but has been replaced by computerized automated systems. For traceability purposes, food supply chains should create a computer-based system that integrates the database of all the processes and creates a "front end" display in a live web browser that allows the access of the information online, De Cindio, et al. (2011). Few of such software are Aris (IDS Scheer GmbH Prof.); Tibco Business Studio 2.0; Intalio; WebRatio.

Hence, to achieve this flow of information, Food Supply Chain partners use different software solutions, however, examples are MRP and EDI. MRP stands for manufacturing resource planning and is used for the planning of all the operations, it comprises with material requirements and capacity requirements and is integrated with other systems such as finance and purchasing (Toomey, 2012). While, EDI stands for electronic data interchange and comprises with the utilisation of computers to communicate and exchange documents between SC partners, so it is an intra-communication link in the supply chain.

Every information accessed should be calculated, synched and shared between partners in the supply chain. According to Kiil, et al. (2018) discuss automated replenishment program (ARP) to share information in the food supply chain. This shared information within partners in the value chain would assist in having an insight into demand and inventory level orders. Secondly, shared information determines the lead time at each phase of the food supply chain to enable partners to know the node where the products spend more time before getting to the end consumers. Thirdly, shared information is used in determining and improving performance within the chain. It is worth noting that information sharing within the food supply chain increases transparency which makes coordination of decisions more effective and creates an integrated balance between availability and food waste metrics (Kiil, et al., 2018).

Hence, a considerable number of sources have discussed the inventory management in collaboration perspective among them Mishra, et al. (2018); Yiannas (2018); Bottani and Rizzi (2008, 2017); Chande, et al, (2005); Sarimveis, et al, 2008. According to these sources, a whole chain context is required in the standardization of information exchanges, awareness creation and the efficiency of the traceability systems between partners in the FSC. Trying to find a general solution for the whole food supply chain is not an easy task because according to Yiannas (2018), implies that parties in supply chains record their data differently and use a variety of inventory models. Consequently, recent sources suggest accurate forecasting abilities through seamless data sharing and monitoring abilities. According to Sari (2008), the scarcity of information flows between supply chain partners has led in many cases to "bullwhip effect" named as the phenomenon where orders to suppliers tend to have a larger variance than the sales at the buyer.

3.2biia.Tracing and Tracking of Fresh Food Products

The general food law, especially in Europe, has set standard requirements that food should be traceable. This has resulted in legislation and regulations to set food products guidelines and code of practice and recommendations in respect to food labels (e.g. 'best if used before', low fat), food safety amongst others. Food safety violation occurs in different ways from the processing stage through all paths food processes pass through on its way from farm to fork. The focus of food industry to provide food products that are safe for consumption in line with codex Alimentarius, European Union - general food law (GFL) amongst others has resulted in the traceability of food products in the FSC.

Schools of thought have come up with different definitions of traceability mostly addressing the portion of the system under consideration. According to Olsen and Borit, (2013) based on the ISO definition, traceability is the ability to access any or all information relating to that which is under consideration, its whole life span using recorded identification. For this thesis, according to Dabbene, et al. (2014) defines traceability as representing the ability to identify the source of the products, the sources of input materials as well as the ability to conduct full backward and forward tracking and tracing to identify the specific location and life history in the food supply chain.

This implies for traceability to be effective information of a product at any given point of time can be accessible by collaborators of the chain. Another school of thought is of the opinion traceability is not the product and process information itself, but a device that assists in retrieval of such information at any stage of the process chain and even at the end of the process. Karlsen et al, (2010). In summary, traceability according to Aung and Chang, (2014) is a tool used in retrieving information, a record-keeping system and a part of logistic management. It can be likened to a filing cabinet used for orderly storage and retrieving of data. It is worth

noting traceability is not information but a system of retrieving and storing information in the FSC.

Traceability is a two linked process: *Track* - locating articles or items physically inside a facility - to a specific location or to identify articles or items used to fulfil an outbound sales order (e.g., where it is and where it went). It is the process of finding the product downstream in the food supply chain. Mishra, et al., (2018). *Trace* - Searching historical records about identifying manufacturing processes and the source of ingredients or components, etc. (e.g., how information about a product was processed). It is the process of finding the products data in upstream in the food supply chain Mishra, et al., (2018). This results in a comprehensive system.

Traceability in the retail sector of the Food Supply Chain has an enormous benefit. In many cases traceability is understood as a way to match the physical stock with the computer reports Ilie-Zudor, et al. (2011) and as EU legislation has made it mandatory companies sometimes see it even as a burden (Mishra, et al., 2018). In referencing Bailey et al., (2016) traceability elongates the shelf life of products. The comprehensive traceability information of products available enables actors to be able to trace the period of time products spend in different nodes of the food value chain. This helps to shorten the time frame spent in a particular node thereby elongating the remaining shelf life of such product in the retail outlets. Traceability is also used in monitoring the timing and temperature of highly perishable products to ensure these products are controlled with the right temperatures, which also affected the remaining shelf life of products. Traceability also in referencing Aung and Chang, (2014) can also help in building the confidence, trust customers have in a product.

To be able to implement an effective traceability system which in the long run reduces the expiration of fresh food products in the retailers' shelf, there are basic methods and principles to follow. First Traceable Units (TU) should have unique identifications. In referencing Karlsen et al (2011), TU or a Traceable Resource Unit (TRU) for this literatures are grouped into units of products. These units should have a common property of having undergone the same processes or possess the same characteristics. This gives the products some form of uniqueness. For instance, unique identification of the cow a pack of milk was gotten from. A TRU is made up of three traceable units: a batch size of a product, according to Karlsen et al, (2010) must first be established before linking the information to the product. A batch is also referred to as a lot which is the measure of materials going through the same process. A second traceable unit is the Trade Unit (TU), which according to Karlson et al, (2010) is any item upon which there is a need to retrieve predefined information and may be priced, ordered or invoiced at any given point in time in the SC. Examples are a box, a carton, crate of drink etc. The third type of TU is the Logistics Unit (LU) which in reference to Karlson et al, (2010), is a component of any composition established for transportation or storage and needs to be controlled in the SC.

Examples are pallet, container load or truckload etc. Documentation of transformation within the SC is important. For the seamless implementation of conventional traceability technologies, there are laid down structures to be followed. In reference to Aung and Chang (2014), there should first exist hardware: (measuring equipment, identification tags and labels), and secondly, a software information system. Thirdly a scanning and digital technology for product identification (image capture, storage and display).

3.2iia. Tracing and tracking technological innovations.

To trace products in their journey and facilitate extraction of information from the product, auto-identification methods were invented. The most frequently used methods are Barcodes, Radio Frequency Identification (RFID), Near Field Communication (NFC) and Global Positioning Systems (GPS).

The technologies used in data collection give advantages and limitations regarding human intervention, labour, range of applications, cost and accuracy. The choice of method to trace products is subject to actors individually, however it is also imposed by the tracing methods used by partners in the supply chain. Systems that facilitate traceability of products can be classic (paper-based) or computerized such, machine vision, barcoding technology or latest traceability technologies that secure seamless information access about products (Bottani, et al., 2017). The traditional traceability consists of the manual identification where products are counted and checked up for expiry dates and other purposes. As this method is always prone to human errors it is also enormous time consuming, costly and inaccurate in many ways (Bottani and Rizzi, 2008).

- *Barcodes*

Barcodes are the most widely used technique to auto-extract product information via electronic devices. The barcodes are codes that are machine-readable using readers that encode, store and recall information when required (Óskarsdóttir and Oddsson, 2019). Barcodes could be one dimensional (1D) - which is known as a linear barcode or two-dimensional (2D) know as a quick response code. In figure (4 & 5) and example of an image of barcodes are inserted.

