

Implementation of quality controlled logistics in the food waste valorization chain

A multiple case study analysis of how the required quality and availability of fruits and vegetables waste streams are fulfilled



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All the effort behind this work has been supported by my beloved family and friends from my wonderful country, and now also around the world.

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Abstract:

One-third of food produced is lost or wasted globally per year along different agri-food supply chains, with the fruits and vegetables supply chain representing the highest wastage rate. These generated waste streams can be valorised by recycling strategies in order to add value and deal with negative impacts. However, the valorization strategies of these streams are affected for their variability and perishability. For this reason, this study analyses how the concept of quality-controlled logistics (QCL) and its six elements might deal with these characteristics in order to fulfil the expected quality and availability requirements set by the buyers of these streams. For this, theoretical semi-structure literature reviews comprise theory on valorization chains design and how the six QCL elements are deployed along these. Besides, three projects that give added value to fruits and vegetables waste streams are selected as cases to carry out semi-structure interviews to gather empirical evidence and contrasted it with the conceptual framework developed. Overall, it was found that the QCL approach can be implemented in valorization chains but the deployment of the QCL elements and their interaction might differ based on the valorization chain design and the quality and logistics management decisions made. Therefore, it can support the fulfilment of the quality and availability requirements in this kind of chains.

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CHAPTER 1: INTRODUCTION

1.1 Background

The 12th Sustainable Development Goal (SDG) established by world leaders in September 2015 at an historical United Nations summit supports the inclusion of the sustainability concept in consumption and production patterns. For this reason, looking for strategies to reduce the generation of food waste along the agri-food supply chains is a relevant objective in the specific case of the food industry. One-third of food produced is lost or wasted globally per year (1.3 billion tonnes approximately) along different agri-food supply chains, with the fruits and vegetables supply chain having the highest wastage rate (66% by weight of the total food waste). Additionally, this entails an inefficient use of natural resources and represents a source of greenhouse gases production (Gustavsson et al., 2011, Lipinski et al., 2013). In this context, the transition from the current mostly applied linear economy (take-make-dispose) to a circular economy (make-use-reuse) is a development aiming to achieve this SDG based on different kind of initiatives promoted by various governments, worldwide institutions and industries. One of these initiatives focuses on the valorization of food waste streams (Rood et al., 2017).

Sagar et al. (2018) report that around 25 to 30% by weight is waste generated by processing operations in the fruits and vegetables industrial sector, whilst Gustavsson et al. (2011) establish a distinction between high/medium and low-income regions presenting a percentage of 5% and 20 to 25% respectively in the same stage of the supply chain. Whichever percentage is correct, the amount of biomass that they represent brings severe nutritional, economic, and environmental complications by cause of not only the waste of the edible commodity but also the indirect waste of valuable resources such as water, land, fertilizers, energy and human labour (Venkat, 2011).

Lobo & Dorta (2019) describe the emerging role of different ways to add value to the fruits and vegetables waste (FVW) streams by defining four types of valorization: biological, chemical, biofuels and thermal. The authors argue that these activities emerge as feasible sustainable alternatives as FVW can be reused as raw materials for new and existing products because they are a good source of bioactive compounds with potential applications. This approach considers FVW streams a resource and thus their introduction to the economic circuit should be studied in order to set up their valorization and achieve economic and environmental benefits.

FVW valorization chains involve biomass exchange between different stakeholders playing specific roles at different stages and, added to the main objectives of a traditional agri-food supply chain, giving new value for these biodegradable resources is also an aim. Along this network, several operational and logistics strategies need to be considered to achieve a good performance taking into account the natural features of these waste streams. In other words, a major problem of these chains are the biological characteristics of the FVW streams, which hinder their proper transport, storage, and preservation, as these are associated with increased risk of microbial contamination and thus their degradation along the valorization chain. In this context, logistics challenges arise to fulfil the required physical availability of these waste streams and, as these present characteristics of perishability and variability, some quality aspects also need to be reached otherwise the streams would not be suitable for a specific valorization strategy for different reasons (e.g. high water content). Therefore, the optimal integration of quality control and logistics activities will allow to fulfil the expected quality and availability of FVW streams demanded by these types of chains.

Regarding the means to achieve this goal, the concept of Quality-Controlled Logistics (QCL) by Van der Vorst et al. (2007) appears as a useful approach in order to manage the FVW streams quality aspects and ensure their required availability for their valorization process. This approach establishes a synergy between quality and logistic aspects by supporting the fact that for meeting customers' requirements in terms of quality and availability, the utilization of relevant information about quality characteristics is needed in the logistics operations decision-making processes (see also Luning & Marcelis, 2006). To ensure this interaction, Van der Vorst et al. (2011) proposed the integration of six elements: (1) 'consumer preferences and product acceptance period, (2) critical quality points, (3) product quality measurements and prediction, (4) logging and exchange of information, (5) local dynamic/adaptive logistics and quality control, and (6) supply chain management'. In other words, the improvement of logistics performance in the supply chain design not only is desired but also the preservation of the quality level in order to obtain the right product delivered at the right place and time (Van der Vorst et al., 2007).

Given these points, to obtain a structural way to recognize how the QCL approach supports the fulfilment of both quality and availability aspects, a conceptual framework is elaborated (Chapter 2) catching different factors involved in both the quality control activities and the logistical activities in this type of chain, and afterwards applied in different cases study (Chapter 3) in order to validate its applicability. This approach has been used previously by Delgado

(2019) who carried out a multiple case study research but analysing fresh agri-food supply chains. Her findings are used to make a comparison with the results obtained by this study (Chapter 4) in order to visualize the differences presented in the application of QCL between fresh agri-food supply chains and food waste valorization chains.

Although the topic of FVW management at industrial level has been developed by different authors (Arvanitoyannis, 2008; Sagar et al., 2007; Lobo & Dorta, 2019), most of them are restricted to show the potential applications, technologies, or processes to reuse the FVW, but there has not been any discussion on the application of the QCL approach along FVW valorization chains. Therefore, research is needed to analyse how the QCL approach implementation might support the delivery of these waste streams ensuring the required quality and availability in the context of FVW valorization chains.

1.2 Demarcation of the research

The food industry generates different kinds of food waste streams. This study considers the valorization chain of fruits and vegetables solid waste streams commonly known also as by-products (e.g. peels, seeds, stones) and the fruit or vegetables that are not any more visual accepted by the consumers but still edible ('ugly fruits'). The FVW streams studied are generated during the primary production, postharvest, processing steps (e.g. selection, cutting, peeling) and consumption stages. This demarcation is supported by statistics that demonstrate that fruits and vegetables processing sector have a big wastage rate along their supply chains (Gustavsson, 2011), and also several studies (Lobo & Dorta, 2019; Waldron, 2009; Mirabella et al., 2014) that have highlighted the potential benefits and feasibility of FVW valorization chains with a circular economy perspective.

There are different valorization strategies that use FVW as raw materials to obtain a target output. Article 4 of Directive 2008/98/EC, introduces a waste hierarchy approach prioritizing the prevention of waste generation and considering the waste disposal as the least desirable activity. Demirbas (2011) also describes a waste hierarchy approach of six valorization strategies that make a more sustainable use of waste streams. Although in the sector of fruits and vegetables processing there is always unavoidable waste presented as by-products, this represents a new source of feedstock for valorization strategies. In this context, the hierarchical level of recycling offers a broad quantity of valorization strategies involved and its main advantage is the generation of valuable products from low-cost raw materials as major modification of their characteristics is realized (Plazzotta et al., 2017). Consequently, the

literature review and the empirical research of this research consider only the analysis of previous studies and real application cases related to recycling valorization strategies of FVW streams in order to describe how they are designed. It is also important to consider that even if the economic value of waste streams processing does not represent the same economic feasibility as a fresh food product, once the waste valorization strategy is planned, these are considered a new resource for the companies involved. Under this perspective, waste streams are also treated as perishable products presenting shelf-life constraints and variability in their composition as agri-food fresh products.

