Implementation of Quality Controlled Logistics in the Fresh Food Supply Chain

A multiple case study research on global food supply chains

Master Thesis

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Executive summary

Horticultural products are living systems with a short shelf life due to their continuous quality decay since they are harvested. Furthermore, they are harvested seasonally and come with inherent heterogeneous variation (Trienekens & Van der Vorst, 2006). Furthermore, consumers demand high quality products, with homogenous characteristics, all year round and at low costs. Such characteristics of the supply and of the demand bring certain pressure on the supply chain, specially the fresh food supply chain i.e., fast stock rotation, short lead times, specialized transportation and storage facilities

Organizations understood that there is a need of collaboration among firms across the supply chain to increase flexibility, efficiency and competitiveness (Antai & Olson, 2012). Collaboration between chain actors can be shaped by integrating activities, i.e., quality control and logistics activities. This integration is called Quality Controlled Logistics (QCL). The main purpose is to match supply and demand and obtain the highest revenues. Hence, QCL makes use of inherent quality variation of products to match heterogeneous consumers demands that constitute different market segments.

There are different elements in which firms can focus to have a full integrated supply chain. Van der Vorst et al. (2011) describe six elements that are needed to integrate quality control and logistics: consumer preferences and product acceptance period, critical quality points, product quality measurements and prediction, logging and exchange of information, local dynamic/adaptative logistics and quality control and supply chain management. The integration of these six elements in the supply chain eases decision making to improve supply chain performance, optimize product use and minimize shrinkage. However, this can be achieved in different ways. Considering product quality a dynamic variable, the supply chain design and QCL engagement must be flexible and shaped to different needs to accomplish successful management of the supply chain in different manners.

This research aims at analyzing real life supply chains and how they engage in QCL through the six elements that Van der Vorst described to deliver the customer´s desired quality. For that, a theoretical and empirical research has been conducted. The literature review chapter comprises theory on QCL and is completed with quality control and logistics knowledge. The empirical research aims at understanding how the QCL elements are deployed and deciphering certain patterns through observation of real supply chains. For that, four companies that belong to fresh food supply chains are selected as cases. Moreover, to have different perspectives of the supply chain and more compete view of it, companies located in different stages of it were chosen; in this case two producing companies and two wholesalers.

The whole study has been built up around the six elements afore mentioned and the aspects or activities that form each of them. Also, the analysis of the results is done comparing the cases element by element. After describing the aspects or activities companies do per element, they are characterized based on the strategy followed in the supply chain and the extend in which QCL is integrated.

To conclude, it was found that despite the configuration of the supply chain, all six elements can be applied but the specific activities carried will differ. However, the specific activities are indeed influenced by the configuration of the supply chain. Furthermore, customers´ requirements are companies´ main driver to design their supply chains. Both producing companies and wholesalers would carry similar activities. For instance, producing companies' quality control aim is to produce a high-quality product and wholesalers' quality control aim is to maintain and extend product shelf life. Additionally, whereas producing companies would receive customer´s orders annually, wholesalers would receive them daily. Moreover, the size of the supply chain favors having a flexible and dynamic supply chain management towards satisfying customer´s desires. Finally, the strategy followed by each company is not related to the position in the supply chain or the configuration of the supply chain. A pure volume strategy is followed by one producing company and a pure product quality strategy is followed by a wholesaler. However, from the other two cases, the wholesaler has volume-oriented activities but finally labeled as market oriented; and the producing company is both quality and volume oriented, which is finally characterized as supply chain oriented.

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1. Chapter 1. Introduction

The first chapter is a preface of the report that consist of an introduction of the problem situation, a conceptual research design, including objectives, research questions and framework, a technical research design, including research materials and strategies, and the structure of the report.

1.1. Introduction to problem situation

This research is focused on fresh fruits and vegetables. The food supply chain, and specifically the fresh food supply chain, implies additional challenges. Horticultural products are living systems with a short shelf life due to their continuous quality decay since they are harvested. Furthermore, they are harvested seasonally and come with inherent heterogeneous variation (Trienekens & Van der Vorst, 2006). Moreover, consumers demand high quality products, with homogenous characteristics, all year round and at low costs. Such characteristics of the supply and of the demand, bring certain pressure on the supply chain, i.e., fast stock rotation, short lead times, specialized transportation and storage facilities.

Organizations understood that competition is not only financial and are aware that they cannot be competitive on their own, but that there is a need of collaboration among firms across the supply chain to build flexible, effective and efficient supply chains and compete with other supply chains (Antai & Olson, 2012). A way of collaboration between chain actors is by integrating activities, i.e., quality control and logistics activities. This integration is called Quality Controlled Logistics (QCL). The main purpose of it is to match supply and demand and obtain the highest revenues. Hence, QCL makes use of inherent quality variation of products to match heterogeneous consumers demands that constitute different market segments. The level of integration of specific activities, introduced in the coming paragraphs, in the supply chain will influence the success of QCL objective.

There are different aspects or elements in which firms can focus to have a full integrated supply chain. For that, a continuous flow of information and close collaboration between chain actors is needed. The source of information is primarily consumers' requirements and secondly, product quality. Since food products are living systems, quality is considered a dynamic variable changing with the time. Firms make quality measurements, make prediction about product shelf life and make logistics decisions.

The first element is to know what the consumers' demands are and what the period of product acceptability is since all efforts in the supply chain are oriented to deliver products that comply with the different market segments' requirements. Quality is recognized by evaluating attributes such as taste, colour or texture (Bogataj, Bogataj, & Hudoklin, 2017). Subsequently, firms carry quality controls in specific points of the supply chain, called critical quality points, and build up quality decay predicting models to determine the next steps in the supply chain, e.g. which batch should be delivered first or where to ship it. The information used to make product quality prediction is available from the continuous monitoring of the product quality throughout the supply chain. The major factors affecting the speed of quality decay are the temperature and the presence of gases that increase the biological activity, i.e., oxygen and ethylene (Falagán & Leon, 2018). There are different technologies available based on different processes and precisions to measure those conditions, i.e. TTI labels or RFID technology. The latter consist of real-time information about temperature and product quality state (Chande, Dhekane, Hemachandra, & Rangaraj, 2005). The purpose of having a control over the actual product quality is to make batches with products with the same quality and send them to customers complying with their quality requirements. As supply chains are increasingly complex and supplying and selling points are also on the rise and located further, the decision making at every supply chain has a large impact on the product quality. For instance, the distance to market influences the time to the final market and the mode of transport used; the type of issuing policy and stock rotation system determined which product will arrive to the market first; or an efficient maintenance of the cold chain reduce product spoilage and maximizes profitability (Taoukis, Bili, & Giannakourou, 1997).

According to the product quality that is offered to companies and the product quality that is demanded from their customers, they find the way, based on their strategy, to deploy and combine the six elements that belong to QCL in a certain manner. Considering product quality a dynamic variable, also the supply chain design and QCL engagement can be flexible and shaped to different needs, accomplishing successful supply management and customer satisfaction in different manners.

1.2. Problem statement

Different manners and points for quality measurements as well as different levels of cooperation upstream and downstream are performed. Which configurations of the six elements are made in real life supply chains to achieve a certain quality goal?

1.3. Conceptual research design

This section encounters the research objective, research question, research framework and definitions of concepts.

1.3.1. Objectives

The aim of this research is:

To analyze real life supply chains and how they engage in QCL through combination of quality control and logistics activities to deliver the customer´s desire quality.

The sub-objectives are:

- To define the elements needed to deploy QCL
- To define how these elements of QCL are deployed in the real-life supply chains.
- To find certain patterns in the real-life supply chains through gathering information of the elements applied.

1.3.2. Research questions

How real-life supply chains engage in QCL through combination of quality control and logistics activities to deliver the customer´s desire quality?

1. What are the elements that are needed to deploy QCL?
2. How are these elements deployed in the real-life supply chains?
3. Can certain patterns be typified through observation in the real-life supply chains?

1.3.3. Research framework

The following framework is a guideline to answer the research questions. The research starts with a literature review on the general concept of Quality-Controlled Logistics followed by the description of the 6 elements that are needed to deploy QCL. In this description, theory on quality control and logistics is outlined. This research is focused on the fresh food products supply chain; therefore, all the literature takes that into account. Follows an empirical research on four supply chains of fresh products. Different supply chain actors will be interviewed to determine which are the elements that are applied in their supply chains. The aim of having different actors in the supply chain is to have different perspectives from the supply chain on quality control and logistics integration. Afterwards, the results of the primary data collection will be analyzed in combination with the secondary data. The objective of the empirical research is to determine the elements that are used to deploy QCL and find patterns between cases. Finally, some conclusions will be proposed.

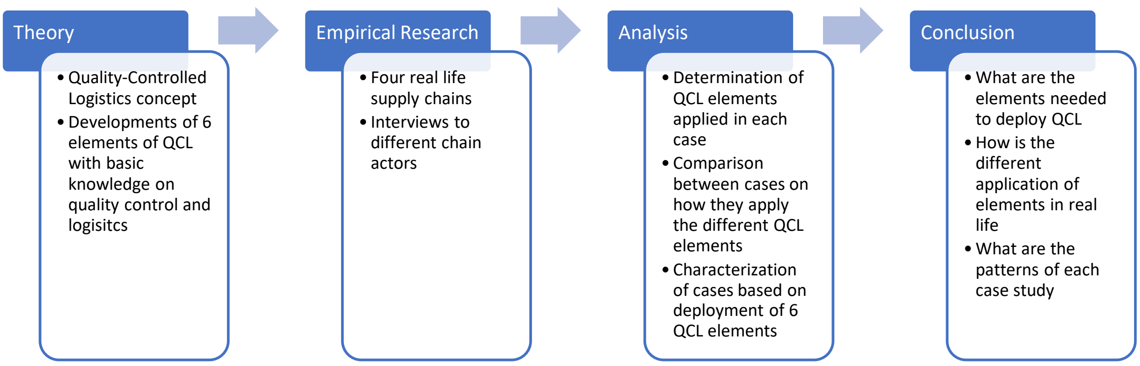

Figure 1: Research framework

1.3.4. Definition of concepts

The following concepts provide the core of the research:

Quality controlled logistics: “is that part of supply chain management that plans, implements, and controls the efficient, effective flow and storage of food products, services and related information between the point of origin and the point of consumption in order to meet customers’ requirements with respect to availability of specific product qualities in time by using time-dependent product quality information in the logistics decision process” (Van Der Vorst et al., 2007).

Logistics: “logistics is the part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point-of-origin to the point-of-consumption in order to meet customers' requirements” (Council of Logistics Management).

Quality control: "a part of quality management focused on fulfilling quality requirements" (ISO 9000).

1.4. Technical research design

This section encounters the research materials and research strategies.

1.4.1. Research materials

The research materials used to cover the literature review and the practical cases are literature and key informants. The specific data sources will be further outlined in chapter 4.

1.4.2. Research strategies

Desk research

The first research strategy followed was desk research. It has been developed during the first phase in order to make findings in the literature about application of Quality-controlled logistics in the companies.

Empirical research

The second phase was empirical research. A number of cases were conducted in order to understand how companies apply Quality-controlled logistics, i.e., how are the different elements of QCL are deployed.

1.5. Structure of the report

Consequently, the following chapter 2 consists of a literature review of the main concepts. Based on these findings, a conceptual framework is developed in chapter 3. In chapter 4, the methodology of the theoretical and empirical research is described. Results of the empirical research are gathered in chapter 5. Finally, chapter 6 and chapter 7 include the analysis and the conclusion of this research, respectively.

2. Chapter 2. Literature Review

This section encloses the description of the concept of Quality-controlled logistics and the description of the six elements that firms can use to have an integrated supply chain in quality control and logistics activities.

2.1 Quality-controlled logistics

Fresh product's supply chain is complex due to the increasing demand of a great variety of fresh, high quality, year-round available products in retailers together with the intrinsic attribute of fresh products: they are perishable and their quality decreases post-harvest. Furthermore, logistics entanglement is increased due to the high number of supplying and delivery points, which are no longer in the local markets but in other countries, transport activities and the different types of products transported. All of this implies a challenge to the supply chain: fresh and perishable products require to be delivered fast, on time and at low price. Thus, supply chains have high logistics demands to shorten lead times and have small stock levels. Due to the great importance of logistics activities, it can be said that product conditions throughout the chain are determined to a large extend by logistics decisions (Luning & Marcelis, 2009).

Another added variable to the high-quality demands is product variability. "Quality is inversely proportional to variability". This means that if the variability of a product characteristic is low, then the quality of the product increases (Luning & Marcelis, 2009). Variation is a natural phenomenon that is inevitable. Such increase in high quality demands is one of the major reasons for companies to switch to chain co-operation and chain control. In this sense, the food industry and the retail sector are spurred to develop control systems.

Since fresh food supply chains deal with a great variety of products with different origins and diverse markets outlets with different demands, the risk of quality degradation is very high. This has an impact on the supply chain design. The common strategy to approach this problem is to have a supply chain design towards average quality. For instance, storage temperature is set at the average of all the optimal temperatures. However, this might not be very effective, since fresh products are not stored at their optimal temperature. Although it is impossible to have a homogeneous production, it is possible to adapt to it. The way of exploiting such characteristic is by making batches with the same quality from the very first stage of the supply chain and the rest of the stages to better match the product's quality with the specific market demand and obtain the best value out of it.

In this sense, it is possible to optimize product quality and minimize shrinkage. This is the goal of the so-called Quality-Controlled Logistics (QCL). Van der Vorst et *al*. (2007) makes use of the definition of logistics management of the Council of Supply Chain Management Professional (CSCMP), and defines QCL as follows: "Quality controlled logistics is that part of supply chain management that plans, implements, and controls the efficient, effective flow and storage of food products, services and related information between the point of origin and the point of consumption in order to meet customers' requirements with respect to availability of specific product qualities in time by using time-dependent product quality information in the logistics decision process" (Van der Vorst, Van Kooten, Marcelis, Luning, & Beulens, 2007). Figure 2 shows an overview of QCL concept. It shows that success of QCL is strongly dependent on consumer preferences, critical quality points, quality measurement and prediction, logging and information exchange, dynamic logistics and quality control and supply chain management (Van der Vorst, Van Kooten, & Luning, 2011; Van der Vorst et al., 2007).

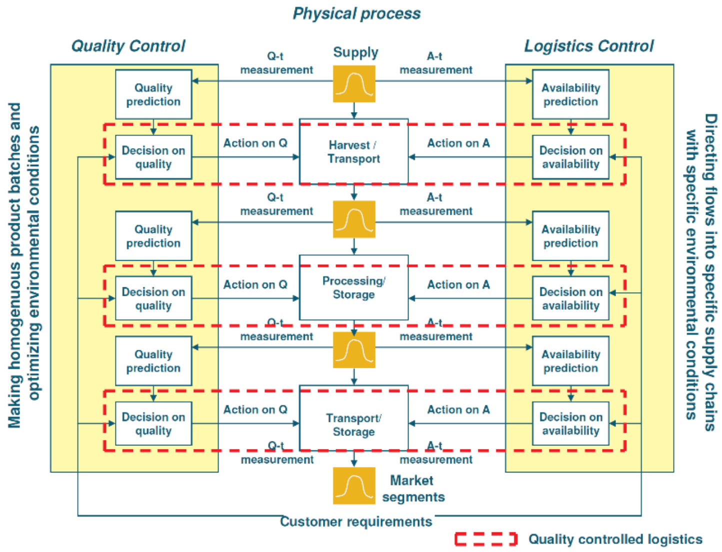

Figure 2: Quality-controlled logisitcs concept

Long supply chains of perishable products suffer from high risk of quality degradation mostly due to temperature exposure along the supply chain (Van der Vorst et al., 2007). Therefore, a temperature-controlled supply chain is required for food products. Apart from the temperature control, time is also a limitation. Each product has a shelf life, that puts additional requirements on speed and reliability of logistics systems.

Modern chains distribute many types of products at the same time that need specific storage conditions. Nevertheless, the traditional approach of an "average" quality tailored supply chain means that the temperature applied is not the optimal for any of the products (Van Der Vorst, Schouten, & Van Kooten, 2014). Apart from temperature, gas interaction during transport and storage also creates product interferences. For instance, climacteric fruits, like bananas and apples, ripen off the plant producing ethylene during storage, which accelerates the ripening process of other fruits (Van der Vorst et al., 2007).

The purpose of QCL is to deal with inherent product variation to maximize quality of each product. At the beginning of the supply chain products are separated in batches with the same quality. Product's quality is not constant along the supply chain, therefore QCL approaches quality as a dynamic attribute using time-dependent quality information and quality decay models to predict quality of product batches. The use of real-time information of product quality enables to improve supply chain performance. Product quality is known in advance prior to arrive to the next stage facilitating further logistics decision making. At each stage of the supply chain quality is controlled, followed by logistics control e.g. making batches with products of the same quality and determining which of them already meet consumer's quality requirements and take actions to redirect good flows to other markets(Van der Vorst et al., 2011). In this sense, product quality on retailer shelves is improved and/or specific market demands match the supplied products at a certain price boosting chain revenue.

Consequently, product variation can be used to design the supply chain and optimize the product delivery with a specific quality level to specific market segments. Batches with high quality can be sent to market segments with higher added value and that are willing to pay more. To be able to match supply and demand, detailed knowledge on customer and consumer's requirements in the different segments is crucial (Van der Vorst et al., 2011). Figure 3 shows the difference between the traditional chain and the QCL chain and the different actions they take.

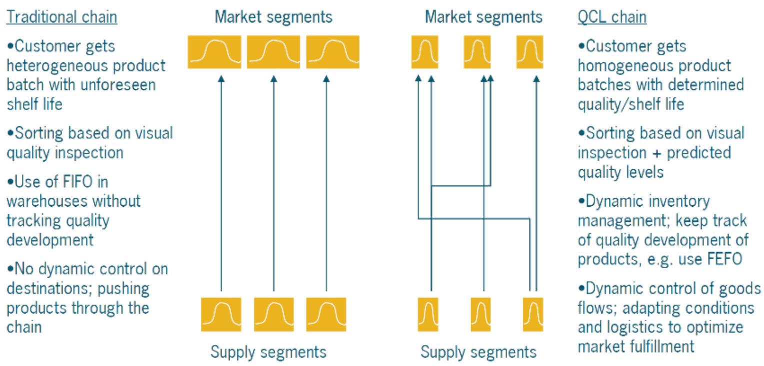

Figure 3: Comparison of traditional and QCL chain (J. Van Der Vorst et t. 2007)

However, making use of product variability and product quality dynamicity to satisfy costumers´ demands through the six elements that belong to QCL can be achieved in different manners and not only as described in the literature. The purpose of this research is to find patterns that describe the different manners of deploying and combining these six elements.

In the following section, several key points that have being mentioned in this section will be further explained, i.e. six elements of QCL and quality control and logistics activities. These key points are essential to understand how QCL works and how it can be implemented in the supply chain.

2.2 Quality controlled logistics elements

In order to have a quality control across the supply chain, design and management is complicated. Logistics systems have been improved at the same time as technological developments and quality assurance systems were available to make it easier (Van der Vorst et al., 2011, 2007). There are six elements that contribute to the successful performance of QCL:

1. Consumer preferences and acceptance period of product quality attributes
2. Critical quality points (CQP)
3. Product quality measurements and prediction
4. Logging and exchange of information
5. Local dynamic/adaptative logistics and quality control
6. Supply chain management (SCM)

Hereafter, the six elements will be explained and build up with additional literature as they will be the base for this research.