The 1D barcodes known as linear barcodes (figure 4) store information through strings between 0-9 and can contain up to 85 numerical characters. This information is retrieved by using a barcode scanner such as barcode hand scanner, pen scanner, laser scanner or a mobile device. Reading through the strings can allow the scanner to access the information that is relevant to the product examined (De Cindio, et al., 2011).

Figure 6: (1D) Barcode

Consequently, barcodes have been modified with another method called s 2D barcode (figure 5). This barcode is also known as a quick response barcode (QR) with the same features as the linear barcodes however the information is stored both horizontally and vertically. Therefore, a QR barcode can encode up to 7.089 characters. They require a QR reader to retrieve information or a camera and is much faster than a 1D barcode and can also provide more information about the products. (Denso, 2011; Aung and Chang, 2014; Bosona and Gebresenbet, 2014; Dandage, et al. 2017).

The benefits in this technique are the low cost of implementation and its coherence in use which has made it a widely used application in the FSC. Also, being able to read via any form of devices with a camera and its cheap running cost is a great benefit. The main downside of this method is the need for a line of sight. (Aung and Chang, 2014; Badia-melis et al, 2015). This implies this device can only transmit and receive data when transmitting and receiving stations are within range with no obstacles intervening during the process of transmission. Likewise, other authors as Ilie-Zudor, et al. (2011) mention that barcodes are sometimes hard to read and unable to store enough information, they are often slow, time-consuming and error-prone. Similarly, Chande, et al. (2005) state that old techniques of bar codes like the 1D are also labour-intensive and unable to ensure up-to-date information. Therefore, according to De Cindio, et al. (2011) reasons why companies have been pushed to replace this method with less time-consuming technologies is due to its inability to read through the bars due to dirt, damages or scanning faults. This has led to the

development of scanning from a range of distance and technological innovations like RFID and NFC.

- *Radio Frequency Identification (RFID)*

The failures and delays associated with barcodes have allowed many leading companies to establish and test high-end technologies to identify products throughout their food supply chains. Therefore, a useful and most spread out model to trace and track is known as RFID (Radio Frequency Identification). The RFID technology is meant to automatically facilitate retrieving the identity and accurate data of items as they circulate through the supply chain Chande, et al. (2005). In comparison to barcode scanning which only provides scanning a product at a time, RFIDs read a hundred tags per second even from a range, thereby making this the most time-efficient technique, accurate and real-time data access (Bottani, et al., 2017).

According to Bottani and Rizzi (2008), RFID represents technologies used to radio identify items. It works simply with the aid of a reader with an antenna and a tag with a chip attached to the product. The reader sends electromagnetic waves when the antenna and the tag are in close range with each other creating thus a magnetic field that activates the microchip's circuits of the tag (Zsigmond, et al., 2018). After this, the chip modulates the requested waves and sends back to the reader data that has been stored within. The reader or RFID scanner converts these waves into digital data. Next, the RFID scanner sends the data signal that is stored to the computer database. A user can then view all the information stored or generated for that product either through the RFID readers screen or via computer database. Data stored into the tags' microchip are in the form of Electronic Product Code (EPC). EPC is a standard product code developed by Auto-ID centre in 1999 by five leading research universities and more than 100 leading retailers, consumer product makers and leading software companies (Bottani and Rizzi, 2008).

An integrated or non-integrated food supply chain RFID will allow substantial cost savings for actors in the value chain in terms of overstock, stock-out reduction, and efficient time management (Bottani and Rizzi, 2008). However, RFID has its downsides when it comes to implementation of products with a short life span.

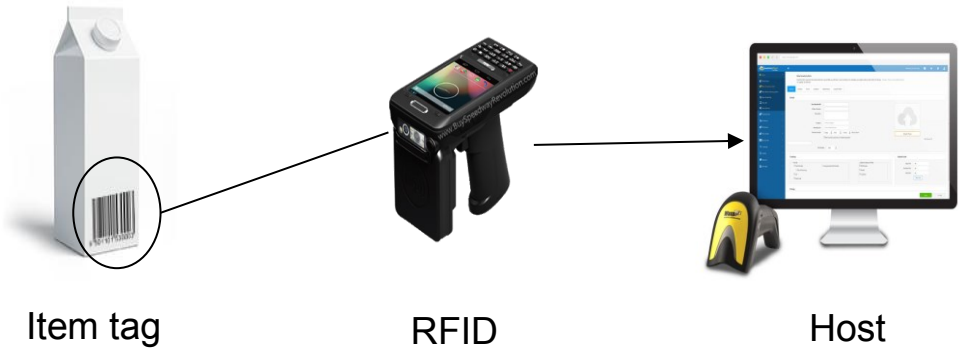

Figure 7: RFID Identification (adopted from Botani and Rizzi (2008)

- *Global Positioning Systems (GPS)*

This application works the same as a navigation device. It assists in determining locations by receiving information from any of the four satellites in the orbit. The Global Information System (GIS) works hand in hand with the GPS as software for interpreting results gotten from the GPS for decision making. It transmits the location information from a global navigation satellite system (GNSS). Communication is enabled by sending microwaves signal. It is highly expensive to implement and used for products with high value. In Perishable context this tool only makes sense if used in cooperation with RFID, then it will be able to provide an endless amount of valuable data about the product and its location history (Aung and Chang, 2014).

- *Near Field Communication (NFC)*

This is a development based on RFID technology. NFC permits a safe two-way interface between electronic devices but in a closer range, they share information between devices within a range of 4 cm. They can work with a mobile application to allow linking of plants and traceability information. NFC use small tags to allow them to be fitted inside products. This enables ease of identification of the product.

The benefit of this technique is the ease of interaction between electronic devices and short-range for sharing and retrieving information. Mainetti et al, (2013); Badia-melis et al, (2015). Efficient data retrieval or storage can be seamless only within a close range which is a major challenge in this device. Quality Checking Sensors (QC)

Recently many kinds of contamination sensors such as C2 Sense, FoodScane, Salmonella Sensing System etc., are being used to monitor and control the quality of perishable products (Pal and Kant, 2019). These sensors are installed in the carrier of the product or boxes of the product which senses the desired information of the product and shares it to a centralized network. QC uses the perishability information obtained while scanning products to predict the level of degradation of an item. An image of the different access steps of the information flow in the food supply chain is displayed in figure 8. In combination with WSN, some companies have also tried to extend the use of RFID in the products that require strict transporting and storing criteria to prevent their spoilage.

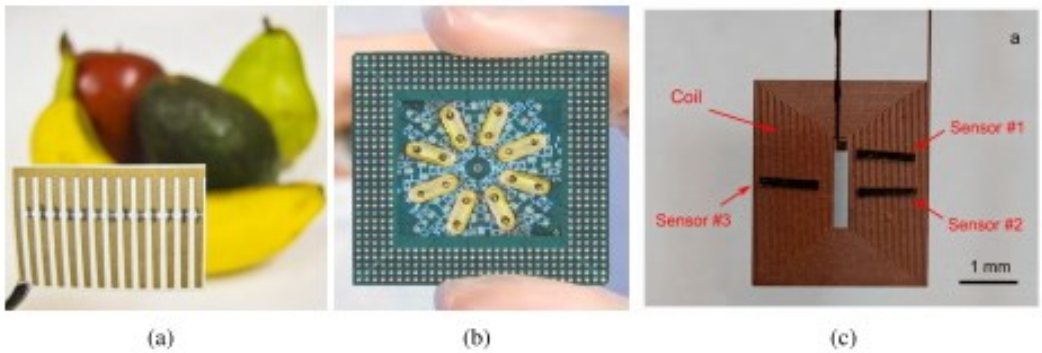

Figure 8: Predictive and Quality control sensor. (Pal and Kant, 2019)