1.3 Research aim and questions

This research aims to analyse how the implementation of Quality-Controlled Logistics approach along the FVW valorization chains might support the fulfilment of the expected quality and availability requirements.

To achieve this, the specific sub-questions which drive the research are:

Sub-question 1: How is the fruit and vegetables waste valorization chain designed?

Sub-question 2: How are the Quality-Controlled Logistics elements deployed in the real-life fruits and vegetables waste valorization chains?

Sub-question 3: Are there any similarities between the scope of the implementation of QCL in fresh agri-food supply chains and food valorization chains?

1.4 Research framework

1.4.1 Literature review

Two systematic literature reviews are carried out in order to answer sub-question 1 and to develop the conceptual framework. Firstly, the design of FVW valorization chains is developed based on the literature findings about valorization chain strategies. Secondly, the review also explains the application of the Quality-Controlled Logistic approach in food supply chains and how the quality information of a certain product influences the logistics decision-making process. Moreover, the description of the Quality-Controlled Logistics elements required to its implementation is also presented and analysed based on the characteristics of the FVW valorization processes. The insights compiled by the literature study are a basis for developing a conceptual framework that describes how the relationship between the QCL elements might support the fulfilment of the quality and availability requirements for the valorization chain.

1.4.2 Empirical study

To be able to answer the sub-question 2, an empirical study is conducted by carrying out a multiple case study analysis. To collect empirical evidence, semi-structured interviews with professionals related to the valorization strategies of FVW are done. The gathered information is analysed by the application for the conceptual framework developed per case, with the development of a cross-case analysis afterwards.

Finally, the information compiled from the experts is also contrasted with the findings of Delgado (2019) in order to find out the main similarities between the implementation of the QCL approach in real-life fresh agri-food supply chains and food waste valorization chains. This comparison might improve the understanding of the scope of the QCL approach objectives for different types of supply chains. Therefore, sub-question 3 is answered.

CHAPTER 2: LITERATURE REVIEW

This chapter includes two systematic reviews of relevant literature sources to answer sub-question 1 and to develop the conceptual framework. This methodology is used as the aim of a literature review is to identify all evidence that fulfil a certain pre-specified inclusion criterion to answer the proposed research question (Snyder, 2019). This chapter is divided into four sections.

Section 2.1 establishes the methodology of the semi-systematic literature reviews and previous concerns before the report of findings.

Section 2.2 explains how FVW are defined and provides technical evidence about their valorization strategies. There is also a description of the FVW valorization chain design process. With the information compiled from these points it is possible to answer sub-question 1:

How is the fruit and vegetables waste valorization chain designed?

Section 2.3 presents an overview of the concept of QCL and how the relationship between quality control and logistics activities leads to ensure the expected requirements along food supply chains. Besides, the six specific elements for implementing QCL in FVW valorization chains are described in detail.

Finally, the section 2.4 presents a summary and conclusions of the literature review. The conceptual framework is also developed in this section by structuring methodically the most important findings about the specific elements required to implement the QCL along the valorization chain of FVW. This framework also aims to establish a support guide for the empirical study.

2.1 Literature analysis methodology

In this section, the methodological procedure for the literature review is shortly described for answering sub-question 1. An overall view of the literature search strategy is shown in Appendix A.

The first semi-systematic literature review aims to explain how are the FVW valorization chains designed. A set of predefined keywords is used: ‘fruit and vegetable waste’, ‘valorization strategies’; ‘by-products valorization’, ‘biomass’ and ‘supply chains’ in combination with the

Boolean operators 'AND' and 'OR'. Reliable databases such as Wageningen University and Research Library database, Google Scholar, Scopus and ScienceDirect are used. The primary search resulted in 66830 papers. Titles, abstracts and keywords of all papers are reviewed and judged based on the inclusion criteria used by Macheka (2010): (i) the documents are published in a peer-reviewed journal or book (ii) the articles are open access, (iii) the information must be in English (iv) the documents, or part of the documents, are about FVW valorization, fruits and vegetables recovery valorization strategies or biomass supply chains and (v) the articles are published within the periods year 2000 to year 2019, as these are current concerns related to the circular economy concept. The screened led to 13 literature sources and repetition of titles is avoided too. Besides, a manual searching applying backward citation was done to identify additional references indicated in the reference list from the retrieved articles considering the inclusion criteria too. Finally, the complete publications are read and judged again obtaining a final body of academic literature of 25 documents.

The second semi-systematic literature review aims to identify the application of the six Quality-Controlled Logistics elements in FVW valorization chains. A set of predefined keywords is used: 'Quality Controlled Logistics', 'quality control'; 'logistics activities', 'quality attributes', 'information exchange', 'quality prediction', 'quality management', 'logistics management', 'critical quality point', 'fruit and vegetable waste', 'valorization strategies'; 'by-products valorization', 'biomass' and 'supply chains' in combination with the Boolean operators 'AND' and 'OR'. Reliable databases as Wageningen University and Research Library database, Google Scholar, Scopus and ScienceDirect are used. The primary search resulted in 5533 papers. Titles, abstracts and keywords of all papers are reviewed and judged based on the inclusion criteria mentioned before: (i) the documents are published in a peer-reviewed journal or book (ii) the articles are open access and downloadable, (iii) the information must in English (iv) the documents, or part of the document, are about quality-controlled logistics, either of the six elements, food waste valorization practices and fresh food products involved and (v) the articles are published within the periods year 2000 to year 2019, as these are current concerns related to the quality-controlled logistics. The screened led to 27 literature sources and repetition of titles is avoided too. Besides, a manual searching applying backward citation was done to identify additional references indicated in the reference list from the retrieved articles considering the inclusion criteria too. Finally, the complete publications are read and judged again obtaining a final body of academic literature of 39 documents.

2.2 Fruits and vegetable waste

The situation of the FVW streams produced globally throws alarming values with respect to its volume and the diverse negative impacts this causes. Million tons of fruits and vegetable waste are generated annually after processing steps representing a loss of resources involved in the production of the original raw materials as energy and water (Ayala et al., 2011; Kowalska et al., 2017; Garcia et al., 2019). It has been reported by Sagar et al. (2018) that the percentage range which represents waste generated during the processing operations of fruits and vegetables commodities is about 25 to 30% by weight of total waste produced along the supply chain depending of the type of by-product. These waste streams are mostly constituted of seeds, skins, rinds, and pomace depending on the kind of fruit or vegetable processed and the production method used. Moreover, the disposal of these by-products represents not only an economic issue (high capital investment) for companies involved in the supply chain but also an activity with negative environmental impacts (Alzate et al., 2017; Banerjee et al., 2018; Mirabella et al., 2014).

The terminology of fruit and vegetable waste has been defined by Plazzotta et al. (2017) establishing that fruit and vegetable waste is all the inedible parts discarded during collection, handling, transportation and processing activities. Besides, many studies converge that the major characteristic of these waste streams is their high biodegradability related to their high moisture content (Plazzotta et al., 2017; Anwar et al., 2019; Galanakis, 2012). This intrinsic feature promotes microbial growth and thus microbial spoilage of the fruits and vegetable biomass (Alzate et al., 2017; Sagar et al., 2018; Galanakis, 2012). Among other characteristics, fruits and vegetables by-products contain also a high fibre content, low protein content, and concentration of high-value added bio compounds as pectins and phenols (Plazzotta et al., 2017; Galanakis, 2012; Sagar et al., 2018).

In this context, the application of different conversion processes to transform the huge amount of fruits and vegetables processing by-products into high value-added products appears as a feasible alternative to reduce the negative impacts caused by the disposal of these waste streams (Kowalska et al., 2017).

2.2.1 Valorization strategies

The application of the industrial symbiosis concept explained by Prosman & Waehrens (2019) as the practice of reusing waste or by-products from other companies, might involve several valorization strategies which have been studied by different authors. They consider that fruit

and vegetable waste are low value resources with a huge valorization potential and there exists an increasing interest in their upgrading which can become a potential source of incomes for processing industries (Plazzotta et al., 2017; Spatafora, 2012).