2.2.1 Consumer preferences and acceptance period of product quality

As aforementioned, knowing consumer's preferences is key to start applying QCL. Quality requirements are the drive elements of QCL because the main goal of all actors in the supply chain is to comply with customers and consumers' quality requirements. Therefore, it is crucial to know which quality attributes consumers value the most and the acceptance period within which consumers find these attributes acceptable and will buy the product. The operational requirement would be undergoing a consumer research to find the limits of acceptability of those quality attributes of all market segments.

Quality is a subjective concept that varies according to the consumer or user of the product or service. It can be described from six perspectives namely: product quality, cost, availability of the product, flexibility, reliability and service. For this research, only the product quality will be taken into account (Noori & Radford, 1995; Van Der Spiegel, Luning, Ziggers, & Jongen, 2004). Food products have specific physicochemical properties that are translated into quality attributes. These attributes are intrinsic or extrinsic to the food product. on the one hand, the intrinsic factors are objective, measurable and usually perceived by sensory observation e.g., the nutritional value, safety, the shape, colour, etc. On the other hand, the extrinsic factors are related to the way in which the product was produced and noticeable via communication e.g., the brand, packaging characteristics, ethics around the product, etc. (Linnemann, Benner, Verkerk, & Van Boekel, 2006). According to Zuniga-Aris et al. (2008), size, shape, colour and shelf life are the attributes that retailers focus more on; however, consumers are also interested in other aspects like taste, freshness, appearance or safety. Producers and processors on the other hand, rather grow varieties with higher yields and suitable for mechanical harvesting and processing. Being quality requirements different at each stage of the supply chain, quality is approached from a production point of view. A production-based quality approach aims at producing a product that complies with the specifications required by the next stage in the chain. In this sense, physical product properties are translated to production system characteristics and supply chain management (Zuniga-Arias, Ruben, & Van Boekel, 2009).

Furthermore, a food system is a complex system with a dynamic and variable behaviour. First, nature is very variable and inevitably offers products with different levels of quality. The production of an apple tree field is different from the field some kilometers away. Even if the variety of apples is the same, and even within the same field and the same tree, the quality of individual apples will vary. For this reason, food production is especially challenged to deal with variation (Luning & Marcelis, 2009). Sharing consumers preferences with producers allows them to make better choices and produce products that will comply with consumers preferences. Second, inside of a food system, numerous dynamic processes take place. Fresh products are prompted to suffer internal food processes like microbial, chemical, biochemical and physiological reactions. These reactions are responsible for the continuous decay of quality. The speed of reactions depends on intrinsic food properties like state of maturity, compositions, microbiological burden; and external conditions like temperature, gas composition, packaging, etc. Therefore, the acceptance period or the shelf life is limited. To know the acceptance period, quality decay models and prediction systems are used.

2.2.2 Critical Quality Points

Critical Quality Points (CQP) are points in the process where control is needed, otherwise variation results in unacceptable and/or irreversible deviations in the final product quality attributes. These QCP may need of certain measurements and logistics and quality controls such as temperature, storage time, etc. to understand dynamic behaviour of product quality attributes and carry a continuous analysis of CQPs.

When quality is measured, it follows a decisions-making process. If the measurement is done to a product and the result is out-of-tolerance, the product is rejected unless if with the corrective actions it can meet the standards; whereas if it´s done to a process or equipment and results are not satisfactory, the production line stops to take the corrective actions. Quality control and decision-making processes is usually carried out at three major points of the food production process: at receipt of raw material, ingredients, etc., during processing and prior to distribution of the end product. Control is applied to products and resources. Product control consists of measuring product properties; whereas resources control measures process parameters and resources characteristics.

- <u>Supply control</u>

The quality of final products depends to a large extend to the quality of the supply quality. Therefore, obtaining supplies and purchasing activities are crucial, especially in fresh-products business. Product control consists of checking quality of products when the order is received. Products must be in satisfactory conditions, otherwise they can be returned to the supplier for credit or replacement. Afterwards, received goods are stored at optimal conditions and also a quality control is maintained.

Resources control refers to the evaluation of supplier’s performance and reinforcement of supplier relationships. It is common to make periodic supplier audits to check supplier’s production capabilities, quality and delivery problems. Nowadays, organizations do not audit suppliers themselves, but ask suppliers to be certified with some of the industry certifications like ISO 9000, BRC, IFS, etc. In this sense, suppliers are responsible for the quality of the products delivered. Factors to take into account when choosing a supplier are: price and location, quality and reputation, services, inventory policies and flexibility (Luning & Marcelis, 2009).

- <u>Production control</u>

It consists of evaluating processes performance by measuring process outputs. If results are unacceptable, a corrective action is needed. If the quality of the input is known, with the correct process, the output quality, should also be known. If the output quality is not the desired one, it means that the process has a defect; therefore, at this level, process control is carried, preferably feed-forward control. Although additional product control may be necessary to verify the good functioning of the process.

- <u>Distribution control</u>

The target of quality control at this stage is the outgoing flow of materials to customers. This is, products that are stored and/or transported to customers. Organisations must make sure that all delivery orders meet the quality specifications and that are available at the agreed time and price. Transportation can be of long distances and time. Product control consists of monitoring product conditions and taking corrective actions; whereas resource control refers to evaluating the well-functioning of the transportation equipment and measuring distribution and storage performance. Suppliers and distributors should keep long-term close relationships to improve quality.

2.2.3 Product quality measurement and prediction

Once the CQP are defined, quality control takes place. It consists on measuring product quality and predicting ripening rate or quality decay under different environmental conditions making use of prediction models. Supply chain actors can use such information to act pro-actively and send food to retails shelves at the optimum quality moment.

Tools and methods for quality control

The following methods are applied for quality control (Luning & Marcelis, 2009; Stevenson, 2006):

- Acceptance sampling: incoming raw materials undergo quality control before entering the production systems. The purpose is to accept or reject a batch according to determine standards. This method is also applied to the outgoing products.
- Statistical process control: if operational processes suffer special variation, quality of outgoing products will not be the desired one. Therefore, final product assurance requires optimal operational conditions. Statistical process control evaluates the manufacturing processes by comparing the measurements with control charts
- Quality analysis and measurement: The way of determining the quality of products or processes is by doing an analysis and/or measurement. The analysis consists of sensory, physical, compositional, microbial or enzyme evaluation. The choice of analysis is dependent on the type of product or process and the availability of analysis or measurement techniques

Measuring product quality and developing decay models is not enough when dealing with fresh products. Quality preserving techniques are crucial to meet customer's quality standards and cope with the supply chain intricacy. Hereafter, product quality preserving techniques are presented. They are applied in the distribution centre when storing products but also maintaining them during transportation and throughout the supply chain is crucial.

Preserving techniques: precooling and modified atmosphere

Postharvest technology is essential to extend fruits and vegetables shelf life and reduce food waste. It is proved that lower temperatures slow down fresh product deterioration. Respiration and maturation rate decreases, as well as the activity of deteriorating enzymes and microorganisms. After harvesting, it is crucial to cool down fruits and vegetables as soon as possible for two reasons: it extends the shelf life of the product, and it is important to do it at this stage because it is when products are more vulnerable. It has been observed that a delayed of 4 hours of the precooling process implies an increase of water loss rate of 50% (Pelletier, Brecht, Nunes, & Émond, 2011). Several precooling techniques are available. Depending on the mechanical properties of the product, its sensitivity to chilling injuries, harvest volume, and economic factors. These are the existing precooling techniques (El-ramady, Domokos-szabolcsy, Abdalla, Taha, & Fári, 2015; Mercier, Villeneuve, Mondor, & Uysal, 2017):

- Forced-air cooling: the air flows through the product thanks to a difference in pressure created in both sides of the tunnel. The air comes in at low temperature and goes out at a higher temperature; then it passes through the refrigeration unit to cool it again and is used again to cool the product. It is a fast method used for a wide range of horticultural products.
- Hydrocooling: as the name indicates, the fluid used for cooling is cold water. It is a fast cooling method used before packaging.
- Room cooling: the traditional method consists of putting the products in boxes or pallets inside of a cold room. Sometimes it is used after other precooling technique to stabilize the temperature.
- Vacuum cooling: the pressure is decreased to a point where water evaporates at very low temperatures and the product get cooler faster.
- Cryogenic cooling: it uses liquid nitrogen which is at -196ºC.

While postharvest period is getting longer and market requirements are more demanding, cooling techniques are not always enough. Controlled atmosphere (CA) or modified atmosphere packaging (MAP) are used to improve cold storage. These techniques alter the atmosphere around the product to reduce catabolism in climacteric fruits and vegetables and inhibit enzymatic reactions. This is, they reduce respiration rate, slow down maturation process and extend product shelf life. CA technology consists of increasing CO_2 concentration and decreasing O_2 concentration. The optimal gas concentration is adapted to each type of product and can be adjusted over time with monitoring systems that control the concentration of oxygen, carbon dioxide, ethylene, the temperature and the humidity. With MAP, fruits and vegetables modify the atmosphere themselves while consuming O_2 and producing CO_2 inside the packaging; nitrogen can be added as well. Thanks to the packaging film permeability and thickness, the exchange of gases with the outer atmosphere can be controlled (Falagán & Leon, 2018).

Transportation conditions

Conditions during transportation have an impact on the quality of shipped products. Poor handling practices like applying pressure to cargo, kicks, sunlight, high temperatures, air velocity, etc. on the freight can cause mechanical, physical, chemical or biological damages on products. Horticulture products are usually transported packaged, not bulk. The purpose of the packaging is to contain the product itself to protect it from injuries and environmental conditions, facilitate handling and marketing, and to provide information to consumers with labels. Spoilage due to interrupted cold chains is common in food chains resulting in financial loss for both suppliers and customers. But if we are able to interpret the behaviour of fresh products against the manipulation conditions of the supply chain, food waste can be reduced (Bogataj, Bogataj, & Hudoklin, 2017). Even though a standard temperature is set for the transportation and storage activities, it is not always the optimal temperature for all the products that are being transported. Additionally, when transportation times are long, i.e., 20-30 days by ship, the composition of the atmosphere in the container where products are stored also plays a key role in the evolution of the product quality. The use of CA technology or MAP is an added value in such situations. It is of importance to know how to maintain product quality against deterioration in order to obtain the maximum profitability and competitiveness in the marketplace (Cai & Zhou, 2014). The conditions in which fresh products are transported determine the final quality state and shelf life.

2.2.4 Logging and exchange information

Since fresh products' quality is strongly dependent on temperature history, monitoring and exchanging critical parameters information between partners is crucial. The use of data loggers like TTI labels ad RFID to records real-time information.

Information systems

With the intention of minimizing post-harvest loss and delivering high quality fresh products, products are transported and stored at least in temperature-controlled containers, trucks, etc. However, it has been reported (Jedermann, Nicometo, Uysal, & Lang, 2014; Jedermann, Praeger, & Lang, 2017) that the temperature does not reach all products in the same level and that the temperature can fluctuate 1.5º C on average. Some factors are: the location and the number of cold sources, packaging materials, ethylene production and the creation of "hot spots" by some fruits, etc. (Haflidason, Ólafsdóttir, Bogason, & Stefánsson, 2012; Jedermann et al., 2017).

In order to put a solution to temperature fluctuations, several devices have been developed. These detectors base their functioning on different technologies, processes and precisions, and therefore different timing detection (Bogataj et al., 2017). Depending on the characteristics of the supply chain, any of these devices can be chosen. Traditional means of temperature tracking were charts recorders and data loggers (Dada & Thiesse, 2008). The main disadvantages of these gadgets are that records must be gathered and interpreted manually, they have high prize and size, and it is not possible to react quickly to any change in environment conditions.

Nowadays RFID (Radio Frequency Identification) and TTI (Time-Temperature Identificatory) labels are used in combination. RFID are sensor tags that allow automatic and in real time data collection (Dada & Thiesse, 2008). It is an emerging technology that continuously records the temperature digitally allowing quick reaction to environmental changes and therefore, an efficient management control system. The main purposes of these devices are product identification and recording and communication of relevant data (Chande, Dhekane, Hemachandra, & Rangaraj, 2005). On the other hand, TTI labels have a totally different functioning. They are low-cost devices attached to the products that are based on mechanical, chemical and electrochemical, enzymatic or microbial irreversible reaction systems. These reactions are time-temperature dependent, that only show the actual quality state of the product, but not when and where the abuse of temperature happened. As a result of the cumulative exposure to temperature, the device shows a visible response (Jedermann et al., 2014; Taoukis et al., 1997). Although RFID seems to be the best option for temperature control, the use of RFID devices requires a lot of energy and in consequence low-power sensors like TTI labels are implemented (Dada & Thiesse, 2008). These devices calculate the remaining shelf life (RSL) of the product according to the record of temperature, humidity and gas concentration and a given model (Bogataj et al., 2017). Once the RSL is determined, some corrective actions can be applied, and/or the products can be relocated to different end users. According to Chande et al. (2005) RFID technology is a way of providing information in a dynamic manner. In this sense, it is time and cost saving for the manufacturer, whereas for retailers, current inventory profile of the store is available which enables taking correct decisions whenever inventory is low or in excess.

Many authors have studied the application of sensor technology for different materials management. It is probed that making an efficient use of these devices improves stock rotation (Giannakourou, Koutsoumanis, Dermesonlouoglou, & Taoukis, 2001); that measuring the remaining shelf life with TTI technologies the price of the final product can be adjust according to its quality obtaining higher profits for retailers; that RFID technology can be an efficient tool to manage perishable inventory and that is cost and time saving (Chande et al., 2005).

Monitoring transport conditions

A great part of food losses due to temperature deviation can be avoided if there is real-time temperature control. Remote temperature monitoring like TTI (Time-Temperature Identificatory) labels and intelligent packaging enables to detect irregular transport conditions and to take corrective measurements on time (Jedermann et al., 2017). There is an extended literature about perishable products in cold chains (Haflidason et al., 2012; Jedermann, Praeger, Geyer, Moehrke, & Lang, 2015; Laniel, Emond, & Altunbas, 2008; Požar, 2001). Jedermann et *al.* (2017) gathered in their study some research projects carried that develop hardware, shelf life models and prototype systems for Quality Oriented Tracking and Tracing (QTT) and FEFO systems. Some of this research were the following:

- Intelligent container: the container is equipped with an internal low-power short-range network that measures the temperature inside the container and an external long-range communication by GSM (Global Systems for Mobile Communications) cellular or satellite services to transmit the temperature data to longer distances.
- CHILL-ON: a device that contains a chemical substance which kinetics match with the bacterial growth in fish and poultry. Both reactions are temperature dependent. The reaction level is throughout a RFID interface.
- DANAHMAT: an intelligent label that measures the remaining shelf life achieving a dynamic expiring date.

Furthermore, other technologies used are able to control the ethylene concentration during transport and storage, specially when dealing with climacteric fruits and vegetables (Jedermann et al., 2017). One is the use of ethylene absorbers that can capture the ethylene from a container air reducing hot spots and biological activity. Another way of reducing biological activity is by reducing the O_2 concentration and increasing the CO_2.

The use of information systems has an added value when the data is shared with others. Therefore, interactions between entities is needed.

Integration of logistic activities

Organizations are aware of the fact that they cannot compete with other firms without integrating their suppliers and the rest of the actors in the supply chain (Antai & Olson, 2012). Interdependence among actors creates new opportunities within suppliers and customers improving supply chain performance, which is where the value of a firm lies. The integration of processes and partners lead to create advantages for each partner and thus, provide a win-win situation. To achieve the required cooperation between all actors it is essential to be able to demonstrate the potential benefits of integration to each actor (Slats, Bhola, Evers, & Dijkhuizen, 1995).

Depending on what level of integration between firms exist (strategic level, tactical level or operational level), the relationship between them will come in a diversity of forms, each with different characteristics (Slats et al., 1995). There are four forms of logistics integration (Dekker & Van Goor, 2000): physical integration, which aims at improving the efficiency of the physical flow of products; information integration, which focuses on achieving more efficient coordination of operational information flows; control integration, which allows firms from the same channel to have access to information from other firms to improve processes; and infrastructure integration, which is the most intense form of interaction where activities are being relocated to more efficient and/or more effective places in the channel. These interactions are stronger at operational level, in contrast to the strategic level where decisions range a wider scope.

2.2.5 Local dynamic logistics and quality control

QCL is open to listen to customer wishes and adapt the flow of products and environmental conditions to reach high quality products. The objective of logistics and quality control is to be dynamic based on real-time product quality information. The objective is to match existing product qualities with specific customers' requirements. Some operational actions would be defined target for specific quality attribute, make small batches with homogenous characteristics and reduce variability internally and apply inventory issuing policies according to quality demand.

Consequently, available logistic activities will be explained.

Inventory management

Food degradation and the inherent variation of products are added difficulties for inventory management. The issuing policy used to deliver products will have an impact on the supply chain performance (Bowersox & Cooper, 2002; Dada & Thiesse, 2008). These policies have no other purpose but determining which stored product at a distribution centre (DC) is picked and sent to the store, when and in what quantity. Traditional issuing policies like First-In-First-Out (FIFO) and Last-In-First-out (LIFO) are based on how long the product has been on that storage. However, there are new rotation systems, that unlike FIFO and LIFO, are based on the product quality. With the improvement of sensor technology like RFID (Radio Frequency Identification) and GIS (Geographical Information System), it is possible to monitor the logistics conditions and the quality of a larger number of items and in real time (Bogataj et al., 2017). This is the case of First-Expired-First-Out (FEFO) issuing policy based on the expiration date of products. Using decay models that forecast quality deterioration of perishable products, the remaining shelf life (RSL) is calculated. Once RSL of a batch is determined, correcting measures can be applied and/or based on consumers demands, batches can be relocated.

Dada and Thiesse (2008) describe seven different available issuing policies:

1. Sequence in Random Order (SIRO): at the distribution centre products that are going to be delivered are selected randomly.
2. First In First Out (FIFO): products that have been storage the longest time are selected first.
3. Last In Last Out (LIFO): products that have been storage the shortest time are selected first.
4. First Expiry First Out (FEFO): the products manufacture earlier are selected first; this is based on age.
5. Lowest Quality First Out (LQFO): product selection is based on quality; then products with lowest quality are selected first.
6. Latest Expiry First Out (LEFO): again, products are selected by age; products manufactured latest are issued first.
7. Highest Quality First Out (HQFO): items are selected by their quality; the items with the highest quality are issued first.

In the research that Dada and Thiesse (2008) performed with perishable products, they concluded that products issued based on LEFO and HQFO resulted with the best average qualities. Only LIFO showed slightly better results. Additionally, FIFO, FEFO and LQFO presented the least spoiled delivered items; being LQFO the policy with the lowest percentage. These results were obtained under known demand conditions. Furthermore, Pierskalla & Roach (1972), also found that when the supply and demand of perishable items is random, the best rotation system is FIFO. Nevertheless, natural products are subject of variation, therefore, it cannot be expected that food products arrive to the DC with the same level of quality or that they have the same quality deterioration rate (Luning & Marcelis, 2009).