3.2iib.. Smart Traceability for Perishables

In referencing Ilie-Zudor, et al. (2011), due to the fact fresh food products have a short lifespan, they require unique stock-keeping and transportation policies. Retailers are always struggling between handing the freshest items to their customers and distributing products with a minimal shelf-life left to avoid product expiration. Referencing same authors, RFID has the role of multi-tasking levels of identification. The identification task needs to go beyond the product type identification by being able to access more information about the product such as the expiry dates, spoilage level etc. By so doing, RFID promises high accuracy data for fresh food inventory control. However, a major challenge is the seamless collection of information and data exchange between the actors in the chain. However, this is a great era for FFR because seamless traceability techniques have been developed and are being tested

in real life. Such technologies are: Internet of things (IoT); blockchain traceability; Internet of perishable logistics (IoPL);

- *Internet of Things (IoT)*

Riad, et al (2018) have offered a seamless method of traceability through the use of "Internet of Things" (IoT). IoT is referred to as a network that can connect everything within a supply chain, including people, machines and systems, thereby ensuring an efficient supply chain management. This is done through visualizing any physical and virtual component within the chain by monitoring and tracking it and giving a third dimension to organizations' data. Analyzed data can enhance all food supply chain processes (Riad, et al., 2018, pp.,4). The advantage of tracing perishable products with the help of IoT is the provision of real-time information about product data, transportation and storage conditions and the role of different actors with the food supply chain. IoT connects to physical objects and transmits live information effectively via the internet with the support of RFID tags, sensors, actuators and positioning systems. Adam, et al., (2010).

- *Blockchain Traceability*

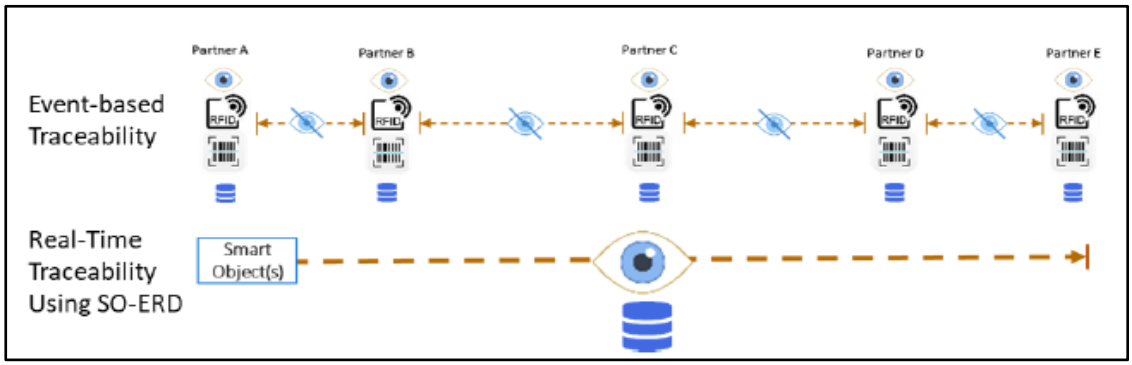

Figure 9: Real-time traceability supported by IoT. (Riad et al., 2018).

Nowadays researchers on traceability are showing interest to work with high-end technologies such as blockchain. Yiannas (2018) has suggested in his work, product traceability through blockchain technology. Hence, blockchain allows creating and sending high trusted digital ledgers. These ledgers are decentralised, respectively not owned by anyone in a network but can store and encrypt information. A record in the blockchain cannot be altered without altering all the previous blocks and the consensus between all the users. This technology has been invented for cryptocurrencies because it is meant to be cheaper, free of charge and very secure, creating no chance to frauds (Yiannas, 2018).

However, in the food supply chain, this technology is tested by Walmart because they believe that traceability should surpass the goals for food safety and can be used beyond that. Blockchain will be able to secure more transparent traceability in food production because information saved by a user such as the processes a food product went through (including its growing process) and so on, thus breaking down product information even to a single item. According to Yiannas (2018), the implementation of blockchains is a bit sceptical just because of how futuristic it looks but the foodborne and frauds in the USA has made governments, stakeholders and governments demand blockchain traceability in food supply chains.

Figure 10: Tracing in Blockchain perspective. (Ozorut, et al., 2018)

- *Internet of Perishable Logistic (IoPL)*

Internet of Perishable Logistics is a technology which falls under the bigger term 'Physical Internet'. Due to the high reliance on fresh food products, there is a need for advancement in the technological logistics of perishable food products. This has brought about the effective automation of the logistics network of perishable commodities (which is inclusive of fresh food products). IoPL offers agile inventory management and manages it in a sustainable way reducing the carbon footprint while traditional supply chain logistics only focuses on economic performance (Pal and Kant, 2019). This automation is known as the Internet of Perishable Logistics (IoPL). In reference to Pal and Kant, (2019), Perishability is a key driver in IoPL. This is due to product deterioration in its quality, value and usefulness as a result of its flow time within the value chain. Pal and Kant, (2019). Tracing of perishables is done by placing tiny sensors which are assumed to be GS1 and compatible with RFID into shipping boxes or containers. Pal and Kant, (2019). These sensors are stacked with local indicators or communication interface and can trace spoilages and contamination and transmit the sensed data to the central controller. This technology is still under development and thereby have some challenges. The first being the radio

frequency used for communication between inter containers or through water does not have a high signal absorption. Also, the inability of the sensors to alert before the real deterioration sets in.

3.4.Operationalization of RQ1

The table below highlights the summary of key concepts from Research question 1 (RQ1) with definitions and operationalization used.

Concept	Definition with sources	Operationalization
Shelf-life management	- An effective food supply chain with a focus on the fresh food sector, expiration dates should be taken into account in the planning of inventory target levels. (Olsson, 2014). - Inventory policies and tools currently used comprises of guidelines and accounting policies for proper control and management of fresh food products to avoid expiration or deterioration of fresh food products at retailers' shelf. (Dolgui et al.,2018)	- Replenishment decision methods (Ketzenberg et al., 2018). - Stock rotation (Akkas et al., 2018). -promotion strategy (Riad et al.,2018).
Technological innovations	-Technological innovations are a balance between science, technology and processes for effective management of fresh food products from deterioration/expiration on the shelf of the retailers. (Luo et al., 2016) - in avoiding expiration of products on the shelf of fresh food retailers, a seamless flow of information and comprehensive traceability system needs to be implemented. (Amorim et al., 2011)	- Cold chain (Tromp et al., 2012; Bharti, 2014). -Software technologies (Amorim et al., 2013) -Tracing and Tracking technologies (Olsen and Borit, 2013; Bottani et al., 2017).

Table 4: Operationalization of RQ1

3.5.Implementation Challenges

This section of the chapter highlights theoretically the challenges experienced by Fresh Food Retailers' to effectively implement fresh food inventory management systems to enable them to curtail the rate of deterioration on their selves.

According to Li et al, (2016), the control of inventory of fresh food products referred mostly as perishables could be challenging due to its short life span. This is linked to the fact freshness stands as the main criteria in the evaluation of quality. This coupled with FSC becoming more complex to manage every day. Fresh food retailers are faced with a dilemma of not wanting to be associated with the cost and stigma known for having a high level of deteriorated fresh food products as well as wanting to maintain availability on their shelves at all times. Over the years fresh food retailers have been implementing different solutions in the management of fresh food products to reduce perishability on their shelves but its effect is still not fully felt. These challenges are elaborated below:

- *Customer Shopping Habits*

In referencing Bottani et al. (2017), to avoid product expiration at the shelves of fresh food retailers', FEFO practice should be allowed. Products closer to expiration are first sold. Replenishment based on FIFO/FEFO where products getting to the retailers first or expiring first are displayed closer to the customers' hand while the freshest ones (last in) sit at the bottom of the pallet or behind the First In / First to expire products. Due to the urge for freshness, customers tend to stretch their hands to pick products lying behind in the shelves. Misinterpretation of best before dates and use-by-dates by customers have also resulted in the challenges encountered in implementation. It is also worth noting that due to the changing desire of customers, it is quite challenging to make a proper forecast to avoid overstocking or understocking.