As mentioned in Section 1.2, Demirbas (2011) describes the waste hierarchy approach whose main objective is the establishing of six strategies that make a more sustainable use of waste to reduce environmental impact. Prevention, minimization, re-use, recycling, energy recovery and disposal are the strategies ordered by priority being the prevention and minimization the highest priority strategies. However, as food processing operations always generate unavoidable waste, the author concludes that the recycling strategies have the highest priority for this kind of waste, as this implies its use as raw material for other purposes and the extraction of valuable resources from it.

A large and growing body of literature has investigated the methods and applications to give added-value to the FVW regarding recycling strategies. Sagar et al. (2018) promote the valorization of horticultural waste by the bioactive compound's extraction. The authors describe the nature of the waste originated from fruits and vegetables processing steps, the bioactive compounds which might be obtained and the methods of its extraction. Dietary fibres, phenolics compounds, enzymes and proteins are the compounds studied.

Mirabella et al. (2014) present a broad literature review where three big clusters of food waste are studied: fruits and vegetables, dairy products and meat products. About the fruits and vegetables commodities, the authors conclude that their large quantity of waste produced represents a potential feedstock for production systems like biorefinery and a potential alternative for animal feeding. They also argue that to promote a functional food waste valorization strategy in the industry, the first actions to take are identifying, quantifying and characterizing the by-products.

Collectively, these studies outline a critical role of FVW as raw material for different kind of products with high potential value. Different processing technologies are used and mentioned in the literature to obtain these new products but the details of them are beyond the scope of this work unless future explanation is required to understand better the relationship with quality and logistics aspects. Besides, all studies reviewed agreed that FVW generation is a serious worldwide environmental, social and economic concern and measurements to minimize this in a sustainable way need to be developed and promoted accordance with circular economy (CE) principles.

2.2.2 Valorization chain design

There have been several studies promoting the reuse of FVW streams by establishing a valorization chain, and in order to define how this can be generally structured it is necessary to gain insights about its main stages.

Topi & Bilinska (2017) established a valorization chain for exhausted coffee grounds waste to produce high value compost by defining five scenarios covering logistics and economics aspects into account. The waste streams were collected from catering companies and then stored at a waste management site until obtain a specific quantity to finally be transported to the composting process site. Henriquez et al. (2010) collected apple peels to produce a powder ingredient from commercial manufacturers of dried apple. These were packed into polyethylene bags and frozen at -20°C previous to their transportation to the production site where the raw material was examined (chemical composition, pH, moisture content, colour), pre-processed (cutting, water addition) and finally dried using a drum-dryer. Górecka et al. (2010) produced a dietary fibre rich ingredient from raspberry pomace. The raspberry by-product was sourced directly from fruit production facility in a dried form to facilitate the distribution activities. Benítez et al. (2011) collected onion skins from a Spain production plant and then these were dried and stabilized by pasteurization and sterilization to obtain safe dietary fibres. Djekrif-Dakmouche et al. (2006) used orange waste (peels) powder as a substrate and *Aspergillus Niger* to produce α -amylase concluding that this waste stream was a perfect source of carbon. Moreover, an example about the drying of apple pomace, previously to its conversion into pectin, for shipment and warehousing allowed to deal with location and seasonality constraints. (Panouillé et al., 2009). Ajila et al. (2010) dried mango peels to obtain a powder that enriched macaroni preparations by sourcing antioxidants to the matrix. The previous fruit by-product is also studied by Asif et al. (2016) who extracted bioactive compounds and concluded that the variety of mangoes is a key factor in the chemical composition of the waste streams. Consequently, characteristics of FVW streams are mostly related with their high-water content (or low dry matter content) and the variation of chemical components they present. A summary of these findings is presented in Table 1 indicating the type of waste, the pre-treatment, processing operations and final outputs.

Table 1:

Fruits and vegetables waste valorization strategies examples

Waste	Pre-treatment	Processing	Output	Reference
Apple pomace	Sun and hot air drying	Grinding	Dietary fibre	Majerksa et al., 2019
Black carrot pomace	Heating	Microwave assisted extraction	Polyphenolic compounds	Majerksa et al., 2019
Pineapple core	Crushing	Solvent extraction, purification and precipitation	Bromelain	Banerjee et al., 2018
Mango peel	Freeze drying	Supercritical fluid extraction	Carotenoids	Asif et al., 2016
Onions skin	Cutting	Enzymatic digestion	Dietary fibre	Benitez et al., 2011
Raspberry pomace	Drying	Grinding	Dietary fibre	Górecka et al., 2010
Mango peels	Drying	Grinding	Dietary fibre	Ajila et al., 2010
Apple peels	Drying,	Grinding	Dietary fibre	Henriquez et al., 2010
Orange peels	Sun drying, grinding	Mixing and centrifugation	Culture medium for α -amylase production	Djekrif-Dakmouche et al., 2006

Previous real valorization practices provide insights about how the valorization chain of FVW can be designed. However, these evidences have been mostly carried out on a laboratory scale and thus, in order to present a more structured way to scale up these valorization strategies, the integrated approach of four steps proposed by Plazzotta & Manzocco (2019) appears as a suitable methodology.

Firstly, the methodology establishes the accurate characterization of the waste streams in terms of quantity and composition, identifying critical features that will influence further stages of the valorization chain. Besides, the identification of the type of processes involved during the waste generation allows to determine how homogeneous in composition are the waste streams. This is important to simplify the collection activities because separation processes are avoided. Prosmann & Wæhrens (2019) highlight that initial waste streams quality is a key factor to

consider in future production and operational processes in industrial symbiosis schemes. Garcia et al. (2019) and Asif et al. (2016) also consider that featuring fruits and vegetables by-products in terms of quantity, patterns of generation and variability is a relevant factor for the success of the chain depending on the processing step.

The second step regards to define the valorization chain output. As the feedstock has been already characterized, potential final products might be proposed based on these characteristics. At this point, research and development (R&D) activities cope with different possibilities of waste streams valorization strategies as the same raw material can be utilised in a wide range of final products. As it is observed in Table 1, same outputs can be obtained from different fruits or vegetables waste streams but also different processes, so as Galanakis (2012) mentions, the functionality of final product is altered based on biomass specifications and processing methods. For instance, Majerska et al. (2019) studies the influence of initial chemical composition of apple pomace in the final quality of polyphenolic compounds as output but also considering the drying process conditions as preliminary treatment.

The third step is the valorization strategy process design required to produce the established outputs. For this procedure, the application of the 5-Stages Universal Recovery Process developed by Galanakis (2012) is a suitable approach for recycling valorization strategies. The author observed five stages describing as follows:

a) Macroscopic pre-treatment: the objective of this stage is to adjust the food waste streams in terms of water content, enzymatical inactivation, reduction of microbial load and other similar aspects. In the specific case of fruits and vegetables by-products, the author explained that a wet milling step as a pre-treatment activity might support the yield increasement of next stages. Table 1 present the different drying methods as the most used pre-treatments followed by grounding. Moreover, while drying aim also to extend the shelf life by reducing the moisture content, the grounding increases the surface area, and thus to ease the extraction process of bio compounds. (Górecka et al., 2010; Majerska et al., 2019).

b) Macro and micro molecules separation: in this stage different procedures as alcohol precipitation and isoelectric solubilization aim to the separation of micro molecules as antioxidants, acids, or ions from biopolymers.

c) Extraction: solvent extraction (Banerjee, S et al., 2018), microwave-assisted extraction (Majerska et al., 2019) and supercritical fluid extraction (Asif et al., 2016) are only some of the techniques used to obtain the target molecules. This is the most important stage according to

the author as the final output is finally obtained and involves the control of different process parameters like temperature and pH.

d) Purification: this stage aims to isolate the target compound. Adsorption, membrane processes and electro dialysis are some of the purification techniques.

e) Product formation: this last stage is related to obtain final product stability. Encapsulation and spray drying are the most popular techniques for this purpose.