These issuing policies are applied when there is a demand, thus when there is an order. They are driven by customer demand. However, customer demand is usually uncertain, leading to several inefficiencies in the inventory management. *Collaborative Inventory Planning* aims at reducing dependence on forecasting customer's demand and let orders be served on time by suppliers and to reduce inventory (Bowersox & Cooper, 2002). To achieve so, firms should cooperate and share information through the distribution channel in order to reduce inventory and improve customer service (Rushton, Croucher, & Baker, 2014). A typical replenishment technique is *Vendor-Managed Inventory (VMI)* where the manufacturer itself has the responsibility of supplying the retailer. This is done by having a continuous flow of information between retailers and suppliers to assure that retail orders and inventory are constantly covered thanks to an efficient and flexible supply chain arrangement. Suppliers have the responsibility to decide when to make a shipment, as well as what products and in which quantities. Retailers send continuous information of their sales and suppliers are committed to keep retailers shelfs full. *Quick response (QR)* has the same dynamic, however, replenishment orders from retailers are needed every short period of time (6 days or fewer) so manufacturers are able to be flexible against demand changes.

Choosing the appropriate issuing policy is crucial to maximize revenues and get the most out of food products since the way items are managed and removed from inventory have an impact on the price charged to the item and the usage of it (Lee, Mu, Shen, & Dessouky, 2014). Keeping low stock level may create difficulty to fulfill orders and high stock levels creates a risk of product deterioration. With the appropriate issuing policy a balance is created (Rushton et al., 2014). Once it is decided which batch is to be sent to the store, distribution activities take over. The following section explains how organisations deal with the flow of materials and goods.

Distribution management

Distribution consists of integrating and coordinating the logistics activities of inventory and transportation operations. The modus operandi is the following: the DC receives the freight from many suppliers and according to purchaser´s requirements, the DC schedules the shipment with the right order, knowing the time of arrival and the quality of the products, thus processing orders fast and efficiently.

Distribution centres differ from warehouses in two main activities: whereas DCs focus mainly in receiving and shipping goods, warehouses additionally store and pick goods. Furthermore, DCs carry adding value activities contributing to maximizing profit. Lambert et al. (1998) defines the concept of *time utility*. It is an added value created at the warehouses or distribution centres and consists of storing products until they are needed, coordinating supply and demand. Moreover, together with transportation, aims at making products available at the right moment and also at the right place, namely *place utility*.

The objective of a DC is to reduce overall logistics costs. The following activities contribute to costs reduction (Bowersox & Cooper, 2002; Lambert, Stock, & Ellram, 1998):

- Consolidation and break-bulk: its purpose is to increase the economy of scale. Consolidation means that warehouses receive material from different suppliers that are combined into larger shipments to required destination. Break-bulk does the opposite, breaks down a large load from one supplier to different customers. Freight costs are low and on time.
- Cross-docking: it is a type of assortment that consists of having multiple sources of material that are combine into one assortment according to customer requirements. Arrival of materials to the DC must be precise on-time to make the orders and ship them on-time too. No storage is placed.
- Processing/postponement: sometimes final products are sent to a warehouse to store them and whenever they are demanded, products are finalised with the final packaging, labelling or light manufacturing.
- Stockpiling: this is for seasonal production or demand. It is the case when a product is produced year-round but only sold in a short period of time; or when a product is produced in one season and the consumption is year-round. In both cases, great inventory storage is needed.
- Reverse logistics: includes activities such as product recall, reclamation, damage inventory etc.

Distribution management has a direct impact on customer satisfaction and level of competition with other organisations. Decisions made at this level are critical to the total logistics process. It is a way of holding inventory to create transportation and production economies, thus to achieve larger freights, to adjust to changing market demand, or to provide customers with a mix of products instead of a single product on each order (Lambert et al., 1998). Additionally, distribution also comprises the transport of goods to the next stage

Transportation management

Transportation has the purpose of moving inventory to the next stage of the business process and is the most visible element of logistics. There is a wide range of alternatives to move products from origin to destination, that are crucial to give continuity to the other supply chain activities. Either if it is sea, air or land cargo, transport activities can be private or leased transportation. Thus, firms possess their private means of transport like trucks or they outsource that service to other transportation or logistics company in order to reduce the total logistics costs. The latter is the most chosen one (Bowersox & Cooper, 2002).

Main transportation modes are rail, highway, water and air. Choosing a mean of transport or another is according some factors like: origin and destination, accessibility, distance, delivery time, storage conditions, price, environmental conditions, volume, density, etc. Moreover, there should be a balance between costs and customer service (Rushton et al., 2014). Although rail transport costs are low, its network is not as extensive as the highway network and its scope is terminal-to-terminal service. Nowadays, transport through highways leads freight moving from manufacturers to retailers due to its delivery flexibility. Carriers are adapted to transport small shipments in small distances to high weight and long distances, what makes it a versatile service. Additionally, costs are low (Mathisen, Hanssen, Jørgensen, & Larsen, 2015) and allows a point-to point service (Lambert et al., 1998). However, unlike water transport, the cargo weight is more limited. Ships and barges have an extremely large weight capacity. Additionally, water transport costs are low, and they can travel longer distances, therefore, ocean transport remains the dominant mode for global logistics. Airfreight is the fastest option, which offers a great advantage for urgent shipments or long-distance transport for perishable or high value products. However, it is the most expensive and the weight capacity is limited, therefore its used is not very extended.

It is common to use a combination of transportation because it is more economical and offers a more flexible service. This is called intermodal transportation. The use of trailers or containers between motor freights, railroads and water transportation facilitates the intermodal transportation. They have a big weight capacity and can be transported in different means of transport. They are versatile and flexible. Furthermore, in-transit damages and times are minimized and allows higher volumes shipping (Lambert et al., 1998).

Transportation planning has an impact on consumer service level. It includes tasks like choosing the mode of transportation, the route and the schedule, how much should the container be filled, and negotiating with carriers. The latter is of great importance for transportation performance. Carriers and shippers usually sign contracts and create alliances to assure some advantages like low prices and a certain service level (Lambert et al., 1998).

2.2.6 Supply Chain Management

All the practices discussed can be used along the whole supply chain to match supply and demand. Collaborative and integrated decision-making is needed and attempt to match products with highest value market. Decision making can be related to logistics or to quality control.

Logistics management

Managerial activities consist of decision making at different levels of the organization, that are called hierarchical decisions. Depending on the nature of the decision making, e.g. frequency and timing of decision making, level of detail, level of uncertainty, there are different logistical management levels (Ganeshan et al., 1999): strategic planning, in which decision making has long horizons (months of years) and consist of organizational goals and strategies; tactical planning, which comprise shorter time frame and contribute to achieve high strategic goals like integration of operations, transportation and distribution and information systems; and operational control and management, which decisions are related to daily operations taking place in the plant or distribution centre and aim to fulfill order requirements through inventory management, information sharing, etc. Higher-level decisions have longer lead times, longer planning horizons, and are concerned with aggregates such as total manpower requirements and total product line-demand. The higher the decision level, the longer the planning horizon, and the greater the uncertainty under which decisions have to be made.

For decision making, firms use forecasting. By predicting the future demand, price and suppliers, firms plan production more efficiently, negotiate better terms with suppliers, improve pricing and promotion and finally increase customer satisfaction. Forecasting can be applied at any of the three decision-making levels, thus long, mid and short term using market information or computer algorithms (Lambert, Stock, & Ellram, 1998).

Product quality management

Quality management comprise all the activities and decisions executed to produce goods or services with the required quality level. Due to food products' special characteristics, food quality management is a complex process that should ensure the production of safe and high-quality food products.

Like logistics decisions, quality control decisions can also take place at different management levels. Moreover, decisions can also be resource or product oriented. Resource oriented decisions are related to the capital, property, means, infrastructure, etc. that the organisation makes available to produce a good; product decisions are directly related to the good itself. At the operational level, decisions can be *programmed* when it is in response to routine situations; or *unprogrammed* decisions when there is new situation. For instance, temperature deviation at a refrigerating camera occurs quite often, therefore the decision to apply the corrective action is programmed.

2.3 Conclusion

Given the enormous product variability and continuous product quality decay collaboration and integrated decision making among supply chain actors is needed. QCL makes use of the information exchange to bring products to final customers that match their quality standards requirements. The information comes in the first place from consumer research and the acceptance period of a specific product. Second, from monitoring product quality throughout the supply chain and the construction of quality decay models. Food product´s quality is considered dynamic, therefore the information of product quality at each stage is used to redesign the supply chain and offer the final customer a product that matches their expectations making the most out of the products and reducing food loses. This is, based on companies' strategies, supply chains are reshaped to match the initial product quality with the final customer´s requirements

3. Chapter 3. Conceptual framework

In this chapter, a conceptual framework is developed as a connexion between the theory and the development of the questionnaire for the data collection. For the construction of the conceptual framework, this chapter includes first an explanation of the QCL concept. Section 3.1 includes the concise diagram defining QCL (breath) and an in-depth explanation of all its parts. Finally, in section 3.2 QCL is integrated in the supply chain including the six elements introduced by Van der Vorst.

3.1 QCL in breadth and depth

This research revolves around determining the requirements to engage in QCL and how quality control impact logistics activities to obtain an optimal final product quality. The objective of QCL is to optimize the final product quality based on customer's requirements starting from a given product quality (Van der Vorst et al., 2011, 2007). In figure 4, the concept of QCL is explained. The initial product quality determines the degree, or the activities of quality control needed. The need for quality control will have an impact on the logistics and the design of the supply chain activities (Schouten, Van Kooten, Van Der Vorst, Marcelis, & Luning, 2012). Altogether, the integration of quality control and logistics, results in quality-controlled logistics. Finally, this combination will result in a final product quality that should match customer's requirements.

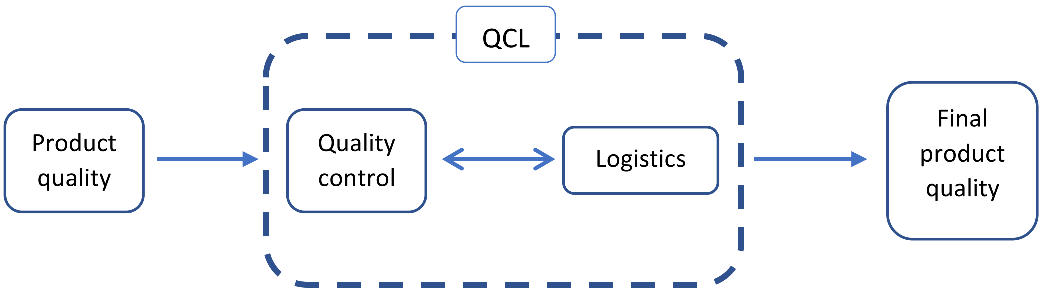

Figure 4: Overview of QCL concept

Hereafter, the parts of the following framework will be explained in detail and finally it will be outlines how it is integrated in the supply chain. The integration of QCL in the supply chain results in the conceptual framework of this research (Figure 5).

First, the components of product quality and final product quality will be explained. Then the components inside the QCL box are explained, i.e., quality control and logistics.

From initial product quality to final product quality

Quality is understood as the ability to meet or exceed customer and/ or consumer's expectations (International Standardization Organization, 2005). Given an initial product quality, final product quality is achieved through quality control logistics. In Food Supply Chain, whereas there is a great variation in the initial quality, customers want a homogeneous final quality. The initial quality of fruits and vegetables is given by the seed's variety, the cultivation conditions and the harvesting time. When harvested, fruits and vegetables have certain physical attributes (colour, flavour, size, weight, etc) and shelf life. Since a product is harvested, its quality starts to degrade (Barbosa-Cánovas et al., 2003; El-ramady et al., 2015). Therefore, agricultural practices are key to harvest a product with the optimum quality. Throughout the supply chain, quality degradation can be slowed down through quality control activities and good logistics practices. A good balance between quality control and logistics activities makes it possible to meet customers final product quality requirements. The final quality is given by the shelf life of the product which is usually measured by some physical attributes namely colour, texture and flavour. These attributes are very visual. Other customers' requirements may include size, shape and weight (El-ramady et al., 2015; Falagán & Leon, 2018). Furthermore, the quality of the final product is also influenced by the distance the product has travelled from harvesting point. It is assumed that the further the market from the crops, the longest it will take to arrive to the destination market and the shorter will be the remaining shelf life (Van der Vorst et al., 2007).

Quality control and logistics

Hereafter, the definition of QCL is unravelled. QCL is that part of supply chain management that plans, implements, and controls the efficient, effective flow and storage of food products, services and related information between the point of origin and the point of consumption in order to meet customers' requirements with respect to availability of specific product qualities in time by using time-dependent product quality information in the logistics decision process (Van der Vorst et al., 2007). Simplifying the definition, QCL is the control of a time dependent quality attribute of food products that impacts logistics activities and has the goal of meeting customer´s quality requirements.

Foods are dynamic systems that suffer internal reactions responsible for continuous decay of their quality. By controlling external conditions like temperature and/or gas interaction, these reactions can slow down and maintain the product properties within acceptable tolerances (Luning & Marcelis, 2009). These tolerances are stablished by customers. All fruits and vegetables have an optimum temperature in which their internal reactions that cause quality decay are at the slowest rate. By having a temperature control the speed of these reactions can be reduced (Mercier et al., 2017). High temperatures increase the speed of these internal reactions favoring maturation of the product and therefore shelf life is shortened; whereas very low temperatures can cause cold damages in fruits and vegetables. Furthermore, when ripening, some fruits and vegetables emit gases (ethylene) that accelerate the maturation process of other fruits and vegetables. Climacteric fruits such as tomatoes, emit great amounts of ethylene during the ripening process and the presence of ethylene in the atmosphere promotes ripening; and non-climacteric products such as citrus that produce a low amount of ethylene during ripening and also are unsensitive to its presence in the atmosphere (Toivonen & Brummell, 2008). By sorting products between climacteric and non-climacteric, gas interaction (ethylene) is minimized (Jedermann et al., 2014).

Perishable products bring additional requirements in the logistics activities like speed or specialized transportation and storage equipment and conditions (Van der Vorst et al., 2011). Temperature control and sorting are done throughout the whole supply chain: during distribution, warehousing and transportation. Distribution center conditions and activities are driven by product quality. For instance, some DCs are under controlled temperature, so fruits and vegetables are not exposed to high temperatures during handling activities such as classification, calibration or packaging. Products are sorted by their quality (maturation degree, type of product, …) before being packed. They can be calibrated based on the size and weight and separated based on their maturation level. Cross-docking is a way of sorting the products based on customer's requirements (Bowersox & Cooper, 2002; Lambert et al., 1998). Finally, products are cooled down before shipping. When a distribution center works with different products, they'll count with several refrigerated rooms for two main reasons: products have different optimum storage temperatures and there can be gas interaction between climacteric and non-climacteric products.

Regarding inventory management, although traditionally issuing policies are driven by storage time, namely FIFO and LIFO, new rotation systems are product quality driven. These are FEFO, LEFO, LQFO and HQFO. In the food supply chain, in normal conditions, the first products that come in are usually the first to expire or the ones with the lowest quality, thus FIFO, FEFO and LQFO are equivalent (Dada & Thiesse, 2008; Pierskalla & Roach, 1972). However, in this research we want to find out in which occasions this policy can change. The application of stock rotation based on shelf life, i.e. FEFO is better to adapt product quality to transport duration, reduce product waste and provide product consistency for customers (Jedermann et al., 2014).

Finally, transportation should be also quality driven. From choosing the adequate mean of transport based on travelling time and price to the storage conditions that affect the handling practices and the cold chain. Transports can work as a fridge that cools down the freight or as an isolating chamber that maintains the temperature of the freight. Furthermore, shipping can be delayed or changed destiny due to product quality. In any case, temperature of products should be within specific ranges. Usually during transportation, freight travels together with data loggers to have a record of temperature history; data loggers are read upon freight arrival but modern IT systems can provide with real time information of temperature, i.e. RFID (Bowersox & Cooper, 2002; Dada & Thiesse, 2008; Jedermann et al., 2014).

3.2 Conceptual framework: QCL integrated in the supply chain

Once the concept of QCL is understood (Figure 4), it is included in the actual conceptual framework that is used in this research. QCL and all its elements are integrated in the supply chain (Figure 5). This framework is inspired by figure 2, developed by the author Van der Vorst (Van der Vorst et al., 2007).

QCL is applied in each step of the supply chain. The quality control activities and the logistics activities are explained in section 3.1. There are two starting points in this framework. On the one hand, on the left side, the supply chain begins with a product (P) which characteristics are determined by a quality measurements (QM) and prediction and the availability of it, i.e., shelf life, volume, location. This information is received by the immediate supply chain actor. In theory, this is described as logging and exchange of information (I). On the other hand, the final customer shares with the suppliers their desires (CP), which are defined in the theory as de consumer´s preferences and acceptance period of product quality attributes. These consumer´s requirements are passed from actor to actor. Therefore, the supply chain actor receives information from the product characteristics and the customer´s requirements. The exchange of information is done in both directions between supply chain actors. This information will influence the quality decisions and the availability of the products, thus on the quality control decisions and logistics decisions. This corresponds to the thick arrows. These decisions have an impact on the quality control and logistics activities done at every stage of the supply chain. Thus, dashed line refers to local dynamic logistics and quality control is applied.

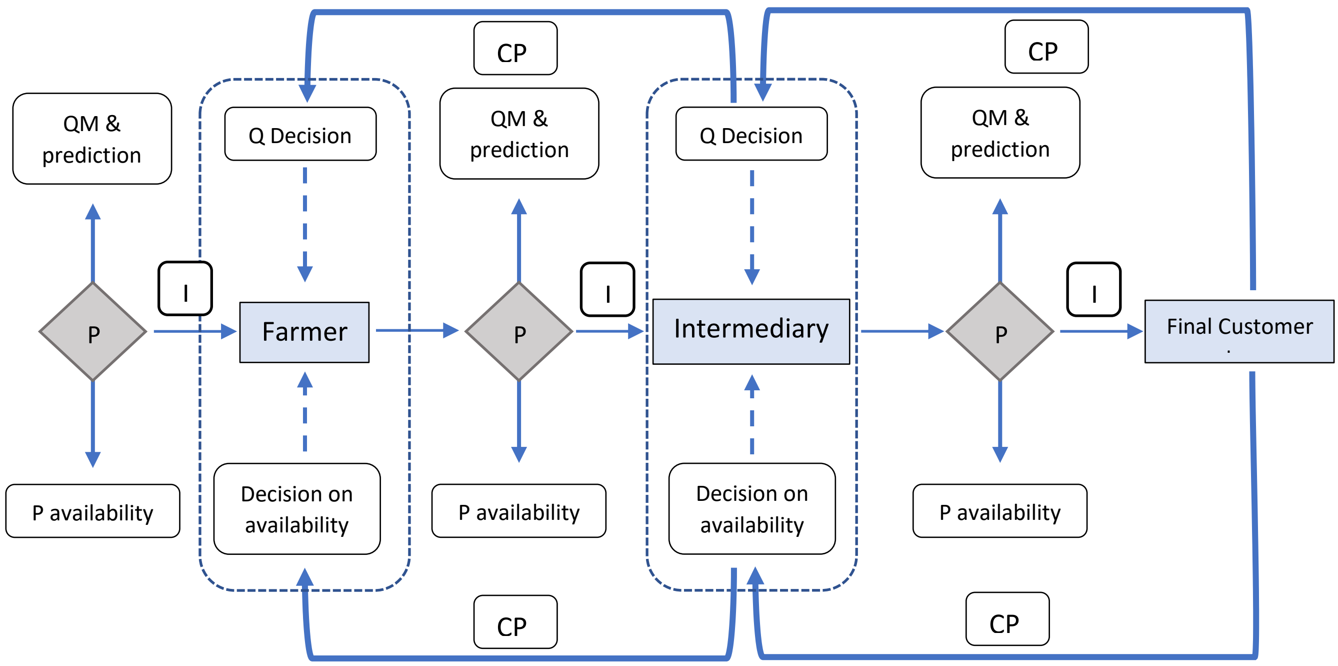

Figure 5: Conceptual framework

Finally, every actor produces a final product which is also characterised by its quality and availability. The critical quality points (CQP) are distributed in all steps according to the needs of the product and supply chain. They can be located at raw materials reception, during processing and/or before shipping. Since product quality is understood as a dynamic variable, the flow of batches is not linear as described in the figure, but changes direction as quality is been measure quality decay is predicted. This is according to supply chain management.