- *Cost of Implementation of Technological Innovation*

(Bhatt et al., 2013; Bottani et al., 2017; Yiannas, 2018 Bosona and Gebresenbet,2013), believes the cost associated with the implementation of technological innovations for traceability is high compared to the overall value of fresh food products. Barcodes which due to its low cost of implementation that has been widely in use have now become obsolete (Aung and Chang, 2014) thereby causing companies to transit to more prominent technologies such as RFID which are unaffordable by small or medium-sized enterprises (De Cindio et al,2011; Rindsberg 2015). However, seamless and advanced tracking technologies that would auto-identify the due dates are still expensive to implement in food traceability (Feng et al. 2017). implementation at perishable inventories is still a challenge and opportunistic for the future (Bottani et al. 2017). The cost does not include only the tags and the readers, the costs keep increasing for other aims such as synchronizing

tags attaching those to products and training of the employees to use the technology (Feng et al 2017)

- *Level of Human Interference*

In referencing (Aung & Chang, 2014; Bosona and Grebresenbet., 2013; Badia-Melis et al.,2015; Mgonja et al., 2013), the need for a line of sight, the low-speed of perceiving information and alphanumeric codes which are not automatic are some reasons for barcodes being considered obsolete. Labels need to be properly positioned to enable the reader to detect and identify the codes. The level of human intervention is high which makes them time-consuming and highly prone to error.

- *Product Identification*

In referencing (Ilie-Zudor et al., 2011; Storoy et al., 2013) to be able to achieve an effective promotion strategy, identification of products should be in more granular levels which imply single product identification. According to Tromp et al., (2012), due to perishables having several product batches with several expiry dates in same pallet or shelf, hinders to a great extent effective identification of products data and its quality. This affects the proper monitoring of products close to expiration. Ketzenberg et al., (2018).

- *Collection and exchange of information*

Storey et al.,(2013), believes having no standardized data handling practice results in the implementation of traceability technology quite challenging due to it being costly and time-consuming. To be able to have seamless inventory management control to reduce deterioration of fresh food products, information needs to be exchanged in a precise, effective and electronic manner between partners in the food supply chain (FSA,2002; Moe, 1998). It has become cumbersome to achieve seamless traceability in the FSC mainly due to the fact different actors use different technological innovations which are not compatible thereby making integration difficult (Yiannas, 2018). Due to lack of trust between partners in the food supply chain who see data sharing as opening up to their competitors, implementation of data sharing to increase transparency between the nodes of the value chain is challenging Aung And Chang, (2014). Data security is breached due to the sensitivity of the information, partners are not ready to share if no protected storage repositories. (Storey et al., 2013; Aung and Chang, 2014).

- *Storage condition*

The processes and equipment needed for the temperature-controlled environment according to Aung and Chang (2014) incorporate all the activities of controlling

temperature within FSC such as production, processing, packing, storage, transportation, distribution and even when displaying at the retailer's shelf. Hence, Pal and Kant (2019) state that challenges like shared logistics, standardized labelling of products, automated tracking of shipments is a real challenge between partners when dealing with perishables.

3.6.Operationalization of RQ2

The table below highlights the summary of key concepts from Research question 2 (RQ2) with definitions and operationalization used.

Concept	Definition with sources	Operationalization
Implementation Challenges	The control and management of the inventory of fresh food products referred mostly as perishables could be challenging due to its short life span. (Li et al, 2016)	-shopping habits of customers - The high cost of implementation of technological innovations (Bhatt et al., 2013; Yiannas 2018 and Bosnia and Gebresenbet 2013) -product identification (llie-zudor et al., 2011) - Collection and exchange of information (Yiannas,2018) - Cold chain/storage condition (Pal and Kant 2019).

Table 5: Operationalization of RQ2

4.0.Empirical Data

This chapter presents the data of the empirical findings. The presentation of data is based on the result obtained from the semi-structured interviews which are attached in the appendix. The chapter starts with a short presentation of the company. The characters, in this case, are characterized.

Data collection in the empirical study was through the use of semi-structured interviews. The respondents were allowed to fully express their views about the topic under study. The table below summarized the respondent views about the methods and innovation used by the company with their implementation challenges. The inventory method used by the Companies is portrayed in the resultant column on a(*).

This does not imply those listed on the table are all the companies use but the are the most comfortable method used by the companies.

4.1 Company A:

Company A is a Swedish Food outlet which occupies approximately 7900 sq meters. Company A is a hypermarket into the retail of bulk groceries products and also fresh food products like fruits (oranges, banana, apple pear etc) and vegetables (carrots, cabbage, spinach etc). They also service individual customers, restaurants and are in collaboration with 302 group owned retail stores. They are made up of approximately 9,900 employees with diverse experience and background. They collaborate with about 1200 stores in Sweden with an operating profit of 2025 MSEK. The have approximately1,040 Swedish labelled products on their shelves. Company A overall customer base per week is approximately 4million.

Contact was with the outlet manager for fresh food products division in one of their prominent outlet. There are identified several control methods used in the management of fresh food products to prevent deterioration and expiration on the shelf of company A. In the aspect of shelflife management, company A makes use of the automatic replenishment system where the POS does the analysis by the support of their software and relates the forecast directly to the DC for replenishment. Company A is focused on dynamic expiry date instead of the fixed expiry date in the replenishment decision. The use of FIFO/FEFO is also applied in the stock rotation.

In the aspect of a promotion strategy, dynamic pricing and shelf differentiation, as well as shelf allocation system, are applied.

In the aspect of technological innovation, company A makes use of cold chain technology in the movement and storage of products. This, they can control better as 70% of the movement trucks are owned by company A. In the area of tracing and tracking of products, company A thinks that the implementation of tracing and tracking systems had always been uppermost in their agenda and has to a great extent reduced the expiration of perishables on their shelves. Company A makes use of Barcodes provided by GS1 company for item, carton and pallet level tracking. Company A makes use of RFID and customers make use of self-scan devices.

Company A has good control of their software solution as they can retrieve and exchange data between partners thereby making .information integration seamless and in real-time.

- *Implementation challenges*

Due to fluctuation in the buying habit of the customer which changes unexpectedly, they have had issues of understocking or overstocking of products. This mainly due to replenishment figures normally generated by the POS and sent directly for replenishment. In referencing Company A, RFID does not indicate the period when the product would be deteriorating as most perishables even deteriorate before their best-before date. This he attributed to the handling and logistics model used. This is affected by temperature level, humidity level etc.

Company A	
Method Used	**Resultant**
Shelf Life Management	
Replenishment	
Manual replenishment	*
Automated replenishment from POS	*
Automated replenishment by use of dynamic expiry date	*
Stock Rotation	
FEFO	*
FIFO	*
Promotion Strategy	
Dynamic pricing	*
Shelf allocation	*

Shelf differentiation	*
Technological Innovations	
Cold Chain	
Wireless Sensor Network(WSN)	*
Software Solution	
MRP	*
EDI	*
Tracing and Tracking Technology	
Barcode	*
RFID	*
GPS	
NFC	
QC	
Smart Traceability Technology	
IOT	
Blockchain	
IOPL	
IMPLEMENTATION CHALLENGES	
Customer Shopping Habit	*
Cost of Implementation	
Level of Human Interference	
Product Identification	
Collection and Exchange of Information	
Storage Condition	

Table 6: Summary of empirical findings. Company A - (source: Own work)

4.2. Company B

Company B is a Swedish retail grocery store that falls under convenience stores. It trades also in fresh food products like fruits and vegetables (pear, bananas, oranges, carrots, lettuce etc). Company B has a decentralized line of authority from the main group. Company B operates on approximately 680 sq metres of store space. It is a

part of the 1932 retail store owned by the holding company. Net sales for the group are approximately 115 billion SEK/year with employee figure of approximately 40,000.