The last step refers to the feasibility analysis of the waste valorization chain. This analysis deals with the evaluation of the relevant costs presented. Feasibility is managed in some studies via optimization modelling. For instance, Abdulrazik et al. (2017) modelled mathematically the oil palm empty fruit bunch supply chain for energy recovery processes. The authors concluded that there are three main sources of cost: biomass costs, production cost and transportation costs. In the valorization chains, waste stream are valuable resources and as soon as they are considered as raw materials, a purchase cost is also set. As Raimondo et al. (2018) explain, the price of biomass should be a fundamental agreement in the contract design between the supplier and the buyer of it. Moreover, Anwar et al. (2019) point that availability of biomass and externalities as seasonality can influence in the biomass price. Some studies have highlighted the great impact of transportation cost in the economic viability of the valorization chains. Banerjee et al. (2018) explain that disposal of waste streams involves a high capital investment mostly in regards to transportation activities, while Plazzota et al. (2017) argue that the overall cost of setting a valorization chain is directly proportional to waste transportation. Abdulrazik et al. (2017) optimize the biomass supply chain profit by considering the distances between the collection points and the biorefineries, but also the cost of using different transportation modals in their model. About the processing costs, the drying processes as pre-treatments are the main source of expenses as it is pointed by Alzate et al. (2017) who concluded that cost of drying represents an economical obstacle for by-product valorization strategies.

Given the evidence provided by these studies regarded to the activities and methodologies to establish the FVW valorization chain, this is depicted in Figure 1:

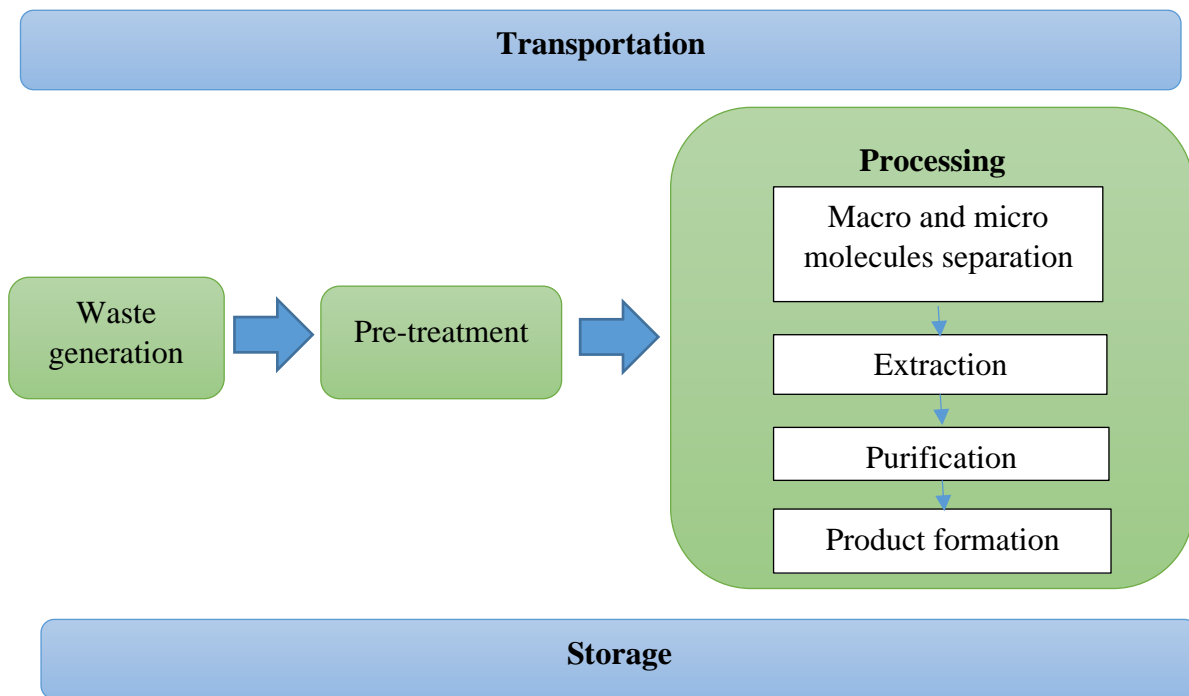


Figure 1: Fruits and vegetables waste valorization chain considering the 5 Stages Universal Recovery Process defined by Galanakis (2012)

The FVW valorization chain starts at the waste generation point where the FVW streams are collected and the initial quality control might be carried out in order to characterize the raw material too. Afterwards, the waste streams are pre-treated with the aim of adapting its required characteristics for the final processing stage. For this last one, it is relevant to mention that even if the pre-treatment step has been described as one of the 5-stage universal recovery process defined by Galanakis (2012), in Figure 1 this is treated as a previous stage before processing as most of the reviewed literature sources made use of a pre-treatment to conditionate the FVW streams for their following processes, and not all the other four steps are necessary applied in every recycling valorization strategy.

Regarding the storage and transportation, the activities related to these logistics processes are carried out at any or between of the three stages presented in Figure 1. It might be possible that the FVW streams must be stored for a period of time previous their transportation to the processing facilities or that their collection occurs immediately after their generation. Moreover, the pre-treatment can be even carried out in the waste generation point, transporting only then raw material ready to be processed. Therefore, storage and transportation are flexible activities presented along all the stages of the valorization chain and that is why they are depicted on a way that cover all of them.

Consequently, the research sub-question 1 about the how are the FVW valorization chains designed is answered and regarding the Figure 1, this will ease to identify how the QCL elements are deployed along valorization chains.

2.3 Quality-Controlled Logistics

Quantity and quality variability of the food waste streams generated during processing activities are affected by different factors along the valorization chains. Sharma et al., (2013) mention that the main sources of variability for this kind of chains are the weather uncertainty, seasonality of raw materials, geographical distribution of the physical activities and the low bulk density of the by-products (high volumes). Moreover, Akthari et al. (2019) consider that the lack of availability of the required quality level of by-products is one of the main barriers for application of valorization chains at industrial level and it impedes to obtain the desired outputs after conversion activities, affecting negatively the economic feasibility of the whole chain. Consequently, as Castillo et al. (2017) conclude, quality control activities must be established to deal with the variability of by-products based on buyers' quality requirements and thus, avoiding overall cost increase resulting from using low-quality by-products in the valorization chain.

Given these points, the Quality-Controlled Logistics concept arises as a suitable methodology to address these concerns. According to Van der Vorst et al. (2007), Quality-Controlled Logistics (QCL) can be defined 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 the availability of specific product qualities in time by using time-dependent product quality information in the logistics decision process'*. The authors also set that the variation in product quality, technological developments, heterogeneous needs of customers and the opportunity to manage product quality along the distribution chain are factors that are involved by Quality-Controlled Logistics.

This approach aims to differentiate products and maximize the overall value of the food supply chain by applying a proactive control of products at different stages. Control of quality and logistics aspects are presented as the means to achieve this. Quality control allows to obtain homogeneous products batches for specific market segments based on their quality

requirements whilst logistic control provides an optimum handle and distribution by setting conditions that avoid quality decay. Both types of control support the decision-making processes to ensure the availability of quality products for specific target customers. (Figure 2)