3.3 Conclusion

The research framework shows how the six elements from Van der Vorst are integrated in the supply chain to implement QCL. Consumer preferences and acceptance period, product quality attributes and product quality measurements and prediction constitute the starting sources of information and quality control activities to implement QCL. Product quality measurements is done at the CQP. Logging and exchange of information (I) is done in both directions of the supply chain following the arrows. Based on the information received, quality control and logistics activities adapt to the current needs of the supply chain. This is shown within the dashed arrows. Finally, the combination and coordination of all activities result in SCM.

4. Chapter 4. Methodology

This chapter is an explanation of the methodology carried in this research. First, a description of the research design is outlined, followed by the data sources used and the research methods and finally the data analysis.

4.1 Research design

This research corresponds to a multiple case study design. It is assumed that every case studied represents a typical case. The major strength of the case study is that it is useful in areas where little is known and to have an integrated understanding of the situation. The literature on QCL is not very large, therefore with this research further relationships between companies that are not known yet regarding this concept are explored. As it is a qualitative research method, it is a very flexible and open-ended technique to collect data. It allows to extensively explore a certain topic and to get detailed information in order to fully understand the topic. The major disadvantage of this study design is that it is difficult to generalize the findings. It is not the right research method to use if you want to confirm or quantify findings (Kumar, 2014).

This research makes a comparison of four study cases. In each case study, a company will speak up for the supply chain they are part of. The main requirement to be eligible for this study is that companies should participate from a fresh fruits and/or vegetable supply chain. From the companies approached, three of them are based in Spain, and the fourth one in the Netherlands. From the Spanish companies, two are producers, and the third is a wholesaler. The Dutch company is also a wholesaler. Table 1 shows the companies participating in the study.

Table 1: List of companies participating in the study

Company	Activity/location
Grupo La Caña (Miguel García Sánchez e Hijos S. A.)	Producer/ Spain
Agroherni	Producer/ Spain
Greenyard Group	Wholesaler /The Netherlands
Frutas Olivar	Wholesaler / Spain

4.2 Data sources

For this thesis, both theoretical and empirical information has been used. For the theoretical part a literature review has been carried out and for the empirical information practical cases have been studied.

Literature

The literature was gathered from databases like Scopus, web of science and google scholar. The first step was to make a research on quality-controlled logistics as it is the core concept of the research to understand. To do so, several articles from the author prof. dr. ir. J. Van der Vorst have been used. To complete the literature, basic concepts of logistics and quality control have been added. The initial key words used to find these articles were a combination of the following: (logistics or supply chain or supply chain management) and (food or foodstuff or agri-food) and (perishable) and (quality) and (quality control management) and (quality controlled logistics) and (high added-value or high quality). The objective was to find background on basic logistics to understand the way of interaction between the chain actors and the way inventory is managed; on quality control to have an idea of the practices used in the food chain to meet quality standards, what are the required storage conditions for fresh products, and what quality requirements will be approached. Extra relevant literature was gathered using the snowball principle.

The structure of the literature chapter (chapter 2) and the analysis chapter (chapter 6) is based on the six elements from prof. dr. ir. J. Van der Vorst. The six elements are listed and built up in combination with theory on logistics and quality control to understand how application of different elements of QCL work.

Practical cases

To complete the theory, four study cases have been chosen. To do so, the information was gathered from key informants. Several questionnaires have been sent to different actors from the supply chain of companies related to fresh horticultural products. The interviewees were mainly involved in production, quality control, distribution and commercialization. One or two interviews per company have been conducted to learn how or if the theory is applied. In table 2, there is an overview of the interviews, including job position of the interviewees, how the interview was done and the date.

Table 2: Overview of interviews

Interviewee position	Interview mode	Date of interview
Grupo La Caña		
Quality control technician	Phone call (1 hour)	02/05/2018
HACCP manager	Questionnaire	25/05/2019
Agroherni		
Quality control technician	Questionnaire	16/05/2018
Greenyard Group		
Exotic fruit buyer	Phone call (40 min)	07/05/2019
Quality manager	Phone call (50 min)	10/05/2019
Frutas Olivar		
Product manager	Questionnaire	11/06/2019

4.3 Research methods

Companies that complied with the criteria were contacted via telephone. Usually, a person from the quality department was contacted. They were given and explanation of the purpose of the research and later invited to participate on it. Once the interviewee accepted to collaborate, he or she would receive the questionnaire via e-mail (see Annex). In order to be more flexible and adapt to their workload, all of them had the option to fill in the questionnaire or make an interview via telephone.

The interview on the phone was semi-structured, thus the questionnaire was a guide to conduct the interview but there was room for further questions and explanations. In two occasions, a second round of interviews was done to clear up some details from the first round and answer some extra questions.

The questionnaire was derived from the conceptual framework in chapter 3. Each level of the framework was linked to specific questions. Furthermore, each question was aimed to be answer by specific positions in the supply chain (see Annex).

4.3.1 Operationalisation of quality-controlled logistics

There is plenty of literature and technological advances on both quality assurance systems and supply chain collaboration programmes like Vendor Manage Inventory (VMI) or Collaborative Planning (Cao, Vonderembse, Zhang, & Ragu-Nathan, 2010) but, up to recently, these concepts hadn't been integrated. In the literature, quality-controlled logistics is operationalised by several authors, being prof. J. Van der Vorst the first to introduce this concept (Van der Vorst et al., 2007). There are four factors that are used to develop this concept: variation of product quality, technology, heterogenous customer demand and managing product quality evolution in the supply chain. Variation of product quality is operationalised in terms of biological variation, cultivar conditions; technology is operationalised through quality control by controlling temperature and sorting products; heterogenous customer demand is operationalised in terms of shelf life and product attributes like colour or flavour; and managing product quality evolution is operationalised through designing logistics activities like issuing policies and transportation conditions.

The structure of the literature follows the breadth and depth learning. Van der Vorst (2011) developed six elements to operationalise quality-controlled logistics and proved them in a case study in the tomato supply chain. These elements are taken as breadth; whereas the description of them, i.e., aspects of quality control and logistics correspond to depth. Furthermore, integration of these elements and aspects will give a better understanding on how QCL is deployed in real supply chains. The table 3 contains a summary of the terms used.

The first step into QCL operationalisation is to know which product quality requirements of the different customers are and which the consumer product acceptance periods are. Thus, understanding the quality attributes that consumers prefer for a specific product by conducting consumer research. For instance, with this information producers will choose to grow a product that will comply with those quality preferences and therefore will select the appropriates seeds for that objective.

Second, product quality is dynamic. Understanding how the quality evolves throughout the supply chain helps to identify the critical quality points (CQPs) of the supply chain in which quality control and logistics decisions will have an impact on the final product quality. Decision making can be related to quality control, e.g., putting the products under controlled temperature; or from the logistics point of view, e.g., changing the issuing policy from FIFO to FEFO.

Third, once CQP are identified, firms should have the capability to measure them by having an automated process of quality control of the CQP and by developing prediction models of their products to calculate real product quality. For instance, depending on the type of CQP, the methodology for quality control can be acceptance sampling, i.e. accepting or rejecting products upon arrival. Besides doing quality analysis to product physical properties, also firms should be capable of doing temperature monitoring in storage or transportation as is the major variable affecting product quality.

Fourth, the use of data loggers and the exchange of information are essential to have real-time information about product quality and the demand. Monitoring transport conditions gives an idea of the product quality state upon arrival to the next state. Exchanging information of supply conditions and demands require a certain level of integration between supply chain actors.

The fifth element is to have a dynamic logistics and quality control. The exchange of information favours adaptation of logistics to match existing product quality with given market segments. For instance, a certain batch will be sent to one customer or another based on its quality and how far the customer is. For this element, knowledge on all the possibilities that logistics activities offer, e.g., what are the available transport modes, or what issuing policies can be applied.

The sixth element implies that the supply chain is designed based on demand. Inventory is managed based on customer's requirements and the supply chain is designed to achieve the quality requirements. Managing the supply chain is thanks to collaboration with supply chain partners taking integrated decision-making.

Table 3: Overview of elements (breadth) and aspects (depth) used to build up the literature review

Element	Theory
Consumer preferences and acceptance period of product quality attributes	Product quality
Critical Quality Points (CQP)	Quality control
Product quality measurements and prediction	Quality control: tools and methods, preserving techniques
Logging and exchange of information	Information systems, integration of logistics activities
Local dynamic/adaptative logistics and quality control	Inventory management, distribution management, transportation management,
Supply chain management (SCM)	Logistics and quality control management

Chapter 3 includes the explanation of the conceptual framework in which the six elements have been integrated in the supply chain to have a better understanding of how these elements can be deployed in real life supply chains. Then, the questionnaire was built up in a way that was easy to follow by the interviewee, i.e. sections are related to different job responsibilities in a company (farmer, quality control, logistics, sales), but making sure that the six elements were covered with questions.

4.4 Data analysis

Once all data was collected, interviews that were done on the phone were transcribed from recordings. Then, the cases were condensed and described in chapter 5 based on the three simplified elements extracted from chapter 3: quality control activities, logistics activities and the integration of these terms, i.e., quality-controlled logistics.

After the first description was done, the cases were contrasted with the theory encountered in chapter 2. The structure followed to build up chapter 6, is the breadth-depth-integration learning. Results were coded following the six elements used in QCL: consumer preferences, critical quality points, quality measurements and prediction, logging and information exchange, dynamic logistics and quality control and supply chain management. Furthermore, cases were labeled based on the level of integration of these elements and the strategy followed

5. Chapter 5. Results

Hereafter, the results of the four case studies are described.

5.1 Grupo La Caña

Grupo La Caña is a family business founded in 1978 in Granada (Spain). Currently, collaborates with 500-600 farmers in the south of Spain, mainly in the provinces of Granada, Málaga, Huelva and Almería. Thanks to the climate conditions of this area, they produce subtropical products, being the three pillars of their economy tomato, avocado and cucumber. They also have other crops namely watermelon, different varieties of peppers, mango or green beans. Furthermore, they also have an organic production of mango, tomatoes, avocado, peppers and cucumber.

Because their portfolio is very extended, for the interview it was decided to focus only in the non-organic tomato supply chain. They work with a wide range of tomatoes varieties: tomato cherry (plum, yellow, tiger red, etc.) and plum tomato.

The company counts with two main distribution centres where they select, handle, packs and refrigerate the products before shipping. 85 to 90% of sales are in the European market. The markets to which they sell their products are France, Germany, UK, and Finland. The rest stays in national market. This national production is mainly sold in auctions.

In the following figure there is an overview of the supply chain.

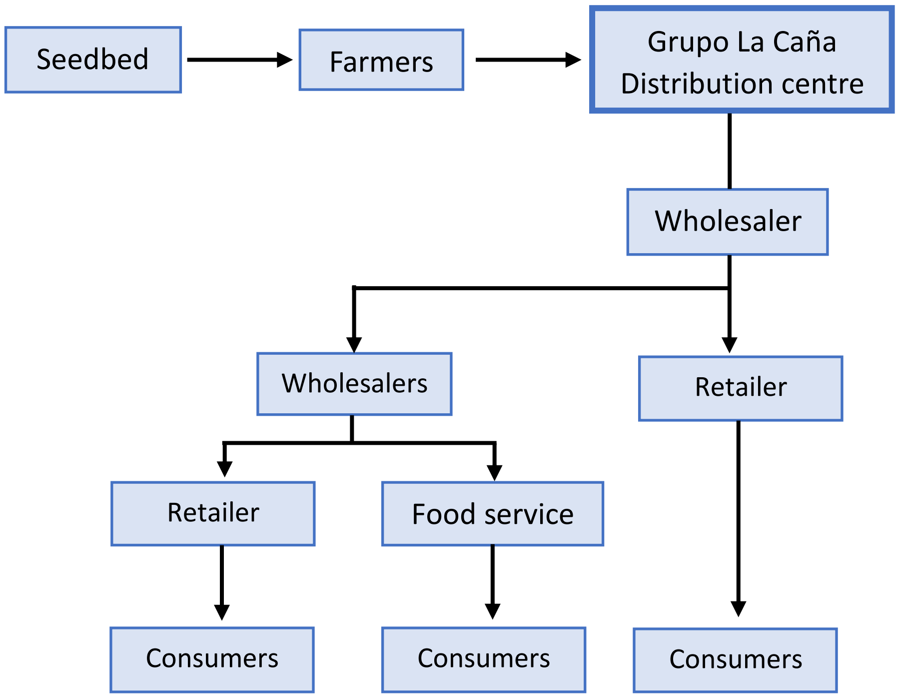

Figure 6: Grupo La Caña supply chain

5.1.1 Quality control activities

In Grupo La Caña, farmers bring the tomatoes to the distribution centre (DC) in their own vehicles at room temperature. The distance from the fields to the DC varies from some minutes by car to 2 hours. Furthermore, sometimes tomatoes are not brought immediately after been harvested but the next day. This means the time elapsed since they are harvested until they are put under controlled temperature is longer. Nevertheless, there is the possibility that if the fields are far away, Grupo La Caña provides the farmers with refrigerated vans to transport the products in chilled conditions, around 10-14ºC.

Every farmer harvest in different conditions so products that arrive to the DC may present big differences. Some farmers harvest the tomatoes when they are green, others when they are riper. The optimum moment of harvest is influenced by intrinsic product and supply chain factors namely the optimum consumption moment, distance to market, time in the supermarket or packaging confection; and other extrinsic factors like market demand and the price can advance or delay harvest. Despite these factors that cause quality disparity, Grupo La Caña makes sure to use the same type of seed for all the crops. The type of seed used is a key component of the product quality. Every type of seed will result in specific organoleptic characteristics in the product. Then, the cultivation methods, climate conditions and pests will shape these characteristics. Farmers from Grupo La Caña have access to periodic advice from a technician to ensure the optimum growth of the product.

Upon arrival to the DC, the inspector checks the vehicle quality conditions absence of phytosanitary products, hygiene conditions, etc. Later, the salesman makes a quick quality check based on the defects of the products. Defects refer to physical damages like scars, or products that are too small or too green. There are three possible classifications: A- optimal, B-normal, C-corrective measurements. The quality control is visual – to look for physical damages- or touching – to look for too soft products. Then tomatoes are calibrated per size and classified per size and colour.

Lately, customers are also interested in the flavour of the tomato, hence Grupo La Caña measures the Brix degree of tomatoes; in this case on cherry tomatoes. The requirement is that tomatoes need to have 7 ºBrix or higher to ensure a good taste. This practice is only carried if it is specified in the customers quality requirements. This extra requirement also implies a higher price.

After being classified, tomatoes are packed and put in cool cameras. Only when there is an order, they are packed, this means that are assigned to a customer. Grupo La Caña counts with five cooling cameras with different storage temperature, two ripening cameras and one pre-cooling tunnel. The cool cameras are conventional fridges that reduce the temperature of the batches usually very slowly; whereas the precooling tunnel cools down the products faster.

Before shipping the products, batch temperature is measured since they need to be at the required temperature because the trucks used to transport the product to the customers only maintain the temperature. Grupo La Caña does not make temperature control during transport regularly. Only if the customer asks them to use a data logger. If it is under Grupo La Caña choice, they will only do it as part of a periodical control.

5.1.2 Logistics activities

In the DC, freight arrives every day, and everyday products are dispatched. Depending on the DC capacity and workload, products can remain up to 2-3 days in the DC. But the main strategy of Grupo La Caña is to dispatch the products as soon as they are ready i.e. classified, packed and cooled down. They do consolidation because they gather products from different farmers and cross-docking because they make batches with mixed products and products from different farmers.

Only when there is an order, products are packed. This means that once products are packed, they are already assigned to a customer. The dispatching order they usually follow is FIFO since it is a way of having an organized sequence over the inventory and dispatching the fresher products first. The latter is important because while products are waiting in the DC, their quality level decays.

Flow of products in the DC is usually well coordinated since it is known which customers and at what time will arrive to the DC to pick up the freight or how often batches need to be sent and what volume needs to be shipped. Therefore, orders are known in advance.

Products are transported by truck. Only batches that have the required temperature are shipped. If a batch should be shipped and it does not have the required temperature, it will be put into the pre-cooling tunnel. This may cause a delay in the shipping. Customers use their tucks but Grupo La Caña also use their own trucks. Batches travel under controlled temperature thanks to the use of thermographs and data loggers. In case the customer is responsible for the means of transport, Grupo La Caña is not responsible for the travelling conditions and the temperature record. When Grupo La Caña uses their own trucks, they are responsible to keep track of temperature. The use of data loggers is optional for Grupo La Caña. When used, Grupo La Caña receives the data loggers back to analyse the graphs of the temperatures.

5.1.3 QCL: integration of QC and logistics activities

Every year Grupo La Caña makes a plan for the crops based on the customers' requirements listed in an annual book of quality standards requirements. These requirements, which usually remain stable throughout the year, include the type of product, in what volumes, quality and characteristics. Grupo La Caña knows the production volume per meter square of each variety and makes sure to have enough supplies by suggesting the farmers what to cultivate. Thanks to the annual agreement, Grupo La Caña knows when a truck from customer A will arrive with the truck, in which frequency and how much volume they need to ship. Therefore, batches can be ready to be shipped (packed and precooled) since Grupo La Caña knows orders in advance. They make a forecast of the production needed to provide all their customers and inform the farmers to cultivate according to it. Farmers receive advice from Grupo La Caña, but they are free to follow it or not. Eventually, Grupo La Caña knows the production level per meter square and can arrange production.

All products are classified by size and colour, but some batches go under specific quality control to determine the brix degree of the fruit. This only applies when the customer asks for it. Products are cooled down in cameras at their optimal storage temperature and as soon as products have reached the temperature, they can be shipped. The processes of cooling down the batches in cooling cameras is slow, therefore when it needs to be done fast, for instance, when a truck is waiting to load the freight, batches are put in the pre-cooling tunnel. Since Grupo La Caña knows the orders in advance, thus which customer is coming to pick up freight and in what quantity and quality requirements, activities can be coordinated to avoid delays in the logistics.

The usual strategy of Grupo La Caña is to ship first the batches that have been longer in the DC, thus FIFO. However, when the workload is high, and batches accumulate (around 2-3 days) this can change. It is the case when a customer with strict quality and firmness requirements arrives, then Grupo La Caña can advance batches that have arrived later to the DC and have better quality characteristics. In this case, the issuing policy is HQFO (Highest Quality First Out). If tomatoes are in the DC more than 5 days, Grupo La Caña thinks of alternative markets to sell them like national companies who will process tomatoes to make tomato sauce or canned tomatoes. In some cases, batches can be destroyed.