In company B, individual stores are responsible for monitoring the expiration of fresh food products. This is by maintaining optimal inventory, which they do with their resources or outsourced to consultants. The retail store visited is in charge of inventory management of its store.

In the aspect of replenishment, Company B shelf filling is done by manual monitoring of stock level on the shelf by one of the store staff. The replenishment is done once the products get to its minimal level. The store is also automatically replenished by the use of figures generated by the POS. The back store is automatically replenished by the hyper store.

In the aspect of stock rotation, Company B makes use of the FIFO and FEFO system. When it comes to promotion strategy, Company B has a system where every week, flyers are distributed into the letterbox of residence within the reach of the store intimidating them of fresh food products placed on their shelves' at a dynamic price. Company B also makes use of the shelf differentiation which is based on the deterioration rate of the fresh food product.

Fresh food products are stored and moved from distribution centres using Cold chains. Information is stored, retrieved and exchanged via the use of software which is between the individual store and the parent company of company B. RFIDs are highly used company B and the parent company.

- *Implementation Challenges*

Company B encounters several challenges in the process of implementation and use of different shelflife management systems and technological innovations in the control of fresh food products. The challenge experienced most is due to overstocking. This arises as a result of using the manual system in monitoring and replenishment of stock. This method most times produce erroneous outcomes due to the level of human intervention present. The cost of implementing technological innovations or hiring of consultants in the management of fresh food products is on the high side for a retail outlet like them. In referencing I-SS, upgrading of technological innovations to perform multi-task functions would be cheaper to implement instead of various innovations for the different task. Exchange of information internally is seamless. In the aspect of RFID being used by the company, Company B is unable to detect the deterioration level of fresh food products at a single package level as the packaging are compact and the high assortment of products with varying use-by-date.

Company B	
Method Used	**Resultant**
Shelf Life Management	
Replenishment	
Manual replenishment	*
Automated replenishment from POS	*
Automated replenishment by use of dynamic expiry date	
Stock Rotation	
FEFO	*
FIFO	*
Promotion Strategy	
Dynamic pricing	*
Shelf allocation	*
Shelf differentiation	*
Technological Innovations	
Cold Chain	
Wireless Sensor Network(WSN)	*
Software Solution	
MRP	
EDI	*
Tracing and Tracking Technology	
Barcode	*
RFID	*
GPS	
NFC	
QC	
Smart Traceability Technology	
IoT	
Blockchain	
IOPL	
IMPLEMENTATION CHALLENGES	
Customer Shopping Habit	*
Cost of Implementation	*
Level of Human Interference	*

Product Identification	
Collection and Exchange of Information	*
Storage Condition	

Table 7: Summary of empirical findings. Company B - (source -own work)

4.3. Company C

Company C is a family-owned chain of grocery stores in Sweden which is a hyper store that operates approximately 13,000 sq metres. Company C started operations in Sweden in 1993. The contact is the Store Manager in one of their outlets. Company C did not divulge a lot of information about the company which is expected in family-run businesses. Company C is one of the fresh food retailers in Sweden known for the freshness of its products on their shelves.

Management of fresh food products in Company C is done with a software known as 'Whywaste'. This software in referencing C-SM can detect the best-before-date of fresh food products weeks ahead. This allows company C to make a decision on the promotion strategy based on the quality of the product. The products close to expiration are moved and placed on a visible position in the store where customers can not avoid sighting them. A second initiate which company C has implemented is the rescue fruit-producing juice from fruits before they expire or deteriorate. Company C focuses on the FEFO system of stock rotation because they are aware of different factors like humidity, temperature etc could affect the quality of fresh food products especially during the period of their movement. Replenishment is done automatically with the POS figures.

In the use of technological innovation, company C makes use of its logistics models as they believe this would help in the monitoring and controlling of the other factors that might affect the quality of the product. In referencing C-SM, we train our staff on how to go about challenges encountered when in transits with fresh food products which they have attributed to one of the skills that make them excel in the freshness of their products. In-store, the temperature requirement for fresh food products are well controlled and monitored. Information exchange has been seamless to a great extent, but not every information is accessible to all partners especially suppliers due mostly to lack of trust. In tracking and tracing of fresh food products, Company C makes use of RFIDand QC.

- *Implementation Challenges*

Company C encounters a few challenges in the control of inventories of fresh food products. The major challenge encountered is in detecting the rate of deterioration in fresh food products as 'Whywaste' is mainly for detecting expiration date as they are aware product deteriorates even before their expiration date. Also keeping in mind expiration date is solely not a control mechanism in the inventory control of perishables as other factors like temperature control, humidity etc could also cause them to deteriorate even before the use-by-date. Secondly, to be able to achieve a more seamless control, the use of multiple tracking and tracing innovations are required, thereby making the cost of implementation cheaper. This implies a technological innovation that is wholistic with different uses. Thirdly, company C is not comfortable with the exchange of information between suppliers mostly due to lack of trust.

Company C	
Method Used	**Resultant**
Shelf Life Management	
Replenishment	
Manual replenishment	*
Automated replenishment from POS	*
Automated replenishment by use of dynamic expiry date	
Stock Rotation	
FEFO	*
FIFO	
Promotion Strategy	
Dynamic pricing	*
Shelf allocation	*
Shelf differentiation	*
Technological Innovations	
Cold Chain	
Wireless Sensor Network(WSN)	*
Software Solution	
MRP	*
EDI	*
Tracing and Tracking Technology	
Barcode	*
RFID	*

GPS	
NFC	
QC	
Smart Traceability Technology	
IOT	
Blockchain	
IOPL	
IMPLEMENTATION CHALLENGES	
Customer Shopping Habit	*
Cost of Implementation	*
Level of Human Interference	*
Product Identification	
Collection and Exchange of Information	*
Storage Condition	

Table 8: Summary of empirical findings. Company C - (source -own work)

4.4.Company D

Company D is a start-up grocery store with a capacity of approximately 5000 square metres in store size and staff strength of 90. Replenishment in Company C is done via POS figures but mostly manual monitoring of the shelf by store clerks. The shelves are refilled when fresh food products go beyond the optimal level. Company D makes use of FIFO and FEFO in its stock rotation process. Company D makes use of dynamic pricing and shelflife allocation in its promotion strategy. In referencing L-PO is executed by having price reduction for specific products weekly especially with fresh food products which most at times are overstocked.

In the aspect of technological innovations, Company D makes use of cold chains in the movement of the products. Temperatures are also controlled on their display shelves. The use of software for exchange of information is also used and RFIDs (But still in the process of full implementation).

- *Implementation Challenges*

In referencing L-PO, cost of implementation of technological innovation is very high. The lack of integration of innovations technology has affected the lack of proper management of fresh food products. Integration and exchange of information between suppliers are difficult due to most of our suppliers using more sophisticated

technologies that are not compatible with their system. At the moment, information is exchanged via telephones and email.