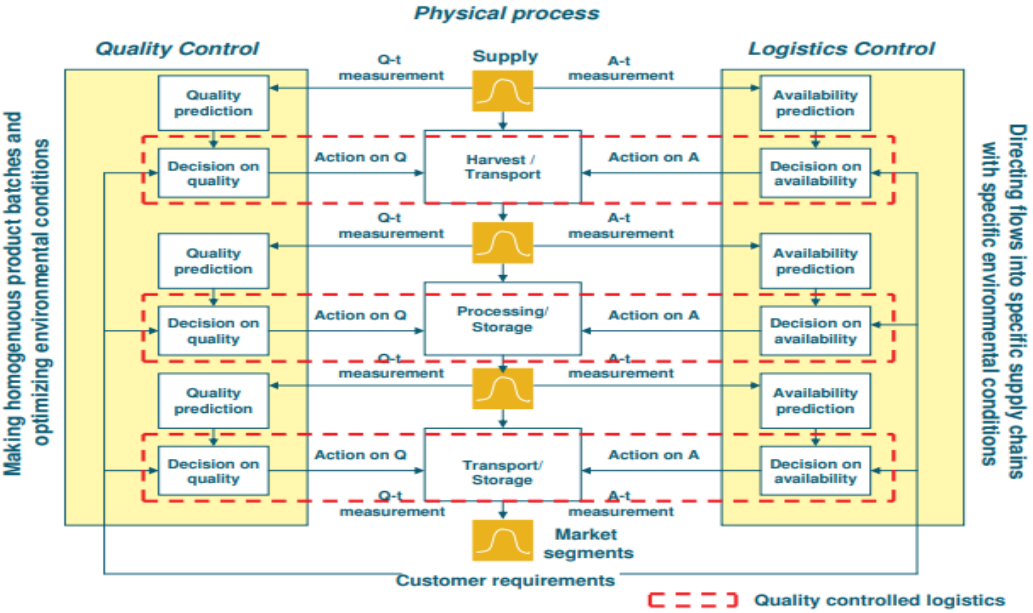


Figure 2: Overview of the Quality-Controlled Logistics approach (Van der Vorst et al., 2007)

Previous studies have reported the application of the QCL approach in fresh products supply chains. Macheka (2010) identified main quality critical points along tropical and subtropical fruits supply chains which contributed to the waste streams generation and proposed solutions based on the application of the Quality-Controlled Logistics concept. He concluded that the lack of quality control and inadequate logistics control at main bottlenecks contributes to high food waste generation. Van der Vorst et al. (2007) identified several improvements opportunities for the case study of tomato supply chain concluding that the added value of the QCL is to provide a framework where prediction of product quality in advance allows to enhance the supply chain activities design. Heinsing et al. (2017) applied the QCL approach to evaluate to what extent the application of intelligent packaging could reduce waste generation of highly perishable food products by setting a continuous monitoring activity and allowing to the system to manage quality changes in the products. Moreover, Delgado (2019) evaluated the implementation of the QCL approach in fresh fruits and vegetables supply chains by a multiple research case study. However, even if there is empirical evidence of the application of the QCL concept, these are mainly related to fresh food supply chains.

2.3.1 Quality-Controlled Logistics elements

In order to enable the integrated implementation of the QCL in a supply chain, Van der Vorst et al. (2011) identified six elements based on literature analysis and case studies. Although the authors studied fresh food supply chains to establish these elements, it is assumed that they can be also applied for food waste valorization chains as they also share the perishability and variability characteristics presented by the fresh food products. The elements are described as follows:

A. Consumer preference and acceptance period of product quality attributes

This element refers to the fact that customers establish a set of quality attributes required to meet their expectations and there exists an acceptance period defined as a time lapse where these attributes are still acceptable based on the final product requirements. The meeting of these requirements is the main driver of QCL as the whole supply chain aims to fulfil what customers need.

Luning & Marcelis (2009) explain by means of the called intrinsic-extrinsic quality attributes model that consumers' quality perception depends on noticeable product attributes which can be split in intrinsic (safety, health, sensory, shelf life, convenience) and extrinsic (production system characteristics, assigned quality by marketing/communication) attributes. At the same time, these are influenced by physicochemical properties of raw materials and intermediate products, technological factors and legislation. Moschopoulou et al. (2019) in Galanakis (2019) propose the same two attributes groups classification but with distinct elements. They identified the pH, water activity, microflora, enzymes and redox potential as intrinsic factors while processing, storage conditions and packaging practices refer to extrinsic attributes. This background is significant to understand that the assessment of quality in fresh products leads to a successful supply chain performance by achieving the overall aim of customer' satisfaction.

B. Critical Quality points

Luning & Marcelis (2009) define a critical quality point (CQP) as a point in the supply chain where variation in the quality attributes results in irreversible deviations in desired quality specifications. Van der Vorst et al. (2011) explains that a good understanding of the dynamic behaviour of the quality attributes allows to explain how different chain configurations might influence quality throughout the chain. Based on this, it is possible to determine in which locations of the chain it is required to take quality control actions.

C. Product quality measurement and prediction

This element is related to the quality dynamics and how this can be predicted in order to enable the chain actors to act proactively (Van der Vorst et al.,2011). Rong et al. (2011) mention that complexities of quality prediction are influenced by the range and dynamics of the product characteristics and environmental conditions during storage activities. The authors also say that most of the approaches of quality prediction are based on the fact that there is one leading quality attribute which can be used to develop mathematical prediction models or decision support tools.

Quality prediction is specifically applied at the CQP already defined in point B. Van der Vorst et al. (2011) recognized as operational requirements for this element the capability to implement an automated quality measuring system and develop prediction models to determine actual product quality status. This is illustrated by the study realized by Heising et al. (2017) who used intelligent packaging to determine fresh food quality applying the Quality-Controlled Logistics approach. This type of packaging allowed to monitor quality automatically throughout the whole supply chain based on the effect of the temperature as the environmental condition factor and thus, pro-active decisions, based on real time information about quality of the products, were made.

D. Logging and exchange of information

This element establishes a relationship between the data logging and the information exchange among chain actors. Some relevant information is about the quality status of the product which is monitored by controlling quality parameters through different stages of the supply chain. This is also linked with environmental conditions during storage and transportation activities. Delgado (2019) highlights the application of some information systems as RFDI (Radio frequency identification) and TTI (Time-temperature identificatory) in order to obtain real-time data during diverse activities along the supply chain. Moreover, information regarding demand, inventory and supply is also important for setting optimal logistics activities (Van der Vorst et al., 2011).

E. Local dynamic/adaptive logistics and quality control

One of the main characteristics of QLC is to adapt control activities and flows of the products based on customer requirements and product quality. Delgado (2019) explains that quality control and logistics activities aims to be dynamic by using real-time product quality

information and to match this with specific buyers' requirements. For this reason, operational activities must be tailored to deal with this quality matching and trying to avoid quality variability. Moreover, some operational requirements for this element presented by Van der Vorst et al. (2011) are the ability to manipulate product quality in line with market demands and applying quality driven inventory management.

- Quality control:

Optimal quality control management is based on scientific knowledge, use of standardised equipment, procedural methods and systematic activities (Macheka et al., 2017). In addition, Luning and Marcelis (2009) explains that quality control can be depicted as a sequence of steps where the main quality attribute of a product is measured to be compared with previous target values and finally to take corrective actions in case the match between the actual and desired quality level is not fulfilled. Delgado (2019) mentions three methods for carrying out quality control: acceptance sampling in order to accept or reject a batch of product according to specific criteria, statistical process control applied for monitoring the operational processes and the quality analysis by evaluation of specific characteristics of the product.

- Logistics activities:

Inventory management: this activity aims to optimize the whole supply chain through the different stages in order to fulfil the demand. For this reason, decisions regarding order sizes, order dates, and delivery dates are made (Gleissner & Femerling, 2013). In addition, Delgado (2019) explains that inventory management implies product quality driven policies whose main purpose is to establish which products at a warehouse are picked and sent to their next destinations.

Transportation management: transportation activities play a fundamental role in moving materials from upstream to downstream stages, returning products when is required and store these ones along the way in the supply chain. The main objective of transportation management is to fulfil customers' orders at the right time, at the desired place and maintaining the quality of the products delivered as best as possible. Therefore, decisions must be made in terms of mode or form of transportation and product handling procedures considering optimal vehicle routing and scheduling (Malladi & Sowlati, 2018).

F. Supply chain management

Van der Vorst et al. (2011) named this element as Agri-food supply chain management based on the target product studied. The authors defined this element as the group of practices applied

whose aim is to match supply and demand using product information and logistics decision policies. The final outputs obtained from this element are the reduction of production and distribution lead times, transparency along the supply chain collaboration and reduction of costs. A similar definition is presented by Delgado (2019) who included also the concept of decision-making process in both logistics and product quality management. The following explanation of this element uses the division applied by Delgado (2019), describing also some decisions made at the strategic, tactical and operational level.