Grupo La Caña deals with different quality levels in the DC. Hence, they make batches according to customer quality specifications. When deciding which customer to send the batch to, they try to match these requirements. For instance, when tomatoes have shorter shelf life, they send them to closer markets. Furthermore, they predict product shelf life buy keeping track of product quality daily until they product quality does not comply with quality standards.

5.1.4 Overview

Grupo La Caña is an intermediary between farmers and customers. From the production point of view, they work customer oriented since their production is based on customers´ annual requirements, from the type of seed varieties they produce, to the product quality and the volumes.

Being part of the upstream of the supply chain and having products for so short time with them, they consider that it is more efficient to put more effort on the cultivation and harvesting techniques to produce a high-quality product rather than on the handling practices. Controlled temperature is used to extend shelf life, which for them it´s just a commercial parameter. In the following table it can be observed that all their activities (both quality control and logistics) are coordinated to serve the customer and satisfy their requirements.

Although production systems are very much customer oriented and, farmers are allowed to manage their fields freely. This causes daily quality variation in the DC, as well as volume variation. Therefore, Grupo La Caña manages batches in a way to get the most out of them, this is by matching existing batches with customer requirements. This is why sometimes batches accumulate or present a lower quality and need to be sent to alternative markets. Nevertheless, focuses on complying with volume arrangements, therefore they work volume oriented.

Table 4: Grupo La Caña activities.
(Abbreviations: PQ: product quality; Q: quality; T: temperature)

Quality control activities	Logistics activities	Integration of QC &Log (QCL)
• Initial PQ control by choosing seeds variety • T control as commercial parameter • Control of ºBrix • Sorting products based on optimum storage T • Storage cameras with different T • Information systems: track of PQ	• FIFO and HQFO issuing policies • Orders known in advance • Crossdocking & consolidation • Means of transport: truck • Storage & transport under controlled T • Fast precooling in precooling tunnel • Information system: customer orders, data loggers	• Annual planning of production • Batches match customer requirements • PQ match market destiny • Alternative markets when PQ is low • Change of issuing policy strategy based on customer´s requirements • When poor T control: claim

5.2 Agroherni

Agroherni started as a farmers’ cooperative that produces fruits and vegetables in the South of Spain. The fields are spread throughout the Spanish provinces of Murcia, Granada, Almería and Alicante. Their ambitious project to reach the European market was the origin of it. Currently, they export to United Kingdom, Ireland, Germany, Belgium, The Netherlands, France, Italy, Slovakia, Poland, Russia, Switzerland, Austria, Denmark, Norway and Sweden. Thanks to the great extension of fields and climate conditions they are able to produce a wide range of fruits of vegetables: spinach, different varieties of lettuce, celery, aromatic herbs, potatoes, broccoli, pepper, tomato, leek and stone fruits like peach, nectarine, apricot and flat peach (paraguayo peach). Furthermore, they also have a part of organic production.

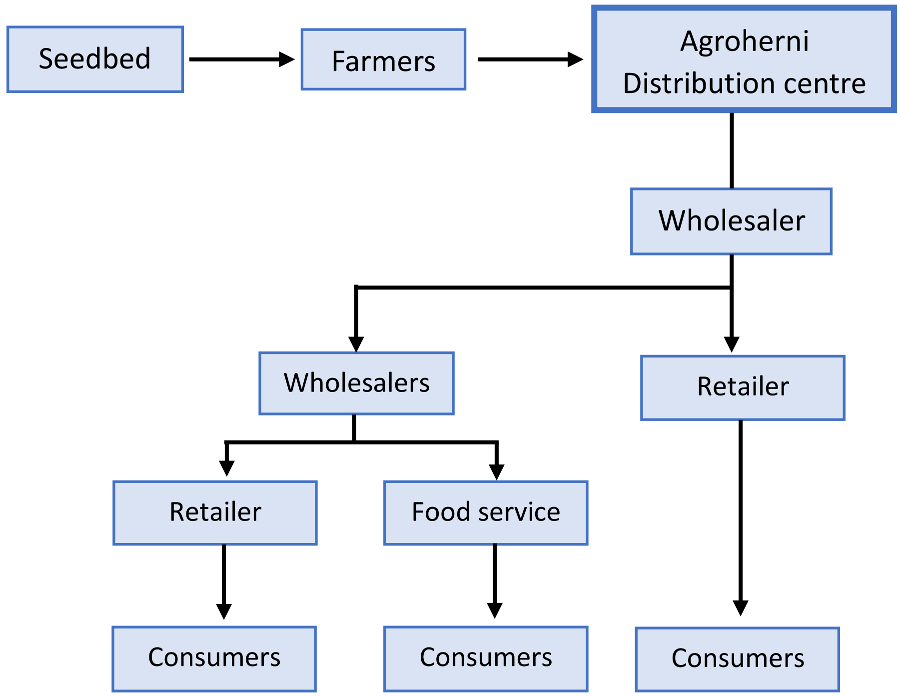

Figure 7: Agroherni supply chain

Agroherni counts with a single distribution centre in Fuente Álamo in Murcia where they gather the raw materials from the farmers. The activities that Agroherni Group carries are production of fruits and vegetables, growing and harvesting, cooling, and distribution of products. Agroherni Group goes a step forward and selects which are the best varieties to grow. They count with a seedbed where they make research on which seeds will adapt better to the climate conditions and own growing methods. Agroherni has two main types of customers: retailer and central markets or wholesalers.

5.2.1 Quality control activities

Quality control in Agroherni starts from choosing the most appropriate seed variety to cultivate. The choice of seeds is based on the customers’ requirements and the suitability to the climate conditions of the area and the season. In fact, seeds are germinated in greenhouses, under controlled conditions, to later plant them in the fields. Then during harvesting they make sure to apply the best handling practices to ensure the highest product quality. In the fields, products that comply with customers ‘requirements are selected and harvested. Hence, during harvest, Agroherni decides to whom will send a specific batch.

Products are brought at room temperature to the DC. The DC is less than 20 km away from most of the fields, so they make sure that the time between harvest and cooling is the least possible. Upon arrival to the DC, the inspector does a quality control to prove that products comply with quality standards, then they are calibrated and precooled in vacuum cooling cameras. Batches are stored in cooling cameras at 2ºC. Since Agroherni deals with fruits and vegetables that have a similar optimum storage temperature (1-5ºC), they don´t have the need to sort the products or to worry about product interactions. In fact, they make batches with different products. Temperature is controlled during storage and also before shipping to make sure the fruit has the appropriate temperature.

During transportation, if Agroherni is responsible of the transportation, they will include a data logger to register temperature history. Customers are asked to read the data loggers. If there are temperature deviations, Agroherni will make a claim to the transport company.

To ensure the longest shelf life, Agroherni also carries research with different packaging materials.

5.2.2 Logistics activities

Products are brought to the DC from the fields in trucks. Depending on the internal capacity and the order volumes, products can be harvested and shipped within the same day; however, Agroherni tries not to store the products for more than 2 days.

They harvest and ship products daily. In the DC they do the batch confections based on customers’ requirements and manage them separately. The way of managing inventory is through consolidation and cross-docking since they gather products from different fields and they also make batch confections with different products. As aforementioned, the destiny of each product is known since harvest and are shipped when it is programmed to be shipped.

Shipping of batches is done by truck. Customers can use their own means of transport but Agroherni also uses leased trucks. Trucks travel full to avoid intermediary loads that will compromise the cold chain. However, during off-season, it might be needed to group orders and consolidate freight mid-way in other distribution centres. This is avoided as much as possible as it is a risk when maintaining the cold chain. The transport can take from 1 to 4 days.

Agroherni is aware that time is against them, therefore they try to reduce lead times to the maximum. For instance, they ship products as fast as possible and/or use double chauffer in the truck to reduce transportation time.

5.2.3 QCL: integration of QC and logistics activities

Agroherni plans the production based on annual programmes. Customers include in these programmes volume and quality specifications, as well as price. Based on the volume requirements, Agroherni manages to supply customers and makes sure to have excess of production that they will later sell on central markets. When selling products to central markets, price is influenced by the market demand and the product quality. Based on customer´s quality specifications they will choose the appropriate seeds to cultivate. Moreover, harvesting time is done when products reach the required customer's quality specifications. For instance, harvest can be advance if the customer is far. Hence, since harvest, products are assigned to a customer. This classification continuous in the DC, where batches are not mixed. Only if any non-conformity is found in the DC, batches can change the destiny, or they can be destroyed.

Although quality requirements are usually fixed in the annual program, when there is a high demand for a specific product, customers may compromise and buy a product with a lower quality so they can cope with the market demand.

Agroherni asks for feedback to their customers on product final quality and shelf life. They also take samples of each batch and keep them under similar conditions to the transportation conditions for 14 days. These samples are checked every day to track their evolution.

5.2.4 Overview

Agroherni plans the annual production on customer requirements, so they work customer oriented. In fact, their decision-making seems to be a systematised process. It starts with the choice of seed varieties and the harvesting time. The latter will determine the following logistics activities, since once products are harvested, they are assigned to a customer. This early connexion between a batch and a customer, does not allow space for improvisation or flexible actions. To have a bit of a balance, they always have excess of production to allow them to have more flexibility; for instance, selling the production extra in the central markets allows Agroherni to get the most out the products as the price is based on the market situation but also on the product quality.

In the following table in can be observed that quality control activities focus on obtaining a high-quality product from the fields and that logistics activities are a supplement to match customer´s requirements with batches. Agroherni work is characterised by having a strict control over all processes to maintain product quality.

Table 5: Agroherni activities.
(Abbreviations: PQ: product quality; Q: quality; T: temperature)

Quality control activities	Logistics activities	Integration of QC &Log (QCL)
• Initial PQ control by choosing seeds variety • Germination under controlled conditions • Harvest based on customer's requirements • Sorting products to match customers` requirements • Information system: PQ track for 14 days	• Issuing policies: based on quality • Crossdocking & consolidation • Means of transport: truck • Storage & transport under controlled T • Information system: customer orders, data loggers, customers´ feedback.	• Annual planification of production • Batches match customer requirements since harvesting • PQ match market destiny • Alternative markets • When poor T control: claim to transport company

5.3 Greenyard Group

Greenyard Group is a family owned wholesaler with Belgian origin. Nowadays, Greenyard Group counts with several bases in more than 25 countries worldwide. The contact for this research is based in Greenyard Netherlands. Greenyard Netherlands trades with fresh, frozen and prepared fruits and vegetables (as well as flowers and plants). For this research only the supply chain of fresh fruits, especially exotic fruits will be analysed. They supply to the top retailers in Europe, but the biggest and most important ones for their business strategy are retailers in Germany. 85-90% of the purchased products are exported to Germany, another small part goes to Belgium or stays in the Netherlands.

Greenyard Group's primary strategy is to make a direct purchase to the producer and sell the fruits to retailers. Their suppliers are exotic fruits producers based in South America, Africa, and Asia. For instance, some countries Greenyard Group trades with are Colombia, Puerto Rico, Argentina, Ecuador, Kenia, Zimbabwe and Zambia. Additionally, they are also sourced from Spain or Netherlands. Since they trade with big volumes of fruits and vegetables, they are usually in contact with farmers cooperatives or traders. In very specific situations when the purchase volume is small, they may trade with small farmers. Exceptionally, if direct import is not possible, Greenyard Group may buy products from other intermediaries to comply with customer order requirements. Products are mainly exported to German retailers but, when the quality of the products is lower, or they have excess of products they may sell them to wholesalers or local markets. Products are transported to Europe by ship or plane in containers under controlled temperature and humidity. The containers arrive by ship to the port of Rotterdam and they are released to Greenyard Group ´s warehouse. Here, they do quality control, storage, repacking and shipping products to their customers.

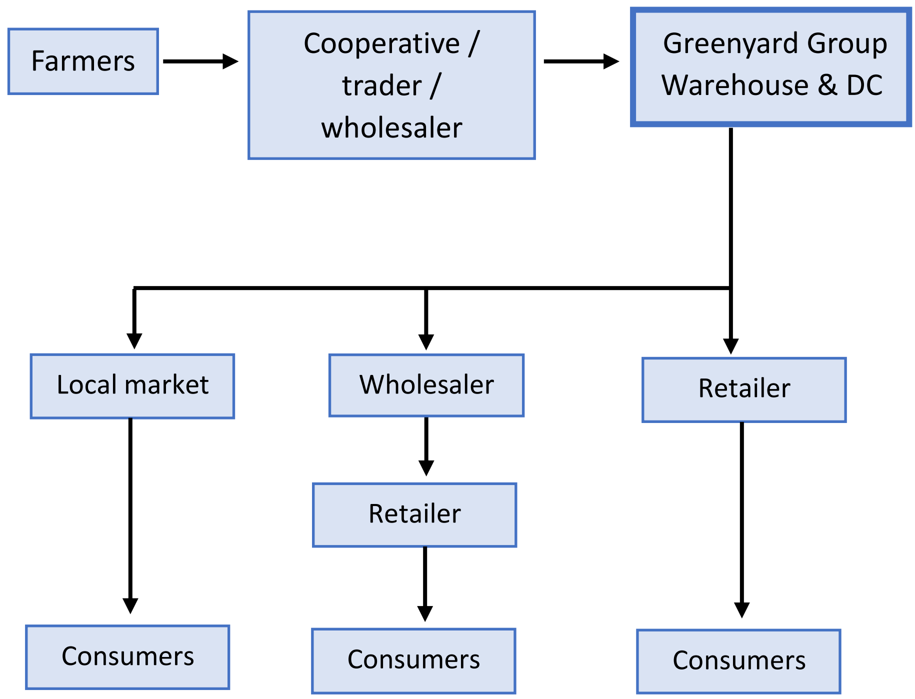

Figure 8: Greenyard supply chain

5.3.1 Quality control activities

Containers arrive to the port of Rotterdam when they come by ship. The port releases the freight after a phytosanitary control and Greenyard Group transports the container by truck to the warehouse. In the warehouse, there is a first check of the documentation. They check in the packing list what products are in the container, from where they come, which supplier, in which quantity, etc. They will give priority to the suppliers that send more volume. The quality inspector continues with a visual control of the batches to identify possible deviations of temperature, physical damages, strange smells, etc. The quality control will continue more in detail.

The reason why the container is opened and inspected in the warehouse is because it is done under controlled temperature. The temperature is a critical parameter to maintain the quality of the product, hence Greenyard Group tries not to break the cold chain of the products. Greenyard Group also checks the temperature history record of the container. This information is a proof of the good handling practices during transportation.

Furthermore, Greenyard Group not only transports products under controlled temperature but under controlled humidity. This can be done in two ways. If the transport duration is around 10 days long, it will be enough to control humidity through air ventilation. Whereas if the trip is longer than 20 days, the use of modified atmosphere container may be needed. The choice between normal ventilation and modified atmosphere is decided together with the supplier and based on previous studies. For instance, Greenyard Group has been observing that avocados transported under controlled temperature and ventilated containers will show a percentage of problems upon reception in Greenyard Group´s warehouse. Through research and experiments, Greenyard Group has been able to adjust the conditions in the container (modifying the atmosphere) to obtain the best results.

To have a control of transport conditions, suppliers ship the freight together with a data logger system. The type of record system used will depend on the supplier. A small supplier that works with low volumes will choose a more economic temperature logger to reduce costs; whereas a more robust and bigger supplier will opt for a digital thermograph to keep a more precise record of the temperature during transportation. The use of more advance information systems helps to have a better control over product quality.

Upon freight arrival to the warehouse, batches that don’t comply with quality requirements, go under an investigation. If the quality is reduced due to a poor temperature control during transport, Greenyard Groupwill make a claim to the shipping company, as they are responsible of the transportation conditions. If it hasn’t been any temperature deviation during transportation and there is a deviation of the required quality standards, Greenyard Group will do a quality control and will inform the sales department, who will make the optimal adjustments to the batch. These are the following possible situations: the batch is classified with a second category of quality, or the batch is repacked discarding lower quality products to obtain a single first category batch. The latter action is preceded by a claim that the supplier needs to accept as he/she will be responsible of paying for the production costs. If the supplier does not agree with the claim and thinks that the batch is in perfect conditions, he/she is responsible to pick up the batch and sell it elsewhere.

Once in the warehouse, products are stored in cool cameras at the optimum storage temperature. Product with similar storage temperature and similar behaviour in ethylene presence can be stored together. Furthermore, Greenyard Group counts with Ultra Low Oxygen cameras in which products can be stored for a long period i.e. apples can be stored for 12 months. In these cameras the breathing rate is reduced to minimum and they can be preserved fresh for longer period.

5.3.2 Logistics activities

Greenyard Group´s logistics start with importing products to The Netherlands. The usual means of transport used is the ship, but also plane. The use of one mean of transport or another is based on the type of product and the maturation process of each of them. For instance, products that have long maturation processes like avocado or passion fruit can be transported by ship; whereas products that consumers want to buy already ripped and ready-to-eat are transported by plane, like papaya. The use of plane implies extra costs in logistics; however, customers and consumers are willing to pay more for those products.

Once in the warehouse, products are stored in the cool cameras or ULO cameras. Greenyard Group receives and dispatches daily; however, not all the products that arrive are dispatched in the same day. Instead, Greenyard Group creates stock as a market strategy to be able to supply to their customers when order volumes increase or supplies are lower, and as a financial advantage. Wholesalers tend to buy and import as much as possible from their suppliers, before import tariffs[1] get expensive, to get a price advantage over other importers.

Determining what products will be dispatched to their customers is not that easy as applying FIFO policy. Greenyard Group knows the stock available and makes a stock selection based not only on how old the product is but also on risks (for Greenyard Group this is quality or expiration). When batches have the same quality, they will dispatch the oldest batch. If they don´t have the same quality, batches with lower quality or early expiration dates will be prioritized. This refers to First Expires First Out (FEFO). The following criteria to manage inventory is applied: arrival time/product age, quality of the product and type or packaging format. The latter refers to the size of the batch and if it is ready to be shipped i.e. it is not the same to have packages of 20 kilograms than 1.5 kilograms.

Finally, batches are dispatched to final customers in Europe, mainly in Germany. Batches travel only under controlled temperature by truck for 1 to 3 days. The commercial department, who is in contact with customers and suppliers, decides where to send the batches. This decision is based on the quality of the batch, the suggestions received from the quality manager and the agreements with the customer.

5.3.3 QCL: integration of QC and logistics activities

Greenyard Group´s purchase activities are dynamic and change every day. They don't sign contracts with suppliers but make agreements regularly with them based on customers´ orders. They receive daily orders for the next day, except on Fridays, that they receive the orders for

[1] In the EU, in order to protect the internal production, the volume imported is controlled through taxes. When a certain volume has entered the EU market, then taxes get more expensive.

Saturday, Sunday and Monday. In order to be prepare, they make weekly predictions based on last week´s orders. If Greenyard Group has a small order, they will choose only one or two suppliers to purchase the fruits, specially the ones with more economic prices. But if they have a bigger order, they may need to buy from a third or fourth supplier. Greenyard Group supplies to important retailers in Germany, therefore they need to work with big volumes. For this reason, they usually trade with big suppliers like farmers associations or traders. Nevertheless, there are occasions when they don´t need to import big volumes, for instance on Christmas or Eastern when customers ask for typical products from the season. Then Greenyard Group can be supplied from small famers.