Company E	
Method Used	**Resultant**
Shelf Life Management	
Replenishment	
Manual replenishment	
Automated replenishment from POS	*
Automated replenishment by use of dynamic expiry date	
Stock Rotation	
FEFO	*
FIFO	*
Promotion Strategy	
Dynamic pricing	*
Shelf allocation	*
Shelf differentiation	*
Technological Innovations	
Cold Chain	
Wireless Sensor Network(WSN)	*
Software Solution	
MRP	*
EDI	*
Tracing and Tracking Technology	
Barcode	*
RFID	*
GPS	
NFC	
QC	
Smart Traceability Technology	
IOT	
Blockchain	
IOPL	
IMPLEMENTATION CHALLENGES	
Customer Shopping Habit	
Cost of Implementation	*

Level of Human Interference	
Product Identification	
Collection and Exchange of Information	
Storage Condition	

Table 9:Summary of empirical finding. Company D - (Source - own work)

4.5.Company E

Company E is a discount grocery store operating in approximately 2000 sq metres of space with branches all around Europe. Company E started business in Sweden in 2003. It presently has approximately 189 outlets and 4200 employees.78% of Company E products on their shelves are their brand name. The contact in the interview is a store manager LL-SM in charge of fruits and vegetables. According to LL-SM (fruits and vegetables), expiration of perishables is food waste - ‘’to grow, produce and transport food then toss it, is completely against our business model’’.

To an extent Company E, has been able to bring to a reduction inventories of perishables expiring on the shelf to a great minimal. One way they have been able to achieve this is by the great improvement on optimization which has helped in balancing the risk of waste and the risk of out of stock. This automated optimization system has enabled them to interpret the customer buying behaviour thereby restocking perishables on the right days. They operate a system where special fresh food products are placed on their shelves with reduced prices at some specific days of the week. The introduction of a concept ‘’take advantage of’’ where food with a short life before it gets to deterioration are sold off at greatly reduced prices has also reduced it's on shelf expiration. Inventory management is automatically generated whereby replenishment is done based on data received from point of sale. They operate more of the Just In Time system of replenishment. The store manager indicated they are thinning off from personal inventory management, which involves more of manual activities.

In the use of tracing and tracking technologies, Company E makes use of different technologies. In the purchase of perishable foods that are not their brand name,

Company E takes charge from start to finish as they have great confidence in their process.

Company E makes use of barcodes and RFID. The highly discounted foods are trashed if not purchase but have had a great reduction due to its weekly price reduction promotion and a substantial time given for the sale of such foods.

- *Implementation Challenges*

According to LL-SM, cost of implementation of technical innovation is very high. He believes a more robust technology all-inclusive (inventory management, tracking and tracing, expiration date detection and deterioration detection) is highly recommended in the Fresh food chain. Secondly, information sharing and integration is quite cumbersome due to different partners using a different system which are most times not compatible with each other. The issue of lack of trust between partners has also hindered a seamless information sharing process.

Company E	
Method Used	**Resultant**
Shelf Life Management	
Replenishment	
Manual replenishment	
Automated replenishment from POS	*
Automated replenishment by use of dynamic expiry date	
Stock Rotation	
FEFO	*
FIFO	*
Promotion Strategy	
Dynamic pricing	*
Shelf allocation	*
Shelf differentiation	*
Technological Innovations	
Cold Chain	
Wireless Sensor Network(WSN)	*
Software Solution	
MRP	*
EDI	*
Tracing and Tracking Technology	

Barcode	*
RFID	*
GPS	
NFC	
QC	
Smart Traceability Technology	
IOT	
Blockchain	
IOPL	
IMPLEMENTATION CHALLENGES	
Customer Shopping Habit	
Cost of Implementation	*
Level of Human Interference	
Product Identification	
Collection and Exchange of Information	*
Storage Condition	

Table 10: Summary of empirical findings Company E - (source -own work)

5.0.Discussion and Analysis

In this discussion and analysis chapter, the cases are analysed with the help of the theory in chapter 3. This starts first with individual analysis and proceeds to a comparison between cases.

5.1. Framework of Analysis

A framework for Inventory Control management tools has been presented in chapter 3.2 to 3.4 of this study. This has contributed to addressing the response to *RQ1:* What Inventory Management Systems presently used in avoiding perishability of fresh food products on the Shelf of Fresh Food Retailers? The stages theorized are shelf-life management, technological intervention and smart traceability for perishables.

To portray this analysis better, findings have been computed on a scale of A-C to show its level of usage, where A=3, B=2 and C=1. In the points assigned, the highest scale is a **3** while **1** represents the lowest scale.

5.2. Shelf Life Management

5.2.1. Replenishment

Companies A to E makes use of a combination of replenishment methods at varying degrees. These combinations used are manually (for on-shelf monitoring by store clerks) or by Automatic replenishment. According to Feng et al, (2017), the inventory levels are monitored manually and replenished when below its surplus level. In referencing Chande et al., (2005), Based on my findings, Automatic replenishment is the core and the most trusted form of replenishment methods. According to Chande et al (2005), replenishment through a strategy of monitoring the first in products and selling them off through differing sales strategy(e.g reduced pricing) is used by the retailers. The figures used for automatic replenishments are still more reliable as it depends solely on the purchase behaviour of customers accessed from the point of purchase or dates computed as received in storeroom (serves as the first point of reception of stocks) dates. Replenishment to the store is done from the stockroom located at the back or side of the retail outlet of the stores

studied. Company A makes use of the dynamic expiry date in fresh food product replenishment. This was argued that fresh food products quality should always be monitored so those close to deterioration placed first on the shelf and sold out before those with high quality without really going by the expiration date. This procedure practised by Company A falls in-line with Tromp et al (2012) and Ketzenberg et al (2018) who believe due to uncontrollable variables like temperature, transportation conditions and bacterial levels, dynamic expiry date should be applied to products and those close to deterioration sold off instead of the sale by dates imprinted by the producers. Company E only makes use of Automatic replenishment.

5.2.2. Stock Rotation

Last In products do not always have the longest shelf-life which brings the FIFO system of effective Inventory Control to question Pal and Kent, (2019). Based on findings, all companies studied make use of one form of stock rotation or a combination of several ones. The most commonly used being FEFO. This method is viewed as more realistic in the aspect of fresh food products, as they are affected by different degree of interaction with other factors like temperature, humidity etc. This has confirmed the theory in referencing (Kiil, et al., 2018) of FEFO been smarter than FIFO and allows first expired to be shipped out first by estimating the accurate shelf life granted by online sensing infrastructure.

5.2.3. Promotion Strategy

Based on my findings, Company A-E makes use of a combination of promotional strategies. Dynamic pricing and shelf allocation are mostly used. In referencing the company representatives studied, dynamic pricing is more suitable for Fresh Food Products because prices are placed on products considering the product quality. This also encourages continuous changes in prices thereby gaining little value for such products till they get to the point where they become unusable. It was noted company A-D places its products on dynamic prices on different shelves making them more visible for customers. For company E, products are left on shelves where they belong due to no availability of factors like temperature controlled shelves. This has been supported by (Yang et al, (2017; Feng et al, 2017) who think having a more visible and larger shelf result in higher sales which yield higher profits for the retail outlet.

ANALYSIS					
SHELF-LIFE					
Replenishment					
Process Name	**Scale(per Company)**				
	A	**B**	**C**	**D**	**E**
Manual replenishment	1	3	2	3	
Automated replenishment from POS	3	2	3	2	3
Automated replenishment by use of dynamic expiry date	3	-	-	-	-
Stock Rotation					
Process Name	**Scale(per Company)**				
	A	**B**	**C**	**D**	**E**
FEFO	3	3	3	2	3
FIFO	2	3	-	3	3
Promotion Strategy					
Process Name	**Scale(per Company)**				
	A	**B**	**C**	**D**	**E**
Dynamic pricing	3	3	2	1.5	3
Shelf allocation	2.5	2	3	2	3
Shelf differentiation	3	3	3	3	3

Table 11: Summary of Analysis on shelf-life - (source -own work)

5.3. Technology Innovations

5.3.1. Cold Chain

This is used by company A-E. which also encompasses the storage facilities and logistics modes for fresh food products. There are uncontrollable variables such as temperature control which is utmost in the inventory management of fresh food products to be able to elongate the life span of fresh food products. Bharti (2014) is of the opinion cold chain is a form of the supply chain (food) which ensures a longer lifetime for perishable products (in this context Fresh Food Products) and its quality through the control of temperature and humidity while transiting through the value chain.