- Logistics management: Luning & Marcelis (2009) explained the role of logistics along the food supply chain. The authors describe that logistics management is complex for this kind of supply chain as the variability and shelf life of food goods as raw materials or final products will require specific conditions during transportation. Other activities which are influenced by the quality aspects of food products are the storage and the production planning operations because of the environmental conditions required and the fulfilment of delivery times agreed with customers respectively. For this reason, logistics activities control along the supply chain is relevant to manage and evaluate the performance of all these activities.

-Quality management: Agricultural and food products are living systems influenced by externalities as seasonality, with a restricted shelf life and often heterogeneous in composition. These features cause that several consequences for activities as storage conditioning, processing, tracking and tracing and quality control appear. In this context, quality management activities deal with these consequences by focusing not only in the production systems but also in the dynamic behaviour of people involved towards quality. (Luning & Marcelis, 2009).

2.3.2 QCL in fruits and vegetable waste valorization chains:

In this section, an analogous description of each QCL element is also presented but focusing on their application in FVW valorization chains.

A. Consumer preference and acceptance period of product quality attributes

Regarding the valorization chain of FVW streams, their main quality attributes required by the final processing stage are related to the moisture content, particle size and chemical composition. These are established in the first step of the integrated approach methodology presented by Plazzotta & Manzocco (2019) and might change depending on the valorization strategy processing methods and technology applied.

Some studies have highlighted the importance of the analysis of the quality attributes in order to provide the right characteristics for downstream operations of the valorization chain. Spatari et al. (2014) mention that biomass quality attributes as moisture and ash content constraint the optimal storage operations conditions. This also occurs with the collection and transportation activities (Malladi et al., 2018). Moreover, Kaderides et al. (2017) characterized by-products generated by orange juice extraction operations in terms of water holding capacity and chemical composition in order to produce encapsulating agents. Henriquez et al. (2014) and Withouck et al. (2019) also highlight the relevance of characterizing the high total phenolic content of apple peels and apple woods respectively as a quality attribute for their production as powder products. O'Shea et al. (2015) concluded that it is important to understand the individual functional components of the by-products to fully utilize them for food applications. This last statement is demonstrated by Gómez et al. (2018) who explained that the loss of consumers acceptability of bakery products enriched with flours produced with fruits and vegetables by-products is due to a lack of understanding of their physical structure and chemical composition, and how this affects the final product quality. The author also mentions that the processing and conditions presented during the generation of waste streams affect their quality attributes and they must be evaluated prior waste utilization.

About the acceptance period, the literature does not mention specific periods of time that conversion factories set regarding the acceptability of the quality attributes for their biomass feedstock. However, this can be established by means of supply and demand contracts where arrangements about terms of delivery can be made (Sharma et al., 2013). This is supported by Keizer et al. (2017) who explained that quality decreases with each logistics operation due to its long duration and the environmental conditions presented. Consequently, optimal delivery terms would allow to establish specific periods of time in which the providing of the right by-products' quality to the conversion facilities is ensured.

B. Critical Quality Points

Previous studies about FVW valorization chains have not mentioned literally the term 'critical quality point', but they mainly allocated the quality control activities at the pre-treatment and processing stages. O'Shea et al. (2012) and Malladi & Sowlati (2018) concluded that most favourable by-products pre-treatments are in the form of drying such as convection drying or freeze drying, sorting and grinding, and they aim to increase the transportation efficiency and keeping the quality level. Quality control during this stage deals with parameters such as

temperature, residence time, moisture content and particle size to provide specific conditions required by the final conversion process (Gianico et al., 2013). A clear evidence of quality control during the pre-treatment stage was carried out by Bchir et al. (2009) who concluded that temperature increase during the drying process of pomegranate seeds favoured the water loss rate, the weight reduction and solids gain. Other example that exemplifies the role of pre-treatment as a CQP in a forest biomass supply chain was described by Marques et al. (2018) as they explain that to obtain the required net caloric value for energy recovery processes, the level of moisture must be controlled during the pre-treatment. On their part, Gómez et al. (2018) studied the effect of the particle size of fruits and vegetables by-products flours in the volume and harness of bakery products.

Although it could be assumed that storage and transportation operations might require also the application of quality control activities, there is no evidence in the articles reviewed about which methods or how they are carried out that supports this statement. Therefore, for the valorization chain defined in Figure 1, the only CQP established are the pre-treatment and processing stages.

C. Product quality measurement and prediction

There is some evidence of the application of this element for food waste valorization chains. Dekker et al. (2014) developed a predictive modelling used during thermal pre-treatments of vegetables by-products in order to evaluate the effect of the exposure time and temperature on the rate constant of softening described by the Arrhenius equation. In addition, Henriquez et al., (2014) studied the degradation of the total phenolic content of apple peels by applying first-order kinetics equation during drying process as a pre-treatment. They concluded that the physical, chemical, structural and biological changes occurred during this process strongly affected the by-products quality attributes. Another attempt to modelling biomass quality was made by Castillo et al. (2017) who developed a model that quantifies and controls the impact of quality variations in terms of moisture and ashes content on the supply chain decisions making process and the selection of the most suitable technology for conversion operations.

D. Logging and exchange of information

The FVW valorization chain depicted in Figure 1 sets three stages (waste generation, pre-treatment and processing) and two key operations (transportation and storage) mentioned also by different authors that studied biomass supply chains (Spatari et al., 2014; Zhang et al., 2012;

De Meyer et al., 2016; Malladi & Sowlati, 2018). Along these stages, different kind of information is exchanged and it is a relevant concern in order to increase the trust between companies involved. Fraccascia & Yazan (2018) highlighted that a lack of information about available and requested biomass, waste quality and content (physical and chemical characteristics), and transportation concerns might hamper the matching between waste supply and demand which is one of the main conditions for the optimum performance of a valorization chain. In addition, Herczeg et al. (2018) set that the logistical integration involved in industrial symbiosis practices is characterized by sharing explicit information about production plans and inventory levels. In the context of the FVW valorization chains, as natural variations of the original products influence the quantity and quality of the by-products generated, exchange of this information allows to establish solid relationships between suppliers and buyers. Knowledge about inventory and supply are also important for setting optimal logistics activities (Van der Vorst et al., 2011).

Logging and information exchange aim to reduce the natural uncertainty presented by the complexity of the biomass supply chains. The main sources of uncertainty described by the literature are related to weather variability, seasonality, geographical distribution, policy conditions and market fluctuations (De Meyer et al., 2016; Sharma et al., 2013; Zema et al., 2018; Akhtari et al., 2019). Fraccascia & Yasan (2018) analysed the role of online information-sharing platforms on the overall performance of a biomass supply chain concluding that sharing information by means of these platforms supports the economic performance of the chain, reduces the uncertainties presented and implements trustful relationships. However, the authors also explained that sometimes companies are not willing to share information because there is private data regarding production technology or final product formulation which they prefer to hide. For their part, Prosman & Wæhrens (2019) remarked that the main objective of information exchange is to align waste quality with the final production requirements and these might involve decisions about waste fraction separation activities or mixing the waste streams with other feedstock. Besides, they explain that sharing information might be practised by means of reports, e-mails, calls, and visits.

E. Local dynamic/adaptive logistics and quality control

-Quality Control:

For the valorization chains, it is seemed that the pre-treatment and processing are the stage where quality control must be applied. As was already mentioned, pre-treatment refers to any

operation whose main objective is to ease handling, transportation and storage activities, and to keep optimal by-product quality based on the conversion process requirements (Rentizelas et al., 2009). In addition, Sharma et al. (2013) explained that this operation may occur at different stages depending on the technology required (equipment, methods) and their geographical location. The target parameters values controlled during pre-treatment processes might be affected by the initial by-product quality level (Prosman & Wæhrens, 2019). For this reason, it is possible to assume that pre-treatment operations might be adapted based on the explained factors in order to provide the correct quality to the by-product's conversion facilities. It is relevant to mention that the flexible nature of this stage will only be obtained together with the application of quality control activities that establish the actual quality status at a specific point in the chain.