Furthermore, if direct purchase from suppliers is not possible, Greenyard Group may need to find the products in other markets i.e. intermediaries in the Netherlands to comply with customers' orders. Products that are imported by ship take up to 3 weeks to arrive, therefore, if a customer suddenly increases the order volume and Greenyard Group does not have enough to provide to the customer, it will take them 3 weeks to reach the specific volume. In this case, is when Greenyard Group, if they cannot comply with the order with the products from stock, will look for other sources in the nearby market.

Transport conditions are based on the product. First, a more economic means of transport (ship) will be chosen for products with long maturation process; on the contrary to products that are sold ready-to-eat and are imported faster by plane. Second, all products are transported in containers under controlled temperature. Products with different storage temperatures go in separate containers. And third, all products are transported under humidity-controlled conditions. For this, there are two options that will be usually, based on how long the trip is: ventilation or modified atmosphere. Greenyard Group makes observations and research to improve and adjust transport conditions for each type of product. It is observed that the transport conditions are chosen to contribute to the maintenance of the product quality.

In the same line, storage conditions in the warehouse are designed to maintain and extend product quality. This is done by sorting and storing products with similar storage temperatures and reaction to ethylene and/or by storing them in ULO cameras to extend their shelf life. Their main strategy is to create stock so they can supply their customers when the market is empty or when they receive an unexpected larger order. The products that arrive one day to the warehouse, are not necessarily shipped the same day. Being fruits perishable products, the use of sophisticated technology like ULO cameras gives Greenyard Group a great advantage to create stock.

As with suppliers, Greenyard Group also counts with several market alternatives to sell their products. The salesman decides which batches will be dispatched for which customer. The market destiny of each batch is based on its quality. If the batch quality has a first category, it can be exported to retailers; whereas if the batch is of second category, it will be sold in the local market. Like aforementioned, if batches have the same quality, the older ones will be sent first (FIFO), but if there are different qualities, the ones that will expire first will be dispatched (FEFO). Furthermore, when they have leftovers because the orders from the usual customers are small, and the batch quality is acceptable, they can sell them to other intermediaries.

5.3.4 Overview

Greenyard Group is part of a large supply chain network. They count with different suppliers from farmers associations to single producers and close by intermediaries. They also count with different alternatives to sell their products apart from their usual customers like local markets and other intermediaries. This helps them to make the most out of all the products.

Greenyard Group invests in monitoring product quality throughout the whole supply chain from suppliers to transport and storage to finally sell product to the customer with the best price based on the product quality. They are not customer oriented but market oriented. Greenyard Group purchases products based on forecasts and finds the trajectory of the batches throughout the supply chain until the final customer. They will sell what they have on stock to the best price they can get from their customers based on the product quality. They create stock by forecasting customer orders and by using the ultimate technology on quality control and logistics. Ultimately, they get the most out of the products by having a smooth inventory management thanks to the integration of quality control and logistics activities.

The following table shows the specific activities carried by Greenyard Group in the fields of quality control and logistics activities and the interaction of them. It can be observed that most of the quality control activities consists of maintaining the cold chain by having a temperature control in order to maintain and extend product shelf life. Moreover, logistics activities and logistics decisions are based on product quality and customers ‘requirements.

Table 6: Greenyard Group activities.
(Abbreviations: PQ: product quality; Q: quality; T: temperature)

Quality control activities	Logistics activities	Integration of QC &Log (QCL)
• Constant T control. T is the most important parameter to maintain PQ • Quality control in the warehouse under controlled T • Transportation under controlled humidity conditions • Storage cameras with different T. Sorting products based on optimum T storage similar reaction to ethylene • ULO cameras • Information system: data loggers, experiments and research quality decay	• FIFO and FEFO issuing policies • Stockpiling. ULO cameras • Means of transport: truck, ship, plane • Containers under controlled T and humidity and/or modified atmosphere • Ship & plane outsourced. Own trucks • Information system: customer orders, data loggers	• Choose suppliers based on customers’ orders • Customer based on PQ • Alternative markets when Q is low • Change of issuing policy strategy based on PQ • Transport used based on product type • When poor T control: claim, repacking, alternative market

5.4 Frutas Olivar

Frutas Olivar is a wholesaler that commercializes fruits and vegetables, as well as other pre- prepared products and edible flowers. Their commercial activity focuses on being a wholesaler for the national and international market. They are located in the central market of Mercamadrid in Madrid, Spain. There they receive products from the national market produced all over Spain, from Almeria to El Valle del Jerte (Cáceres), as well as imported products from South América (Brazil, Perú, Chile, Costa Rica). Products imported are mangoes, avocados or pineapple. Suppliers are usually farmers cooperatives, but in some occasions small farmers as well. In Mercamadrid they count with a selling point and an auxiliary DC. National customers from the local market, namely fruit stores, or from horeca (Hotel, Restaurant and Cafeteria) business come to the selling point in Mercamadrid buy the products directly. Additionally, if Frutas Olivar need to sell to retailers or other wholesalers they will not bring products to the selling point but will ship batches directly from the DC.

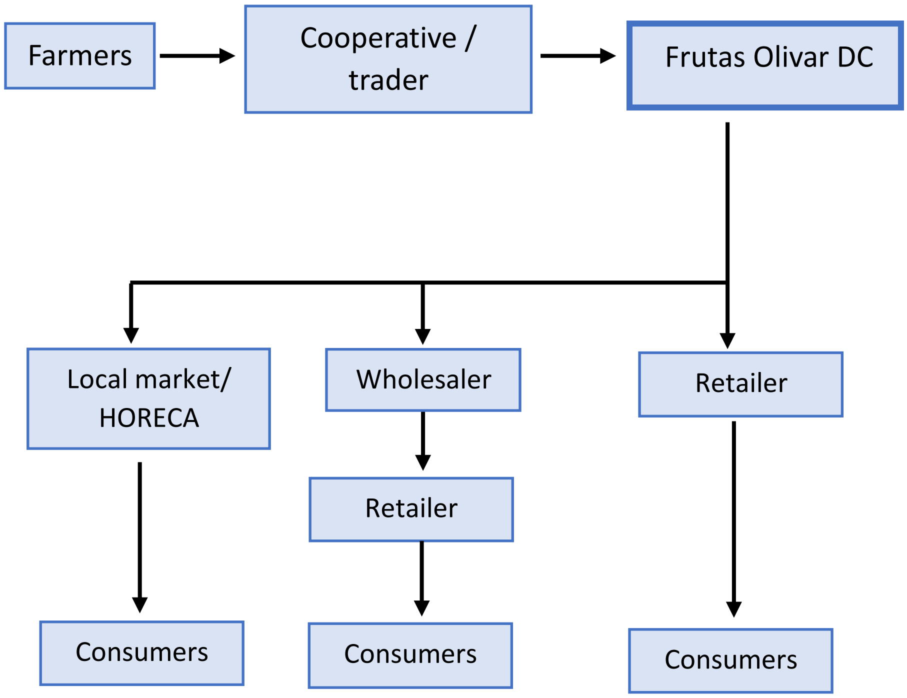

Figure 9: Frutas Olivar supply chain

5.4.1 Quality control activities

The objective of the first quality control upon freight arrival to the DC in Madrid is to know the quality of the fruits and vegetables, in case they have to make any claim. Frutas Olivar evaluates the product quality based on its freshness, texture, colour or taste. Some customers require them to make specific measurements to some fruits and vegetables. They can measure the texture of fruits with a penetrometer, or the concentration of sugars measuring the brix degree. Other physical attributes like scars or smoothness of the product are also taken into account. Furthermore, they check the temperature history record during transportation.

When batches pass the quality controls, they are stored under controlled temperature, each type of product has an optimum storage temperature. Frutas Olivar counts with four main cooling cameras: one for tropical products like mango, pineapple and avocado at 8-10ºC;

another camera for vegetables at 1-2ºC; another camera for stone fruits like apple, apricot, peach, etc. at 4-6ºC; and finally a multipurpose camera of high or low temperature used to ripe products. Apart from using temperature control, they also count with technology that is able to capture ethylene from the atmosphere to avoid maturation. The control of temperature is of great importance for Frutas Olivar, but also for the rest of the supply chain. Maintenance of the cold chain is key to extend product shelf life and preserve the product quality. In the DC, based on the HACCP protocol, temperature in the cameras is checked daily.

When products are imported from South America and the transportation takes 20 or 30 days by ship, besides temperature control, batches also travel under modified atmosphere. In this case, batches are stored in hermetic plastic bags where the concentration of CO_2 is increased, and the oxygen is decreased to avoid maturation. Finally, the transportation of batches from Frutas Olivar to the final destiny is done under controlled temperature.

Temperature control and maintaining the cold chain is of great importance for Frutas Olivar as well as to the rest of the supply chain members. Hence, Frutas Olivar includes thermographs in the pallets that register real time information of the geographical situation, time and temperature of the product. All this detailed information is of importance when their customers make claims It can be known when and where there was an incident in temperature deviation and therefore, who is responsible for it.

If Frutas Olivar receives batches that don't comply with quality requirements, they will reject the freight in which case the supplier is responsible to pick up the freight; or they can negotiate on the price. Frutas Olivar has the advantage of being located on a central market (Mercamadrid) where they can sell all the products, regardless the quality; however, the quality level will determine the price. On the other hand, Frutas Olivar can also receive claims from their customers. For instance, if the customer considers that a percentage of the freight does not comply with the specifications, they will keep the freight but will give a warning to Frutas Olivar. Customers can also reject the whole freight and not pay for it or even charge Frutas Olivar since customers were counting with these products and they will lose money. In both cases, customers will write a report explaining the claim.

The main objective of quality control activities is to extend product shelf life and sell it before it gets spoiled. According to Frutas Olivar, product quality can be improved with good agricultural practices i.e. optimum harvesting time as they will have an impact on product quality ahead in the supply chain.

In general, Frutas Olivar deals with batches with different qualities because the suppliers and specially the customers are very diverse so they should have products that will comply with different customer´s requirements. Their customers vary from local fruit stores, to retailers and gourmet fruit and vegetables stores.

5.4.2 Logisticcs activities

Frutas Olivar receives the freight in batches in big containers in their DC. Frutas Olivar registers those batches in the system and doesn't break them to make new ones, but stores and ships them as they are. Therefore, Frutas Olivar does consolidation of products in the DC. Storage of batches is done under controlled temperature and/or controlled ethylene concentration. Since Frutas Olivar has the DC in a central market (Mercamadrid), they can sell the products directly from their facilities or ship them to other wholesaler or retailers.

The order followed to ship batches (and put batches to direct sale) is FIFO. The main reason for this is that products are perishable, so they try to sell the oldest products first. Only in exceptional situations and when the product quality requires it, this situation will change.

Products can come from the national production or from abroad. When products come from Spain, they come by truck; whereas if they come overseas, they will come by ship, which is the most economic means of transport as volumes are bigger. National products can take around 2 days to arrive to the DC since they are harvested i.e. they are harvested in the morning, trucks are loaded in the evening and arrive to Mercamadrid early in the morning; whereas products imported from South America travel around 20-30 days by ship. Since product quality is the most important factor for Frutas Olivar, they try to minimize the period between harvesting and sale. This period of time depends highly on the origin of the product and the market destiny.

Frutas Olivar does the shipping in leased trucks or via plane. When the destiny is Europe (Finland, Germany, or United Kingdom) products travel around 4 days by truck; whereas if the final destiny is outside from the European market, like Malaysia, United Arab Emirates or Hong Kong, products travel by plane. The use of plane to export is very interesting for Frutas Olivar as they can bring products to the other part of the world in 18-24 hours and at a higher price. Although means of transport are leased, Frutas Olivar makes sure to have travel conditions under control with thermographs. Nevertheless, if upon arrival to the final customer, batches don't comply with quality requirements, it will be evaluated who is responsible for this incident, as the shipping company may be responsible.

The main challenge for the logistics activities is to maintain the cold chain in all stages, maintain product freshness, not damage it and that products reach customers complying quality specifications. Furthermore, having an optimum distribution and storage management i.e. sorting products based on their characteristics would improve the product quality.

5.4.3 QCL: integration of QC and logistics activities

Frutas Olivar receives and makes daily orders. In case the customer is a retailer, they will receive almost daily orders with a stable price per week. Whereas if freight is sold to direct purchase in Mercamadrid, the price varies every day. For instance, Mercamadrid closes on Sunday and Monday, therefore on Saturday prices are lower as wholesalers need to sell as much as possible, otherwise the product quality will decay throughout the weekend. Nevertheless, the price is determined by the market situation in first place. This is, the offer and demand. For instance, during early and late season there is low offer and high demand, so price will increase, even though product quality is not the best. However, some retailers want to be the firsts to sell a specific product, so suppliers demand a higher price. Likewise, during mid-season, when the offer is very high, suppliers are eager to sell as much as possible at any price. In the last stage, price is based on the quality. Frutas Olivar receives a contract from their customers in which delivery conditions are stablished and a fact sheet specifying quality requirements.

The final customer to which Frutas Olivar will dispatch the products is based on the product quality. Shelf life can be determined by the product quality and will influence the final market and price. For instance, early and late season fruits have lower quality (they have less nutrients and less brix degree), therefore they are more vulnerable products with shorter shelf life. This is a limiting factor when shipping products to international markets. Moreover, mechanical processing i.e. mechanical calibration cannot be done to these products because they can suffer greater physical damages.

Frutas Olivar gives extreme importance to product quality pursuing a continuous quality control over the batches, controlling the quality evolution of the product and managing batches to sell them before they are spoiled. In fact, the main quality control challenge is to extend product shelf life and sell it in its optimal moment before its value is reduced. This is specially challenging for Frutas Olivar since they deal with different product qualities. The design of the logistics activities i.e. distribution management and inventory management helps to optimize product use. For instance, they count with more economic fruits and vegetables of lower quality that will be mainly sold in the local market, and other higher quality products that will be sold in more demanding markets.

The relationship with other actors in the supply chain is very close as Frutas Olivar depends on shipping companies to move the products from suppliers to customers and has constant information flow between supply chain actors.

5.4.4 Overview

Frutas Olivar´s supply chain is very diverse from the supplying points to the selling points and type of customers. Fruits and vegetables can come from the national market as well as from abroad. Furthermore, products can be sold in their facilities or shipped to international markets.

Since their customers are very diverse, Frutas Olivar needs to deal with different quality levels to comply with everyone´s requirements. In any case, quality control is central for them. They require their suppliers specific transport conditions to maintain product quality i.e. controlled temperature and modified atmosphere, they store batches under controlled temperature and low ethylene concentration, and they control shipping conditions with thermographs. They give extreme importance to strict quality controls as they deal with high value and high-volume freight that implies a high initial payment. Therefore, they cannot afford having spoiled freight due to poor quality control and management; this would be translated into great economic loses for them. They work quality oriented, as they have access to different markets i.e. retailers or wholesaler abroad and local market through the central market.

The following table has a summary of the quality control activities and logistics activities in Frutas Olivar. It can be observed that they pay attention to quality control activities.

Table 7: Frutas Olivar activities.
(Abbreviations: PQ: product quality; Q: quality; T: temperature)

Quality control activities	Logistics activities	Integration of QC &Log (QCL)
• Constant T control. T is the most important parameter to maintain PQ • Measure of texture and ºBx • Transportation to DC under controlled T & atmosphere conditions • Storage cameras with different T. Sorting products based on optimum storage T • Storage under controlled gas concentration: ethylene absorber • Information system: data loggers, research quality decay	• FIFO issuing policies • Means of transport: truck, ship, plane • Containers under controlled T and modified atmosphere • Trucks, ship & plane outsourced. • Information system: customer orders, data loggers (real time information)	• Orders based on customers‘ requirements • Alternative markets based on PQ • Change of issuing policy based on PQ • Transport used based on origin or market destiny • When poor T control: claim, alternative market • PQ influences logistics design, i.e., market destiny and handling practices

6. Chapter 6. Analysis

In this chapter the analysis and discussion of the results are outlined. The four supply chains will be compared between each other based on the six elements described in the literature review; and main aspects of the study will be highlighted in order to give answer to the research questions. Finally, cases will be labelled.

First of all, the elements needed to deploy QCL are found in the literature (Van der Vorst et al., 2011). QCL starts by knowing what are the consumer´s preferences and the acceptance period of each product; the following elements (elements 2 to 4) are developed to measure product quality, having in mind that quality has a dynamic behaviour in fresh products and that its prediction and exchange of data will enhance supply chain performance. These elements are defining the critical quality points, measuring and predicting product quality and logging data and exchanging information. When this information is available, firms can adapt logistics and quality control activities to the needs of the supply chain. This element is called local dynamic/adaptative logistics and quality control. Finally, follows a demand driven strategy through collaboration between supply chain actors as a last element to aim at a quality-controlled logistics supply chain.

All four companies make use of the six elements needed to deploy QCL but depending on the company strategy and the entanglement of their supply chain, they will apply them differently. This is, they take part of all elements (breadth) but they make use of different aspects or focus in different aspects within them (depth). In tables 8 and 9, these aspects can be encountered.

Table 8: Overview of elements in Grupo La Caña and Agroherni

	Grupo La Caña	Agroherni
Consumer preferences and period of acceptance of product quality attributes	Annual book from customers including product quality attributes, and volume arrangements Acceptance period influences logistics activities	Annual book from customers including product quality attributes, and volume arrangements Acceptance period influences logistics activities
CQP	Reception of products in DC, storing, before shipping batches	Seed germination, harvesting time, reception of products in DC; storage, before shipping batches, during shipping
Product quality measurements and prediction	Basic quality control (damages, shape, size, colour) to classify products. Extra quality controls when required (brix degree) Precooling in conventional fridges or pre-cooling tunnel Temperature control of packed batches Storage of products based on optimum storage T Temperature control of batches before shipment Evolution track of product quality to predict shelf life	Strict control over cultivation and harvesting methods Basic quality control (damages, shape, size, colour) to classify products Precooling using vacuum cooling Temperature c ontrol of packed batches Storage of products at optimum storage T Temperature control of batches before shipment Evolution track of products over 14 days to predict shelf life
Logging and exchange of information	Temperature monitoring during storage Receives claims when batches don't comply customer's expectations	Temperature monitoring during storage Use of data loggers during transportation of batches Research on packaging materials Feedback from customers Receives claims when batches don't comply customer's expectations
Dynamic quality control and logistics	FIFO and exceptionally HQFO Destiny of batches based on product quality Additional quality controls when required (brix degree)	Harvesting based on customer's requirements Issuing policy based on product quality Destiny of batches based on product quality
SCM	Managing based on volume arrangements	Managing based on product quality and volume arrangements

Table 9: Overview of elements in Greenyard Group and Frutas Olivar

	Greenyard Group	**Frutas Olivar**
Consumer preferences and period of acceptance of product quality attributes	Reception of daily orders from customers with volume arrangements. Quality attributes remain constant. Acceptance period influences logistics activities	Reception of daily order with quality specifications and volume arrangements, from some customers (retailers) and other customers come daily to make direct purchase in the Mercamadrid Acceptance period influences logistics activities.
CQP	Reception of batches in DC, during storage, before shipping, during shipping	Reception of batches in DC, during storage, before shipping, during shipping
Product quality measurements and prediction	Very important not to break cold chain: constant temperature control Transport under controlled T and humid/atmosphere Basic quality control (damages, shape, size, colour) to classify products under controlled T Storage of products based on optimum storage T Storage of products in ULO cameras	Very important not to break cold chain: constant temperature control Transport under controlled T and humid/atmosphere Basic quality control (damages, shape, size, colour) to classify products Extra quality control when required: texture, brix degree Storage of products based on optimum storage T Ethylene absorbers in cooling cameras
Logging and exchange of information	Temperature monitoring during storage Record of transport condition with data loggers Adjusting transport conditions: record of transport conditions, and quality control Claims to suppliers when quality is not the one expected Receives claims when batches don't comply customer's expectations	Temperature monitoring during storage Record of transport conditions with data loggers in real time. Claims to suppliers when quality is not the one expected Receives claims when batches don't comply customer's expectations
Dynamic quality control and logistics	Suppliers based on demand FIFO and FEFO issuing policy Import m eans of transport based on product: plane or ship Market destiny based on product quality	Processing based on product quality Means of transport based on origin and destiny: truck, ship, plane Market destiny based on product quality
SCM	Managing based on volume, product quality and market demand	Managing and planning based on product quality

6.1 Consumer preferences and acceptance period

All four supply chains orient their activities to satisfy customer´s requirements. As they are located upstream or midstream, they don´t receive consumer´s preferences directly, but through their direct customers. Results show that producing companies, i.e., Grupo La Caña and Agroherni, make annual contracts with their customers in which they agree on the product quality and the volume arrangements. Therefore, they know how much and when they need to supply their customers. On the other hand, wholesalers, i.e., Greenyard Group and Frutas Olivar receive daily orders from their customers. Although quality requirements are specified in advanced and are usually constant, volumes may change more often. Product quality attributes usually include shelf life and physical attributes, e.g., colour, firmness, brix degree, etc.