5.3.2. Software Solutions

The use of software solutions and technological innovation by FFR would improve efficiency and make product replenishment and inventory control seamless. In referencing Amorim et al (2011), to avoid expiration of products on the shelves of FFR, a seamless flow of information and comprehensive traceability systems need to

be implemented. The integration between shelflife and technological innovation should be implemented in a manner information sharing and retrieval would be seamless. Going back to the analysis, the use of software solutions was seen viable in the companies studied. Varying software solutions were used on the same scale except for Company D, which is a startup that did not make use of an ERP system since it had no branches or parent company to report back to. The use of an Electronic Data Interchange was made by Company A-E as a means of information sharing between the point of sales, back store and for the bigger retail outlets with branches and a distribution centre. These have assisted in the storage, retrieval and exchange of information between partners.

5.3.3. Tracing and Tracking Technologies

The introduction of tracing and tracking technologies in the FFP sector of the FSC has impacted the level of the deteriorated product reported from the retailers' end, but more impact can still be felt in this sector. This could be achieved by introducing strict monitoring of perishables by retailers through the use of tracing and tracking technologies. In referencing Kher et al, (2010), all companies do not stand to profit equally in the implementation of tracing and tracking technologies. Still referencing the same author, medium size Companies are encountered with cost optimization, small Companies are at a cost disadvantage and big Companies encounter diseconomy of scale. The cost of implementation outweighs the overall value of FFP. Based on my findings, the most commonly used tracing and tracking technology by all Company is the barcode where the scale of usage was all high. The use of also RFID is relatively high except for Company B and D (convenience retail outlet and a start-up) that is responsible for the management and control of their inventories with no support from the DC. It is worth noting that in the process of replenishment, DC makes use of RFIDs. The second retail outlet not making use of the RFID instore is Company D, which is a startup. this basically due to the cost of implementation.

5.3.4. Smart Traceability Technology

Smart traceability technology can be seen as a transition from the use of the conventional tracing and tracking technologies in FFP to a tracing and tracking technology which embraces digitalization, interconnectedness and automation. This is known as the emerging technologies within Industry 4.0 (the fourth industrial revolution). FFR needs to be agile and adaptive to the ever-changing business environment by embracing technologies that are all-inclusive of functionality from being able to measure the freshness of the products down to its deterioration. Based on my findings, Companies A-E have not yet been able to implement this technology. This technology produces the best results by using them in combination with RFID. Its non-implementation is due to the high cost of implementation.

ANALYSIS					
TECHNOLOGICAL INNOVATIONS					
Cold Chain					
Process Name	**Scale(per Company)**				
	A	**B**	**C**	**D**	**E**
Wireless Sensor Network (WSN)	3	3	3	3	3
Software Solution					
Process Name	**Scale(per Company)**				
	A	**B**	**C**	**D**	**E**
MRP	**3**	**3**	**3**	**1.5**	**3**
EDI	**3**	**3**	**3**	**3**	**3**
Tracing and Tracking Technology					
Process Name	**Scale(per Company)**				
	A	**B**	**C**	**D**	**E**
Barcode	3	3	3	3	3
RFID	3	2	3	1	3
GPS	-	-	-	-	-
NFC	-	-	-	-	-
QC	-	-	2	-	-
Smart Traceability Technology					
Process Name	**Scale(per Company)**				
	A	**B**	**C**	**D**	**E**
IOT	-	-	-	-	-
Blockchain	-	-	-	-	-
IOPL	-	-	-	-	-

Table 12: Summary of Analysis on Technological Innovations - (source -own work)

5.4.Implementation Challenges

In addressing *RQ 2*, *What challenges are encountered by fresh food retailers in the implementation of inventory control management systems to avoid perishability on their shelf?*

Customer Shopping Habits: Company A to D encountered challenges of effective implementation of *shelf-life* aspect. This is due to *customer shopping habits* in different scales in the aspect of *replenishment*, *stock rotation* and the promotion strategy. It was challenging to properly implement Replenishment Process by use of POS as this has caused sometimes overstocking/understocking of products. Secondly, due to customers' urge for freshness, the use of *FEFO* (Stock Rotation) and *Dynamic pricing* (Promotion Strategy) have not yielded the desired outcome. Customers prefer to pick products that have longer expiration dates than those with

short expiration dates, whereby customers tend to stretch their hands to pick products lying behind in the shelves Also, customers are ready to pay a little more to acquire a product they believe is fresher.

- *Level of Human Interference*

Company E experienced no level of human interference in the manual replenishment of stock simply because it was not a method used in its replenishment method. Company E preferred the use of technological innovation for a more accurate replenishment, thereby fulfilling the opinion of Condea et al, (2011) of automating inventory monitoring which further triggers replenishment of the shelves from the store's backroom. Company B and D has had a high scale in rating the effect of human interference in the replenishment processes of FFP. This occurred in manually replenishing the store shelves where staff check manually the level of products on the shelf and replenish accordingly. Company B and D is faced with the challenge of staff using their discretion to overstock or understocking the shelves on certain days of the week(for instance Saturdays) because they expect a high turn out and it ends up being the opposite. In referencing Olsson (2014) inventory control with simple ad-hoc rules or with standard procedures which are based on assumption results in more cost, holding of inventories and deterioration. In the case of Company C, the scale is low due to a casual manual check of the shelves by the staff but replenishment is still done automatically.

- *Storage Condition*

Reviewing my study, Company B is encountered with the implementation challenges in the aspect of storage condition. Company B buttressed the cost of storage of FFP as high as the cost is being bored by them. This also has resulted in not able to stock up to the maximum level a variety of FFP as these products require specific storage and handling conditions due to its perishability nature. This is in line with Aung and Chang (2014) who believes temperature control within packaging, storage and displaying at the retailers' shelf is of paramount importance for FFP to retain its freshness. Secondly, they are also encountered with space allocation due to the size of the store.

- *Cost of Implementation*

This cost comprises of the acquisition cost, running cost, maintenance cost and cost associated with training of employees. Challenges have been encountered by Company B to E. Company B and D see the cost of implementation outweighing the value total returns on FFP in their stores. This has been buttressed by Bottani et al (2017) as avoiding perishable products expiration at retailers' shelf requires seamless and advanced tracing and tracking technologies that are still expensive to implement. Secondly, a wholistic traceability system with a focus on the detection of expiration date as well as deterioration rate should be put together for the fresh food products.

Most traceability systems only take care of expiration dates which are not visible as other uncontrollable variables play out on the expiration and deterioration of FFP thereby causing its effect before the expected date or period. Having these variables under control would in referencing Bailey et al., (2016) elongates the shelf life of FFP. Company A is passionate about the implementation of technological innovation and working on advancing on their present technological innovations.

- *Collection and Exchange of information*

Exchange of information has posed challenges for Company D. Company D is faced with not needing to collect and share information at this stage due to their mode of operation. Company D believes information shared should be properly arranged and reasonable and see it cost consuming to implement at this point. Presently, the form of information shared is the orders placed, confirming receipts are at per with placed orders and the transaction ends with external partners and the rest is internal. Company D also shares the opinion of Aung and Chang, (2014) of having no trust between partners in the food supply chain and see data sharing as opening up to their competitors especially seeing themselves as a startUp company.