-Logistics activities:

Inventory management

The definition of push and pull logistics principles are required to understand better the inventory management activity in FVW valorization chains. Gleissner & Femerling (2013) explain that the push principle addresses the supply of items on the market without considering their specific demand and is specially applied for low-value goods. On the other hand, the pull principle implies that logistics process begins when the consumer creates demand. This principle is mostly suitable for high-quality investment goods. Malladi & Sowlati, (2018) differentiated these two principles at the waste collection point but describing them as supply-driven and demand-driven collection respectively. While in the first situation the entire feedstock is collected to their further conversion, in the second situation only the required quantity of feedstock is collected in order to fulfil customers' demand. According to Herczeg et al. (2018), the availability of waste streams occurs mostly under a push system and this involves that surplus or shortage might occur because of the variability in supply and demand, and externalities as seasonality. In both situations, decisions must be made to deal with inventory management such as store the surplus volume of waste or purchase additional feedstock in case there is a shortage to fulfil demand. The authors also mention that inventory management should consider the general production system when not only by-products are involved but also other kind of raw materials in order to operate storage facilities in an acceptable way as different raw material flows might require different storage conditions.

Akhtari et al. (2019) analysed the impact of two inventory systems: order-up-to-level and fixed-order quantity on demand fulfilment for a forest-biomass supply chain. They concluded that to ensure biomass availability, a fixed-order quantity system will be more appropriate to fulfil the demand as there will be greater quantity of biomass stored and thus, less probability of shortage compare to the order-up-to-level situation. Although, even if keeping too much biomass permits to avoid possible shortage, this means an increasing of handling cost too.

Therefore, based on the available amount and type of biomass, the inventory management activities should present a certain flexibility in their operations in order to be capable to deal with these factors. Decisions about the location of storage points along the chain, conditions, storage space and inventory policies must be made to deal with possible shortage and provide right by-product quality to further stages in the valorization chain.

Transportation management:

Regarding an industrial symbiosis scenario, Herczeg et al. (2018) explained that transportation management involves a trade-off between distances and efficiency. Since a long distance between suppliers and buyers means less familiarity with each other's activities, the difficulty to agree on by-products exchange will increase. Besides, Domenech et al., (2019) explained that the transportation management decisions affect directly the geographical scope of the whole chain. For instance, if there is a lack of vehicles availability (Malladi et al., 2018) or of the required transportation conditions to keep the specific by-product quality (Sosa et al., 2015), the whole system will not be able to distribute the right by-product amount at the right quality in case long distances are presented between stages of the valorization chain.

It is also relevant to mention that transportation costs are one of the main economic barriers for implementation of biomass supply chains (Zhang et al., 2012; De Meyer et al., 2016). Oo et al. (2012) reported that transportation cost of biomass is based on the transportation distances, density of the biomass and the mode of transportation. Besides, other researches (Zhang et al., 2012; Abdulrazik et al., 2019) studied the biomass supply chain optimization by developing mathematical models to minimize transportation costs as an objective for the overall chain performance.

F. Supply chain management

- Logistics management:

Some important strategic logistics management decision in the food waste valorization chains are the selection of biomass suppliers, setting of collection methodology, terms of delivery and payments (contracts), and the capacity and location of the storage sites (Sharma, et al., 2013; Santibañez et al., 2015). Besides, tactical decisions involving production planning, inventory management (policies) and fleet management (transportation resources) are also mentioned by the literature as relevant factors to determine economic feasibility in the valorization chain. Although, Malladi & Sowlati (2018) argue that logistics decisions are only made at the strategic and tactical planning level, Sharma et al. (2013) mentioned that supplier's allocation and routing planning as operational decisions must be considered too in order to deliver the biomass in the right quantity and on time to fulfil the demand of the conversion facilities.

-Quality Management:

In the biomass supply chain, a clear evidence of quality management is presented by Castillo et al. (2017) who developed an optimization model to quantify and control biomass quality variability and analyse its impact in decision-making processes at both the strategic and tactical levels. The authors considered moisture and ash content as biomass quality attributes to modelling supply chain design and planning. They concluded that the high moisture and ash contents negatively impact the unit delivery cost since additional quality control activities are required to deal with this poor-quality biomass. On their part, Sosa et al. (2015) highlighted the importance of quality management for the biomass feedstock in terms of moisture content as a driving factor to optimize transportation costs. Besides, Akhtari et al. (2019) remarked the importance of the periodic processing equipment maintenance in order to avoid machine breakdowns which can be one quality management issue based on the concept of Luning & Marcelis (2009).

Herczeg et al. (2018) mention that working with multiple suppliers might be necessary to mitigate risks related to the supply of by-products based on their demand. Therefore, each one of these biomass flows coming from different sourcing points might require specific quality management decisions and the whole chain should be capable to cope with them.

In order to summarize the main findings gathered from the literature evidence about the application of the QCL elements along FVW valorization chains, Table 2 is presented.

Table 2

Main findings regarding the application of QCL elements in FVW valorization chains

QCL ELEMENTS	MAIN FINDINGS
Consumer preference and acceptance period of product quality attributes	<ul style="list-style-type: none"> - Moisture content, particle size and chemical composition as the main quality attributes of FVW. - There is a mutual interaction between the quality attributes selected and the processing conditions. - An optimal understood of the physical and chemical properties of FVW streams might support their acceptability for specific valorization strategies. - The acceptance period can be influenced by the delivery terms between supplier and customer. No specific periods of time mentioned.
Critical Quality Points	<ul style="list-style-type: none"> - CQP mostly set at the pre-treatment and processing stages. - Main processing parameters controlled are the temperature and residence time. - Processing conditions applied at the CQP will define the final quality output.
Product quality measurement and prediction	<ul style="list-style-type: none"> - Application of mathematical quality predictive models to explain the influence of processing conditions on the final output quality on time. - Establishment of a main quality attribute is required for model's development. - By measuring and quantifying the impact of quality variations in the whole valorization chain, this element acts a pro-active tool in the decision-making process.

**Logging and
exchange of
information**

- The exchange of information appears along all the stages of the valorization chain.
- Relevant information exchanged: available amounts of FVW, quality conditions, production scheduling, collecting time windows and prices.
- There is evidence that sharing relevant information by using online platforms might improve the level of collaboration between stakeholders creating trustful relationships.

**Local
dynamic/adaptive
logistics and
quality control**

- The initial quality level of the FVW might influence the processing parameters established and thus, these can be adapted.
- The inventory management of valorization chains follows a push system: surplus or shortage are likely to occur. There is a trade-off between surplus storage of FVW and the increment of handling costs.
- Distance between suppliers and buyers might hide the exchange agreements of FVW streams.
- Improper conditions of the vehicles might affect the quality level of FVW.

**Supply chain
management**

- Strategic, tactical and operational decisions presented in both logistics and quality control activities.
 - These decisions provide the guidelines for the application of the other five elements and vary depending on the general objectives that valorization chains have as a industrial activity.
-

2.4 Summary and conceptual framework

This chapter began by describing the global situation of food waste streams generated and their negative economic and environmental impacts. Within this group, FVW streams have been described as potential raw material sources to obtain high value-added products by several researches. A description of the main features related to these by-products is presented.

A review of different mechanisms or strategies for the valorization of FVW was realized based on a hierarchy approach. For the aim of this research, as was mentioned previously, the valorization strategy selected is recycling as this provides most benefits to unavoidable waste generated from fruit and vegetables processing steps.

Afterwards, the FVW valorization chain was designed based on previous studies that also analysed this kind of chains. Main information was gathered in terms of specific kind of waste used, the pre-treatment applied, the processing or conversion steps and the final outputs obtained for each valorization strategy. Although most of the authors only studied this strategy at a laboratory scale, an integrated methodology was described in order to set prior steps to design them in a bigger scale. Characterization of the waste streams, definition of the final output, design of the valorization process and a feasibility analysis are the steps to follow. Finally, with all the literature evidence, sub-question one is answered by establishing the FVW valorization chain design with 5 key processes: waste generation, pre-treatment, processing (conversion), transportation and storage (Figure 1).