Furthermore, they are aware of the acceptance period of the products and take that into account when planning logistics. For instance, Grupo La Caña knows that tomatoes have a shelf life of 15 days, out of which around 5 days products will be travelling to destiny and should arrive to the final customer with a remaining shelf life of 5 days. During harvesting time the optimum moment of consumption of the product and the distance to market is take into account and if tomatoes are more than 5 days within Grupo La Caña facilities, they cannot export them anymore and will give another use to them, e.g., sell them to processing companies to make tomato sauce. Likewise, Agroherni decides when is the best moment to harvest depending on the destiny of the product. Frutas Olivar, who deals with different products and qualities, knows that late season products have lower quality and are more vulnerable to damages; this is a restraining factor when shipping products far. Likewise, if Greenyard Group has lower category products with shorter shelf life, they will sell them in the local market.

Either if its annually or daily, companies are aware of customers´ preferences and try to align efforts to deliver a product within the acceptance period. Whereas in Agroherni this aspect is taken into account before harvesting, the rest of the companies deal with it once they have the product in their hands.

6.2 Critical quality points for quality and logistics

CQP are usually located upon product arrival, during storage and before shipping, i.e., supply, production and distribution control. But the differences between companies that have the same position in the supply chain will be compared.

Looking into producers, Agroherni has its first CQP in seed´s germination and harvesting time. They make sure to use the seeds that will comply with customers' requirements and to germinated them under controlled conditions. Consequently, the second CQP is during harvesting. Since harvesting time, products are assigned to a customer based on its quality, therefore, only products that comply with customer´s requirements will be harvested. The CQPs in the DC are upon reception of raw materials, during storage of products to check the well-functioning of the cooling cameras and before shipping. Grupo La Caña does not carry the same controls. Even though they choose which seeds will be grown, farmers are free to use their own cultivation and harvesting methods. Then, upon products arrival to the DC they encounter the first CQP, followed by storing and before shipping.

Wholesalers, i.e., Greenyard Group and Frutas Olivar, have their first CQP upon freight arrival. This first control is important as they need to check if freight complies with their requirements, otherwise they can reject it. Since they store products for long time, another CQP consists of the well-functioning of the cooling cameras, and the ULO cameras in case of Greenyard Group, or the ethylene absorber in the case of Frutas Olivar. The last CQP is before shipping products to check batches comply with customer´s requirements.

In the four cases, CQPs are located to control incoming and outgoing materials, i.e., supply and distribution control to products, and process control to the preserving processes. Only Agroherni starts the control earlier in the supply chain. The location of the CQP aims at contrasting product quality with customer´s specifications. The next element will reveal what these CQPs consist of for each company.

6.3 Product quality measurement and prediction

The main focus in quality control for producing companies is to follow good agricultural practices and produce a high-quality product; whereas the aim of the wholesalers is to maintain that product quality and extend its shelf life.

The first CQP of Agroherni is in the fields, when transplanting the germinated seeds. This is an acceptance sampling type of control that consists of accepting or rejecting a product based on its quality. The second CQP is during harvesting time, again accepting sampling but this time acceptance means proceeding with the harvesting. In the DC, for both producing companies, products go under another visual quality control consisting in acceptance sampling and quality measurement: products are controlled one by one discarding the products that don’t have the require quality. In Grupo La Caña, additional quality measurements are done, namely measurement of brix degree when the customer requires it. Once products are packed and assigned to customers are put under controlled temperature, as it is the main preserving technique used. Whereas Grupo La Caña cools down products in conventional fridges and sorted by optimal storage temperature, Agroherni does it with vacuum cooling without making any distinction between products. This is because all the products in Agroherni have a similar optimal storage temperature. The advantage of using vacuum cooling is that products reach the optimum storage temperature much faster than in a conventional fridge. In both cases, temperature in the cooling camera is measured and monitored to make sure that products reach the optimum storage temperature. If temperature surpasses given ranges, corrective actions are taken. Eventually, before being shipped, the documentation and label of batches and the temperature of the products are checked in both companies. It is important that batches have the required temperature because trucks only maintain the temperature. Both producing companies use trucks to transport the freight to the customer. In case the truck is leased to the company, Agroherni will include a thermograph together with the freight to have a temperature history record. Grupo La Caña uses their own data loggers sometimes but customers always use their own data loggers. Having a temperature history record is key to predict product quality.

To predict shelf life, Grupo La Caña keeps track of the quality of some products for certain days until the quality decays below the quality standards. Likewise, Agroherni takes a sample of each batch and keeps it in similar conditions to transport for 14 days and checks the quality evolution daily. Furthermore, they also make research on packaging to improve product shelf life.

On the other hand, wholesalers carry their first acceptance sampling in the DC and rejection is usually done to whole batches. Quality control consists of measuring the temperature and checking the temperature history record and a product quality control of physical attributes. Although temperature history is correct, also product quality can be lower due to other factors. When batches don´t comply with quality standards, companies will make a claim. This is further explained in the next section. If batches are accepted, Frutas Olivar take additional quality measurements, e.g., they measure the texture of the products or the brix degree when customers require it. Then batches are kept in cameras and under controlled atmosphere, i.e., in ULO cameras in Greenyard Group or with ethylene absorbers in Frutas Olivar. Conditions are monitored until they are shipped. Before shipping temperature is measured; as well as during transportation. Both Greenyard Group and Frutas Olivar include thermographs during transportation, but Frutas Olivar´s thermographs record real time information including geographical localization.

Whereas in producing companies first acceptance sampling is done product by product, wholesalers to it to whole batches. However, Greenyard Group can also do acceptance sampling by product when they receive a batch where not all products comply with specifications, but the overall batch quality is high.

All quality control activities have the purpose that products comply with customer´s requirements, whether they are acceptance control or monitoring. All companies preserve the products under optimal storage temperature and make sure that the cold chain is not broken once products are cooled down. In the case of the producing companies, Agroherni put more effort on reducing the time elapse between harvest and refrigeration. Companies control the temperature during storage and transportation including thermographs and data loggers. Despite being temperature control so important for the maintenance and extension of product shelf life. Grupo La Caña does not consider it a priority but a mere commercial factor. In fact, they don't always include thermographs in the transporting, as they don't consider they are responsible of it. Additionally, since wholesalers' chains are longer, they also include control of the atmosphere to extend even more the product shelf life. Furthermore, Agroherni and Grupo La Caña follow the evolution of samples to predict product shelf life. Wholesalers predict shelf life thanks to the temperature history record and doing quality control. For Greenyard Group quality prediction is key as they store great volumes of fresh products and based their issuing policies in expiration dates.

6.4 Data logging and exchange of information

Any type of information can be exchange between partners, either information from monitoring product quality and conditions, to claims and supply or demand conditions.

Grupo La Caña usually receives demand information once a year in an annual book. During storage temperature is monitored to avoid temperature deviations. However, they don´t have temperature records during transport to customers in all trucks but are the customers who include themselves the data loggers. Likewise, Agroherni monitors temperature of the cooling cameras but additionally includes thermographs in all transports. They also ask for feedback to customers to improve product quality and carry quality decay experiments. If batch quality doesn't meet the quality standards, customers will make a claim and they can reject the batches or renegotiate the price or not pay.

Greenyard Group receives daily orders from customers and makes daily orders to suppliers. With the orders of one week they can predict the demand for the next one; this is particularly important when products take up to 3 weeks to arrive since the order to suppliers is made. They also read the temperature history records when receiving the freight. Furthermore, they work together with suppliers to adapt transportation conditions and reduce food loses. This is thanks to continuous exchange of information of product quality and monitoring conditions during transport.

Frutas Olivar also receives and makes orders every day. They are in continuous contact with customers, specially with the ones that come to make direct purchases to the central market. They also include thermographs that record real time information including temperature, geographical location and time. Having so much detailed information is useful when making claims, as it is possible to know who was responsible for temperature deviations.

When Greenyard Group or Frutas Olivar receive freight that does not comply with their quality requirements, they will make a claim to their suppliers. Hereafter is how each company reacts when a batch arrives with a lower quality than expected. Greenyard Group can reject the batch, in which case the supplier is responsible to pick up the freight back; or they can repack the batches saving the products that have the expected quality and charging the production costs to the suppliers. It is also possible that the quality of the whole batch is of lower category and Greenyard Group sells it to the local market; in this case the salesman should renegotiate the price with the supplier. Frutas Olivar can also reject completely the freight, being the supplier responsible for picking it up. However, if the supplier does not want to pick up the batches, they can ask Frutas Olivar to sell them in the central market, as many customers go every day and the price is based on the product quality. Frutas Olivar does not make new batches out of the old ones to adjust the quality. Likewise, they can also receive claims from their customers if the temperature data loggers show deviations in the temperature record or if the batch quality is below the standards.

While logging information is part of several quality control practices, exchange of information is optional. Since Greenyard Group and Frutas Olivar receive and make orders daily, they have an intense flow of information used to deal also with the intense flow of products. They are very active in generating and exchanging data. Greenyard Group doesn't doubt to carry research together with suppliers and Frutas Olivar uses thermographs that logs temperature in real time. Likewise, Agroherni records as much information as possible using thermographs or carrying shelf life experiments and asks for feedback to customers. Grupo La Caña on the other hand logs information for own use but not for exchange.

6.5 Local dynamic logistics and quality control

Being dynamic has main objective comply with customer´s requirements. For that, product quality and customer´s desires are taken into account.

Starting from the beginning of the chain, whereas Grupo La Caña does not have a control over harvesting time, Agroherni harvests once products comply with customers' requirements. In the DC, Grupo La Caña will carry additional quality controls, i.e., brix degree measurement, if customers require it, and will change the issuing policy form FIFO to HQFO also if a customer asks for it. In both producing companies, batches are made according to customers´ specifications but if for instance products accumulate in the DC and product quality decays, batches can be sent to alternative markets, e.g., local markets or manufacturers. Furthermore, Agroherni always has production extra to sell in the central market at market price.

Greenyard Group has different sourcing origins and different suppliers that will change depending on the market demand. Furthermore, reception of products is by ship or plane depending on the product type. Then products are stored based on their optimal store temperature and under low oxygen based on the needs of the market. The order of dispatching products with the same quality will be FIFO; whereas if qualities are different then the expiration date of the product (FEFO), will determine the order. The destiny of the product is based on the quality. If the quality is high, batches will be sent to retailers or other wholesaler if they are leftovers, whereas if the quality is of second category, if will be sold in the local market.

Frutas Olivar receives all the raw products by truck in Mercamadrid from where they will dispatch and sell everything following FIFO. They have different market segments to which they will use different means of transport. If customers are in the national territory or in Europe, they will use the truck; whereas if the customers are outside of the EU, Frutas Olivar will use the plane. They also sell batches in the central market of Mercamadrid in which customers come to purchase and Frutas Olivar is not responsible for the transport. The central market can be a shortcut for products with lower qualities as customers with different requirements visit it. Furthermore, the destiny of the products is based on the quality as early and late season products are of lower quality and more vulnerable making it more difficult to send them to far markets and reaching it with the specific quality requirements. Moreover, the processing is limited to high quality products in the mid-season, for the same reason.

It is observed that wholesalers' supply chains are more entangled than producing companies' supply chains because wholesalers have more diverse supplying origins and/or customers from diverse segments. Their logistics' structure is complex since they make use of different means of transport, i.e., ship, plan, truck and require more infrastructure to carry their business. Therefore, their adaptative skills are also higher. For instance, Greenyard Group's supply chain design is not constant since they don't always use the same suppliers but will choose them based on the demand. And Frutas Olivar´s supply chain changes throughout the season based on the product quality.

It can be assumed that Grupo La Caña and Agroherni have a single supplier, which consists of the production from their fields, and have fixed annual customers. Then they will allocate the production to these customers and only if products don´t achieve the required quality, they make use of alternative market segments like local markets or central markets are used. They carry adaptative logistics and quality control activities, e.g., Grupo La Caña changes the issuing policy or makes extra quality controls when needed, but their logistics structure is not so complex.

6.6 Supply chain management

Every company manages these activities in a different manner to fulfil their strategies. These strategies are explained in the next subsection and serve as a pattern description.

Grupo La Caña receives harvested products from farmers and does consolidation and cross-docking to make new batches that will be sent to customers. Agroherni harvests products based on customer´s requirements and makes batches that will not be mixed in the DC. Greenyard Group receives several batches daily and creates stock with them. Then, they will make new batches that will be shipped to customers. Finally, Frutas Olivar also receives several batches from suppliers but unlike Greenyard Group, does not break them down to make new batches. They sell or ship the batches that they receive as they are, as fast as possible without creating stock.

6.7 Characterization of companies 'configuration of QCL

Hereafter, the four companies will be typified based on how they deal with quality-controlled logistics. Their position in the supply chain is taken into account to understand how the wield control over their closest supply chain actors and to what extend they pursue a control of quality and logistics (QCL). Grupo la Caña and Agroherni are producers so they are located upstream; whereas Greenyard Group and Frutas Olivar are wholesalers and are located in the middle of the supply chain. Whereas the producers are able to influence the initial product quality, Greenyard Group and Frutas Olivar can only orient their decision making towards maintaining or extending product shelf life.

Both producers Grupo La Caña and Agroherni make an annual production plan based on the customers' contracts. Taking this perspective into account, both companies´ production is customer oriented, however as companies are further analysed, some differences arise.

Grupo La Caña chooses the seed´s variety that will comply with annual forecast volume forecast as they want to assure supply to customers. With this premise, farmers receive advice from the technician department from Grupo La Caña, but they are free to decide the cultivation methodology, conditions and harvesting time. In this sense, farmers don't follow strict cultivations and harvesting conditions and Grupo La Caña does not have a control over product quality at this stage. Nevertheless, they consider that handling and cultivation practices are key for the initial product quality and they trust farmers will do so. Additionally, farmers bring their production to the DC on their own vehicles and at room temperature. This also shows lack of control from Grupo La Caña.

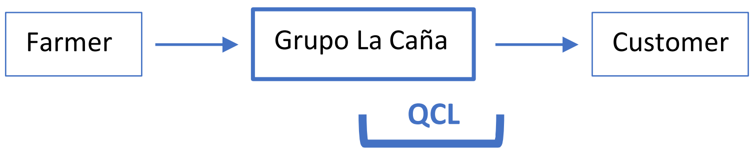

Figure 10: Grupo La Caña simplified supply chain

Subsequently, Grupo La Caña will receive batches presenting a great difference in quality that later will try to allocate to customers. Although Grupo La Caña has a control over product quality thanks to storing them under optimal controlled temperature. They make batches based on their quality, for instance, based on the colour or maturation point. Then they will assign them according to the destiny, thus how far the customer is, and according to customer quality requirements. Other activities, namely brix degree measurement and inclusion of data loggers during transportation is not done proactively, only if customers ask for it. For all these reasons, they use quality control as a commercial tool, assuming that the more quality control they apply, they better price they will obtain. It can be said they are reactively customer oriented. Instead, Grupo La Caña performs more control working **volume oriented**. For instance, they have a lot of control over batch allocation, i.e. when products accumulate, they are able to change from FIFO to HQFO issuing policy to dispatch fresher products first or when production is programmed, they make sure to have enough supply for the year, volume arrangements are crucial. Therefore, it can be said that Grupo La Caña has a **last stage integration** of quality control and logistics (Figure 10).

Unlike Grupo La Caña, Agroherni, even though they are also a cooperative, they have a stricter control over cultivation practices and harvesting time. This control is performed during seeds germination under controlled conditions and during harvesting time when products are selected and assigned to customers based on their quality directly in the fields. Hence, In Agroherni, control starts a stage earlier (Figure 11).

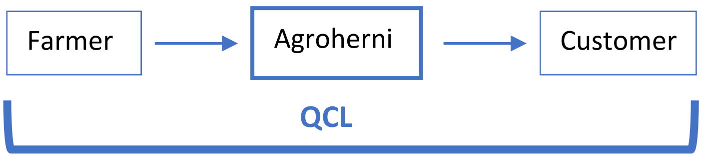

Figure 11: Agroherni simplified supply chain

Agroherni is in control of the processes in a single DC. The DC is close to most of the fields to assure that time between harvesting and precooling is the shortest possible. Furthermore, they monitor storage conditions, have a control over batches dispatches and transport conditions including data loggers; they also include double chauffer when transportation duration is long, carry research with different packaging materials to improve product shelf life, take samples of every batch and analyse their quality evolution during 14 days or ask feedback to customers about the batch quality. All these activities that aim at complying customer product quality requirements, are pursued throughout the whole supply chain. Therefore, Agroherni has a **full supply chain integration**. They use QCL to work supply chain and customer oriented. They proactively put all efforts to have a control of the product quality from the fields until it arrives to the customer and to comply with their requirements, thus they work **supply chain oriented to the customer.**

Greenyard Group, on the other hand, is a wholesaler that does not have control over production conditions. However, they claim a quality control from their suppliers when they demand controlled transportation conditions (temperature and humidity) and appropriate product quality upon arrival to the warehouse. They wield pressure over suppliers (and/or shipping companies) to provide a high-quality product. Nevertheless, they also carry experiments together with the suppliers to understand which the best transporting conditions for each product are. This shows that Greenyard Group stars having a control over the supply chain since products are shipped.