ANALYSIS					
IMPLEMENTATION CHALLENGES					
Process Name	Scale(per Company)				
	A	B	C	D	E
Customer Shopping Habit	3	3	2		
Level of Human Interference		3	1	3	
Storage Condition		2			
Cost of Implementation		3	3	3	3
Collection and Exchange of Information				3	1
Product Identification					

Table 13: Summary of Analysis on Implementation Challenges - (source -own work)

5.5 Case Comparison

This cross-analysis has been conducted vertically (company-wise) and horizontally (process-wise) in reference to the table (14).

- *Shelf-life*

Replenishment: Company A-D all has a medium level of usage of a combination of replenishment processes. Company E makes use of a single process but on a high

scale of 3. Product-wise, the use of manual replenishment process is on a high scale as all companies made use of it except for company E.The use of Automated replenishment by all companies is also at a high scale as all cases had implemented the use of POS as a form of replenishment method. Dynamic replenishment is on a low scale due to just a case company making use of that process.

Stock Rotation: In comparison between companies, A, B, C and E showed a high level of the use of a combination of both stock rotation processes (FEFO and FIFO). Company C makes use of a product in a medium scale. Product-wise, FEFO is highly in use by most case companies. This is due to the belief products deteriorate and not fit for use before the due date as a result of other variables not well-controlled. These factors are temperature, humidity storage, handling etc.

Promotion Strategy: Company A, B, C and E make use of a combination of promotion strategy to a high level. Process wise, the different promotion strategy is highly used by case companies. The has to a greater extend helped in retailing the products that are very close to expiration thereby reducing the quantity that ends up expiring on their selves. General overview, processes under shelf-life management of inventories were mostly used by case companies studied.

- *Technological Innovations*

These have been used on a high scale by the cases studied. There also exist technologies which have not been implemented by most or all case companies such as some tracing and tracking technologies and smart traceability technologies. It is worth noting those implemented are used on a very high scale.

- *Implementation Challenges*

Company B and D experienced a lot of challenges in the implementation of processes. This mainly because they are convenience store and start-up and implies investing more to be able to achieve the desired result. All case companies had the cost of implementation as a major challenge where they believe it would have been cheaper with a more robust technology with different processes inclusive. Customer shopping habits also portrayed some level of set back in implementation as they are not fully able to deduce what customers crave for at a certain period.

COMPARISON ANALYSIS							
SHELF-LIFE							
Replenishment							
Process Name	**Analysis (High/Medium/Low)**						
	A	**B**	**C**	**D**	**E**	**AVE**	**H/M/L**
Manual replenishment	1	3	2	3	-	**3**	**H**
Automated replenishment from POS	3	2	3	2	3	**3**	**H**
Automated replenishment by use of dynamic expiry date	3	-	-	-	-	**1**	**L**
AVERAGE	**2**	**2**	**2**	**2**	**1**		
H/M/L	M	M	M	M	**L**		
Stock Rotation							
Process Name	**Analysis (High/Medium/Low)**						
	A	**B**	**C**	**D**	**E**	**AVE**	**H/M/L**
FEFO	3	3	3	2	3	**3**	**H**
FIFO	2	3		3	3	**2**	**M**
AVERAGE	**3**	**3**	**2**	**3**	**3**		
H/M/L	**H**	**H**	**M**	**H**	**H**		
Promotion Strategy							
Process Name	**Analysis (High/Medium/Low)**						
	A	**B**	**C**	**D**	**E**	**AVE**	**H/M/L**
Dynamic pricing	3	3	2	1.5	3	**3**	**H**
Shelf allocation	2.5	2	3	2	3	**3**	**H**
Shelf differentiation	3	3	3	3	3	**3**	**H**
AVERAGE	**3**	**3**	**3**	**2**	**3**		
H/M/L	**H**	**H**	**H**	**M**	**H**		
TECHNOLOGY INNOVATION							
Cold Chain							
	A	**B**	**C**	**D**	**E**	**AVE**	**H/M/L**
Wireless Sensor Network **(**WSN)	3	3	3	3	3	**3**	**H**
AVERAGE	**3**	**3**	**3**	**3**	**3**		
H/M/L	**H**	**H**	**H**	**H**	**H**		
Software Solution							
Process Name	**Analysis (High/Medium/Low)**						
	A	**B**	**C**	**D**	**E**	**AVE**	**H/M/L**
MRP	3	3	3	1.5	3	**3**	**H**

EDI	3	3	3	3	3	**3**	**H**
AVERAGE	**3**	**3**	**3**	**3**	**3**		
H/M/L	**H**	**H**	**H**	**H**	**H**		
Tracing and Tracking Technology							
Process Name	**Analysis (High/Medium/Low)**						
	A	**B**	**C**	**D**	**E**	**AVE**	**H/M/L**
Barcode	3	3	3	3	3	**3**	**H**
RFID	3	2	3	1	3	**2**	**M**
GPS							
NFC							
QC							
AVERAGE	**1**	**1**	**1**	**1**	**1**		
H/M/L	**L**	**L**	**L**	**L**	**L**		
Smart Traceability Technology							
Process Name	**Analysis (High/Medium/Low)**						
	A	**B**	**C**	**D**	**E**	**AVE**	**H/M/L**
IoT							
Blockchain							
IOPL							
AVERAGE							
H/M/L							
IMPLEMENTATION CHALLENGES							
Process Name	**Analysis (High/Medium/Low)**						
	A	**B**	**C**	**D**	**E**	**AVE**	**H/M/L**
Customer Shopping Habits	3	3	2			**2**	**M**
Level of Human Interference		3	1	3		**1**	**L**
Storage Conditions		2				**0**	**L**
Cost of Implementation		3	3	3	3	**2**	**M**
Collection and Exchange of Information				3	1	**1**	**L**
Product Identification							
AVERAGE	**1**	**2**	**1**	**2**	**1**		
H/M/L	**L**	**M**	**L**	**M**	**L**		

Table 14: Summary of Comparison Analysis - (source -own work)

6.0.Conclusion

In this concluding chapter, a presentation of my opinions are portrayed.

The cost of implementation of technological innovation is one of the greatest challenges encountered by the case companies. Those most affected are the convenience stores and start-up. These stores are more accessible to most of the populace especially the convenience stores which could be found the countrysides. A large extent of deterioration is found on their shelves as they are unable to fund proper management of inventories due to cost of acquisition as well as training of employees and the maintenance cost associated with these technologies. The cost associated with the implementation of technological innovation could be reduced or a convenient form of assistance introduced to the implementation of these innovations. This would also help in this era where companies need to be agile to be able to adapt to the changing environment for the convenience stores and startups especially to remain sustainable. The introduction of more advanced and robust technology with shelflife management, perishability control even to an individual package level needs to be developed and this too would reduce the cost of implementation. Software systems that are more compatible with most systems too are also advised.

From studies, it was noticed different FFP differ in the rate of deterioration. For instance, bananas and lemons deteriorate faster than other products. A study on the causes of why they deteriorate faster than other products could to undertaken to enable implementation of better inventory controls to prolong its shelf life. It could be as a result of handling or other variables.

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Appendix:

Semi-structured interview questions:

General Questions:

1. What position do you occupy in your organization and your responsibilities?
2. Can you tell me more about your company?

Shelf-life management:

1. How do you manage products on your shelf like restocking, counting of products…
2. How do you know when to restock the shelves?
3. What system do you use in restocking?
4. How are about to expire or expired products on the shelves taken care of?
5. Do you encounter some challenges in shelf-life management?

Technological Innovations:

1. What IT (Technological Innovation) is used in your retail store?
2. Are there strengths and weaknesses experienced in the use of these technologies?
3. To what extent has the use of these technological Innovations reduced the level of perishability in your retail store?
4. Are you or the users very knowledgeable in the use of this Technological Innovations or are there difficulties encountered in their use?
5. Are there specific people assigned to use them or everyone can use them?
6. Has the use of these Technological innovations been able to achieve the desired outcome?

General contributions……