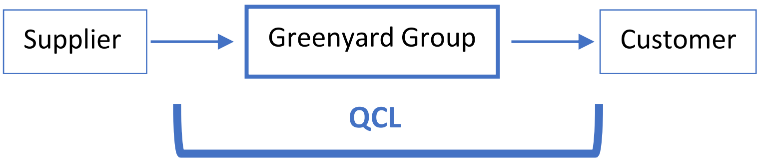

Figure 12: Greenyard Group simplified supply chain

Greenyard Group has control over product shelf life, that they extend thanks to sophisticated technology. Some of these resources are optimal transport conditions under controlled temperature and humidity and optimal storage conditions in ULO cameras. Due to being able to extend shelf life and preserve product quality, they are able to create stock. This gives Greenyard Group an advantage to commercialize with fresh products and find customers who will give a better price based on the product's quality. Therefore, they do quality driven commerce. Furthermore, other aspects show that Greenyard Group also focuses on volume and complying with volume arrangements like creating of stock, making weekly order predictions or looking for alternative suppliers to comply with volumes requirements. On the contrary, when having excess of product, they look for alternative markets to sell it, i.e. other wholesalers. Performing a high control over product quality by monitoring all transport and storage conditions facilitates logistics decision making towards volume strategy. This is, quality control is supportive of volume strategy. Altogether, quality and volume focus, they work **market oriented**. This is, they make use of QCL to fulfil the needs of the market with the stock they have created and making the most out of it. The integration of quality and logistics starts when products are shipped to Greenyard Group and ends once freight is delivered to customers; they do **under scope integration** (Figure 12)

Likewise, Frutas Olivar as a wholesaler does not have control over product production or harvest conditions. However, they require certain product quality to their suppliers. In fact, they make sure that transport conditions are under optimum conditions i.e. transport conditions under controlled temperature and atmosphere to assure long product shelf life, otherwise they can reject freight. According to the description of Frutas Olivar, their activity is **product quality oriented.** They pursue strict quality control over products under their scope. Some examples are: optimum storage temperature and low ethylene concentration storage, use of sophisticated thermographs that include real time information, and track of product quality evolution. The advantage of Frutas Olivar is their location in a central market, where they are able to sell all their stock thanks to the variety of customers. Therefore, they can differentiate by having different qualities that will comply different customers profiles. Being part of a central market means to work from their comfort zone, since they don't need to look for external markets as customers will come to them to make direct purchases. They pursue a **central supply chain integration** (Figure 13).

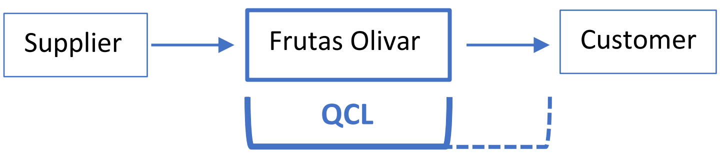

Figure 13: Frutas Olivar simplified supply chain

6.8 Overview

Customer´s requirements are companies' main driver to design their supply chains. Regardless of how often customers send their requirements, e.g., annually to producing companies or daily to wholesalers, the four companies orient all their activities to satisfy them. Likewise, knowing the acceptance period of each product is key to determine the moment of harvest or the market destiny. Whereas the acceptance period and the product quality determine the market destiny for Grupo La Caña, Greenyard Group and Frutas Olivar, it determines the harvest moment for Agroherni. Furthermore, customers' requirements are set as quality tolerances guidelines that companies follow to accept or reject products. Regarding the CQP, they are always located in the incoming and outgoing products, usually doing acceptance sampling and in the processes to check the well-functioning of the preserving processes. Except for Agroherni, that they also include CQP in the previous steps of germination and harvesting.

Whereas producing companies focus on producing high quality products from the fields, wholesalers' purpose is to maintain and extend product shelf life. Grupo La Caña trusts their farmers to carry good agriculture and harvesting practices and Agroherni has a stricter control to ensure it. Furthermore, both make use of temperature to preserve product quality characteristics longer. Subsequently, Greenyard Group and Frutas Olivar also makes sure to maintain the cold chain throughout the supply chain and makes use of modified atmosphere technology to enhance shelf life extension.

Logging information is used for many purposes. Grupo La Caña and Agroherni make daily quality controls to samples to predict shelf life; Greenyard Group records daily orders to predict future demand; and Frutas Olivar keeps track of real time transport conditions to aid the procedure of potential claims. In fact, all companies make use of thermographs and data loggers as a proof of good handling practices and avoid or make claims. Besides thermographs and claims, Greenyard Group carries information exchange with their suppliers to improve transport conditions. Logging and exchange of information facilitates the adaptability of supply chains. For instance, all companies choose a market destiny for a specific batch based on the product quality of it and customer´s requirements; Grupo La Caña and Frutas Olivar carry additional quality controls (Brix degree or texture measurement) if customers require it; Grupo La Caña and Greenyard Group change their issuing policies based on the product quality and customer´s demands; and Greenyard Group chooses their suppliers based on the market demand and uses one transport or another based on the product.

The main similarity between all the companies is that all of them are oriented towards delivering a product that will comply customers´ requirements. In fact, they make sure to deliver a product that will be "useful" for the customer, this is, that has the required quality and shelf life to proceed until the final customer or consumer and reach them with an acceptable final quality. However, all of them follow a different strategy.

Grupo La Caña, who follows a volume-oriented strategy, is able to deal with a great variety of products and allocate them to match customers' requirements with minimal information exchange. Agroherni makes use of QCL elements to work supply chain oriented, having an integrated control, to tackle both volume and quality requirements. This control is imposed very early in the supply chain, i.e., harvesting. Together with information exchange on customer´s requirements, feedback and shelf life improvement experiments, the design of the supply chain is settled early. Greenyard Group puts more emphasis on information exchange with customers to predict demand and with suppliers to improve transport conditions to be able to extend shelf life and serve their strategy to create stock and to make the most out every product; the ultimately work market oriented. Finally, Frutas Olivar, unlike Greenyard Group does not create stock but sells everything as soon as possible. Aiming at a quality-oriented strategy, they make use of QCL to have a diversity of product qualities available to match different customer´s needs; in fact, their supply chain is determined by product quality and customer´s demand.

Comparing the two producers with the two wholesalers, no main similarities or differences can be found; their strategies are not dependant of their position in the supply chain. Whereas Grupo La Caña is focused on having enough supply for their customers, Agroherni takes also quality into account and aims at satisfying customer´s requirements since the very first steps of seeds cultivation and assigning products to customers before being harvested. Similar to Grupo La Caña, the wholesaler Greenyard Group also orients all its efforts to have enough supply by creating stock. However, Greenyard Group’s strategy is wider and also aims at satisfying customer´s requirements by implementing a sophisticated quality control system. Unlike Agroherni, Greenyard Group does not focus on specific customers, but in the whole market. Based on the characteristics of their stock, they will be able to supply one customer or another. Finally, Frutas Olivar focuses all the attention on quality control, just like Agroherni or Greenyard Group do, as well as dealing and managing all products with different qualities as from its privilege position in the central market they are able to reach many types of customers. However, unlike Greenyard Group, they don´t create stock but dispatch batches as fast as possible.

7. Chapter 7. Conclusion

In this chapter, the final conclusion of the research is outlined. Hereafter, the main aspects of the study will be highlighted to answer the research questions.

The aim of the research is to analyse how real-life supply chains engage in QCL to deliver the customer´s desire quality. The analysis was done to evaluate how selected cases carry specific activities that are needed to engage into QCL. These activities or elements described by Van der Vorst et al. (2011) give answer to the first research question and are the core to build up the theory (chapter 2) and subsequently, the research framework (chapter 3) and the analysis (chapter 6). These elements are described in chapter 2 together with the description of the concept of QCL and completed with knowledge on quality control and logistics. These are the following elements: Consumer preferences and acceptance period of product quality attributes, Critical Quality Points (CQP), Product quality measurements and prediction, Logging and exchange of information, Local dynamic/adaptative logistics and quality control and Supply chain management (SCM). The construction of the research framework was based on the relationship of the simple elements of QCL (Figure 4), which are product quality, quality control and logistics, and the subsequent integration of QCL in the supply chain together with the six elements (Figure 5). Then, this research framework was the guideline to build up the questionnaire used in the interviews.

The research methodology (chapter 4), gathers up the strategy followed in the research together with the criteria to choose a case study and the description of them. The objective sought was to have different perspectives of the supply chain, therefore, 2 producing companies and 2 wholesalers in the fresh food supply chain were chosen.

From the analysis it can be highlighted that the engagement in QCL and the deployment of all six elements is possible at any level in the supply chain. Nevertheless, the configuration of the supply chain makes a difference in how these elements are deployed. Producing companies make use of product quality measurements to ensure a high product quality production, and wholesalers use it to extend product shelf life. In fact, the specific activities carried by both producing companies were very similar, as well as those carried by both wholesalers. Grupo La Caña and Agroherni quality measurements in the field are preventive; this means that they will produce a product with the highest quality possible to avoid product spoilage later on. Greenyard Group and Frutas Olivar carry corrective quality control activities as well as logistics activities with the products they receive to extend product shelf life and based on batches quality, orient them towards the required market segments and customers. However, the strategy of the companies is not linked to their position in the supply chain. Whereas Grupo La Caña and Greenyard Group had a volume orientation, Agroherni and Frutas Olivar were more product quality oriented. In this sense, research question 2 will be answered.

It was found that satisfying customers´ requirements was the core of all the activities for all companies and that it is possible through quality measurements and exchange of information. Perhaps, Grupo La Caña is an exception, since they carry less strict actions on information exchange with their customers and shows a reactive attitude towards quality control, e.g., they don´t use own data loggers during freight shipping, only if required by customers, the communication with farmers and the quality control in the fields is not strict, and they make specific quality controls when required by customers. The fact that Grupo La Caña is reactive to customer´s requirements required them to have an adaptative and flexible supply chain management. Both wholesalers carried intense flows of information exchange and quality controls, possibly due to being in contact with more suppliers and more customers. Worth to mention that Greenyard Group collaborates with suppliers to improve product transport conditions. Wholesalers´ supply chains are characterized by having numerous product origins and suppliers and diverse customers and market segments destinies. Additionally, supplying and selling points are far from the DC, adding distance and time to the equation. Frutas Olivar exports not only to Europe using trucks, like Greenyard Group, but also to Asia by plane. On the other hand, Grupo La Caña and Agroherni supply chains are simpler just because they have one single origin of the products, i.e., their farmers, and customers are defined annually. Only in rare occasions they have the need to look for alternative markets. This is the case when products accumulate, or they have additional production to sell. From the results, it is shown that Agroherni has a quite stiff supply chain management thanks to the intense control and integration of quality control and logistics. Whereas, in Grupo La Caña this control is lower, allowing them to be more flexible and adaptative to customers' requirements. Therefore, the more control is wielded over the supply chain, the less flexible and dynamic a supply chain management is. However, it is seen that wholesalers have a flexible and dynamic supply chain and also have control over their supply chain and extended integration of quality control and logistics. This is because the more entangled supply chains are, the more flexibility and adaptability to customer´s requirements are needed.

An additional difficulty point is the creation of stock by Greenyard Group. Even though the main objective in most of the case studies and of all food supplies chains, also extensively mentioned in the literature (Luning & Marcelis, 2009; Schouten et al., 2012; Trienekens & Zuurbier, 2008), is to reduce lead times, Greenyard Group manages not only to enlarge them but to provide a quality product that satisfies their customers. This is thanks to continuous exchange of information to predict market demand and sophisticated technology used to preserve product quality and prediction techniques, like the use of ULO cameras.

Furthermore, larger supply chains need quality control added focus. Both wholesalers transmit their concern to maintain product quality and extend shelf life using it as a commercial tool. They invest in advance technology, i.e., ULO cameras and real time thermographs, to ensure the customer receives the best product quality. This is specially important for Greenyard Group because they can store products for long periods. Although Agroherni also carries important activities to produce a high-quality product, the level of technology sophistication and supply chain size is lower.

Companies are characterized based on the patterns they follow to manage their activities and deploy the QCL elements. The characterization of the cases is determined by what is the strategy they pursue and to what extend they integrate QCL elements in their supply chain. With this information, the third research question is answered. It was found that Grupo La Caña has a volume-oriented management in which supplying the customer is the main concern and that the control to integrate QCL elements was done in the DC before making batches. Therefore, they carry a last-stage integration. Likewise, Greenyard Group also is concern about having enough supplies for their customers to such extend that they are even able to create stock. Fresh product stockpiling is only possible through intense quality control and exchange of information to pursue quality driven commerce. They pay attention to market demand and their activities focus on it; therefore, they are market oriented. The extend in which they follow this strategy is within the immediate chain actors; they have an under-scope integration. The other two companies put volume strategy aside to focus on quality. Agroherni carries an intense quality control since the beginning of the supply chain, aiming at customer satisfaction reducing the time before precooling and reducing lead times, as well as doing proactive product quality control. Being supply chain oriented, Agroherni has control over a wider scope of the supply chain including the farmers and their customers, therefore they have a full supply chain integration. Finally, Frutas Olivar also gives importance to quality control as their commerce is quality driven. They have diverse customers and therefore they need to deal with different product qualities. This is possible and easy for them thanks to their location in a central market, which characterizes them as quality oriented and to have a central supply chain integration.

Two main limitations arise in this research. The first one is the lack of literature on quality-quality controlled logistics, since it is a relatively new concept and only one author has made research about it. Due to this limitation, it was needed to make of this research a case study. Thanks to a multiple case study, it is possible to contribute to literature and to investigate further what other scenarios are found in real life supply chains that apply QCL since the cases provided on the literature are not diverse. And second, is the access to key informants and quality information. Being able to contact companies was in many occasions challenging and the information provided was limited. For instance, interviews through a questionnaire were incomplete and making a second round of interviews was impossible. Furthermore, although questionnaires were designed to be answered by different profiles workers, in the end it was not the case and only one person (sometimes two) would answer to all questions.

A relevant conclusion from this study is that no matter what is the position in the supply chain, the size, scope of action or the strategy followed by the company, application of the six elements needed to engage in the QCL are possible; only the specific aspects or activities carried are influenced by the configuration of the supply chain. Moreover, working customer oriented, which is key to make the most out of the products is eased with quality control measurements and fluent exchange of information. In the early stages of the supply chain, quality control activities are oriented to produce a high quality product, whereas downstream, wholesalers, o quality control activities to maintain and extend product quality and shelf life. Finally, the larger and the more entangled supply chains are, the more flexible and adaptative to customers' requirements companies can be.

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Annex

Questionnaire

This is the questionnaire that all interviews were based on. It is divided in four topics to have diverse perspectives of the functioning of the supply chain and how quality control and logistics were combined.

Production

1. What products and varieties do you produce?
2. Do they show quality variation when harvesting? Do they present difference in colour, texture, size, shape….? What are typical factors that create these variations?
3. When is the optimal harvest moment for each product? Based on what it is decided? Is it based on the product appearance, on the ripeness, on wholesaler's demand, on the distance to market, or others? Which ones?
4. In which conditions are the products transported to the manufacturer? Is it under temperature control (fridge)? What temperature? How long does it take to the raw materials to arrive to the manufacturer after harvest? How long does it take until the raw material is put under controlled temperature?
5. How long does it take to the products to reach the shelves since they are harvested? What factors can delay or advance the arrival?
6. Are farmers or producers informed of the company objectives (quantity of production daily / weekly/ monthly / annually; harvesting conditions / ripeness; …)?
7. As a farmer or producer, what are your major challenges to produce products at the highest quality and harvesting them?

Quality control

1. Which quality control activities do you do at the different stages? Before harvesting, after harvesting, during transport and storage?
2. Is there a temperature control when receiving the raw materials in the manufacture?
3. What is the main objective of the quality control activities?
4. Do you sort products by type of product, level of quality, or another characteristic?
5. Do you make batches with different products? How do you control product interaction?
6. Which activities do you do to maintain the quality longer? (precooling, gas concentration control, …)
7. What temperature do you apply after harvesting? Do you apply different temperatures to different products or batches?
8. Which technique do you use to reduce temperature? Is it forced-air cooling, hydrocooling, room cooling, vacuum cooling, cryogenic? Which technique do you use with each product?
9. How do you keep track of the temperature? Do you use real-time information? Do you use RFID, intelligent packaging,…?
10. What do you do when the result is not satisfactory? What are the consequences of a poor control of temperature and other aspects? Does it have an impact on logistics?
11. How do you measure shelf life? Do you use RIFID, intelligent packaging, ...?

12. What are the main attributes of the product that contribute to quality? (colour, texture, shelf life, …)
13. How does the temperature control affect the final product quality and shelf life? And the other quality controls?
14. Is it worth it to apply a strict quality control? Will the final quality be improved? Will you have higher revenues or more costs?
15. Is the final quality always the same? Do you obtain products with lower quality?
16. What is the average remaining shelf life that the product arrives to the market with? If the product arrives with a relatively short remaining shelf life, is the price reduced?
17. If at the distribution centre you obtain products with different quality levels, what do you do? Do you reallocate product to other markets? Do you remake batches with the same quality level?
18. What are the major challenges for the quality control department/manufacturer to maintain product quality?

Logistics activities

1. Which factors determine the market segment / destiny / customer of each batch? How do you decide which market segment / customer to send each batch to?
2. What issuing policy do you apply? Is it based on the product quality or the time it has been stored (FIFO, LIFO, FEFO, LQFO, …)?
3. What situation at the distribution process would make a change of customer/market segment destiny or the issuing policy?
4. How does quality of the product impact logistics decisions? Do you change product destination? Do you change the issuing policy?
5. Such change contributes to an upgrade or downgrade on the customer/market segment? Do you think that such change would provide higher revenues or just costs?
6. Are you in continuous contact with wholesalers/retailers in order to know real time level of demand?
7. Which countries do you export to?
8. How do you transport the fruits/vegetables? Which mode of transport do you use for each product and destination? What type of packaging do you use for each product and customer?
9. What are the conditions during transport? What attributes do you control (temperature, gas concentration, …)? Do you keep a record of those attributes? Do you use it as a feedback for the manufacturer or a quality prove for the wholesaler?
10. Which distribution systems do you use? Consolidation, break-bulk, cross-docking, stockpiling? Why do you choose this type?
11. How many supplying and selling points do you have? Are they only one or many? Where are they? Are suppliers far from the distribution centre? Are the selling points far?
12. What are the major challenges for logistics to deal with perishable products, take them to the selling point in the shorter time, at the lowest cost and the highest quality?

Commercial activities

1. Could you explain the supply chain structured of the different products?
2. How is the price arranged? Under which circumstances can these price arrangements be changed? From the same production, do you obtain different prices depending on the product quality and the customer/consumer?
3. If you obtain different quality levels (with different colour, texture, shelf life), how does it affect the price?
4. Do you have volume arrangements? How does it impact final price? Is there any relationship between revenues and volumes?
5. Under which circumstances do you request other actors in the SC to change the quality of the products? To which parties?
6. Under which circumstances are you requested or you request from/to other actors in the SC to change the quality of the products?
7. Do you think that you can improve the product final quality? Do you think that by doing so you can have higher revenues or higher costs?
8. Do you think logistics costs can be reduced? How?
9. How is the relationship with other chain actors? Is it long- or short-term relationship? Do you think that the type of relationship with other supply chain actors have an impact on the product final quality and/or on the costs and revenues? How?
10. How integrated is the supply chain? Which level of cooperation is there between the supply chain actors? Are processes aligned? Is the exchange of information in both directions (up-/downstream)?