An explanation of the Quality-Controlled Logistics concept and the six elements that permit its implementation is presented too. The literature analysis provides some evidence about how these are related to the FVW valorization chains (Table 2).

Henceforth, considering the literature review findings, a general conceptual framework (Figure 3) is developed in order to illustrate how the implementation of Quality-Controlled Logistics approach along the FVW valorization chains might support the fulfilment of the expected quality and availability requirements.

The concept of QCL is applied along all the valorization chain stages established and depicted in Figure 1. The starting point is the application of the supply chain management element which involves both quality and logistics management decisions, policies and strategies set by the organization which acquires the FVW streams and processes them. All the decisions regarding how the quality control and logistics activities will be carry out are defined at this point and are

the main inputs for the establishment of QCL as these ease the deployment and allocation of each of the other elements at the specific stages of the valorization chain.

The application of the consumer preference and acceptance period (CP/AP) element is shown between the waste generation point and the pre-treatment and processing stages. Firstly, the processing stage requires to provide a desired final product quality and the quality attributes that defined this are set by the target market of the final product. Therefore, the inputs obtained from the pre-treatment process must be in accordance to these requirements. Secondly, the pre-treatment also requires a suitable initial quality of the FVW streams which is defined by their quality attributes and the acceptance period established. Moreover, both the pre-treatment and processing stages are considered as the critical quality points (CQP) as any deviation in the desired quality of the product during these stages might significate its rejection by the target market.

To define the suitable initial quality of the FVW, the quality measurement and prediction (QM/P) element is used. The quality measurement is carried out at the waste generation point including a comparison between the actual quality attributes values and the required target values. Besides, in order to visualize how the initial quality status might influence in the following stages performance, the development of mathematical quality prediction models can be carried out. All the information about the quality status of the FVW streams is shared among stages but also information about their availability.

This information exchange (I) is done in both directions represented in the framework as a mutual interaction between the stages. At the same time, this information will have an influence in the quality control and logistics activities explained by the application of the adapted logistics and quality control element. In the framework, all the components that are surrounded by dashed lines might be adapted based on the information about quality and availability of the FVW streams. On the one hand, quality control at the pre-treatment and processing stages might be dynamic as variability of the initial quality of the raw material is presented and thus, processing parameters required for processing raw material with this initial quality attributes must be adapted in order to obtain the desired final quality outputs. On the other hand, storage and transportation activities might be influenced by availability and quality issues that surge along the valorization chain and thus, they need to modify their operations to deal with them. Some issues can be related to the surplus or shortage of raw material or the lack of conditions required to maintain the required quality during storage and transportation

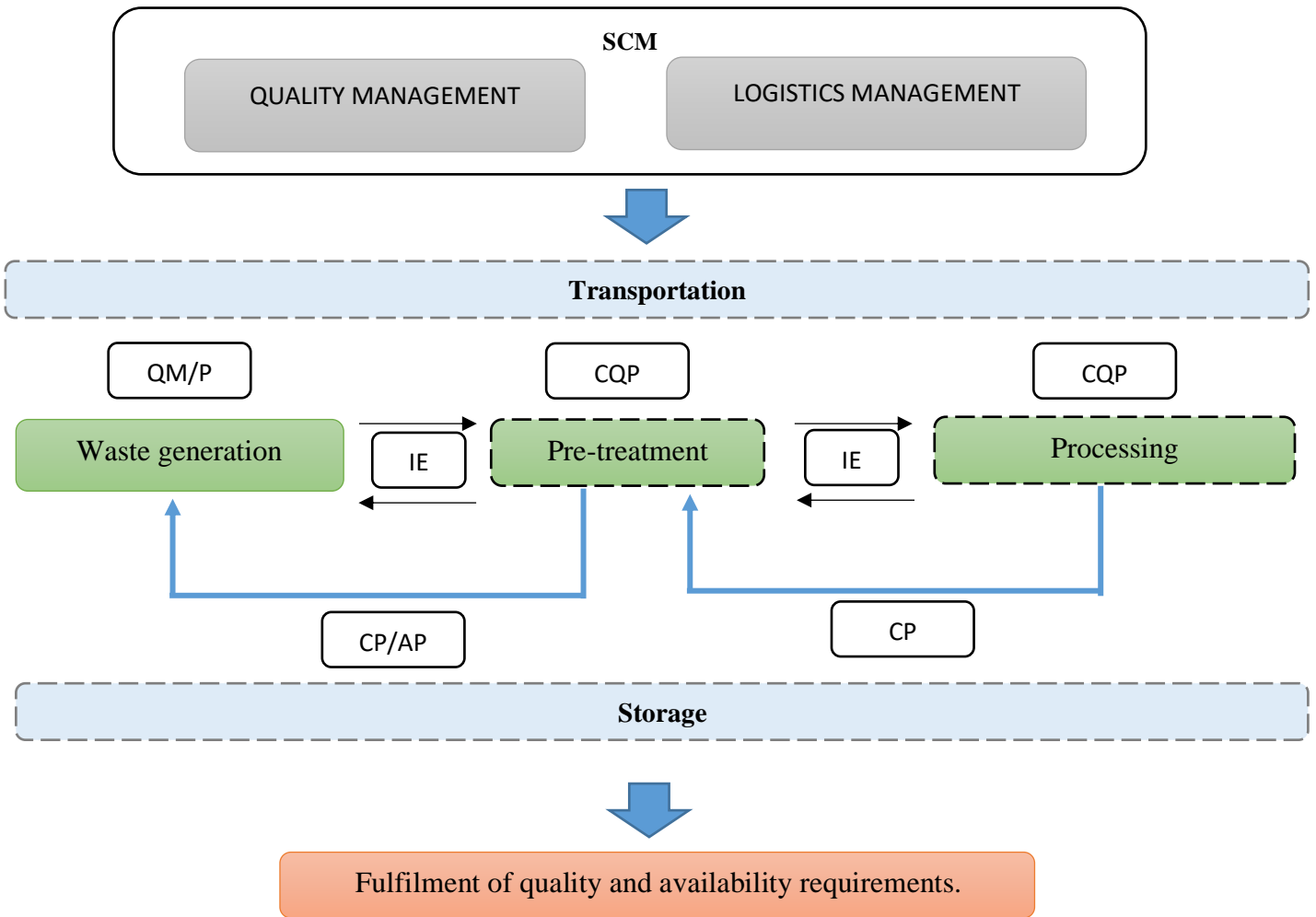


Figure 3: Conceptual framework to depict how implementation of QCL might support the fulfilment of quality and availability requirements.

CHAPTER 3: EMPIRICAL STUDY METHODOLOGY

This chapter describes the methodology used for the empirical part of this study. The research method selected is the multiple case study and in the following sections this is described in detail based on the steps defined by Yin (2009): plan, design, prepare and collect. The last step regarding data analysis is developed in Chapter 4.

The empirical study aims to gain insights about how the quality control and logistics activities are interrelated in real-life FVW valorization chains. The gathered data will support the information gained by the literature analysis regarding the deployment of the six QCL elements in the FVW valorization chains and used to validate the conceptual framework developed (Figure 3). This will allow to answer sub-question 2.

3.1 Planning the multiple case study research

Yin (2009) presents three conditions to justify the use of a case study research: (a) the type of research question must be in the form of ‘how’ or ‘why’, (b) the level of control that the researcher has over the studied events is null, and (c) the degree of focus on contemporary events occurs.

By analysing these criteria in the sub-question 2: ‘How are the Quality-Controlled Logistics elements deployed in the real-life fruits and vegetables waste valorization chains?’, it is seen that the research question is a ‘how’ question and thus, appropriate for a case study. Besides, the author also highlighted that this kind of question has an explanatory research approach allowing a better understating of the studied problem. For the second condition, the researcher will not have any control of the studied events (FVW processing activities). About the third condition, these events are currently occurring and thus, they are considered contemporary. Finally, the selection of the case study research method is justified for the empirical research.

Yin (2009) also described some strengths and limitations about the case study research. The author set that a unique strength for this method is its ability to cope with a variety of evidence: documents, artefacts, interviews, and observations. On the other hand, some limitations have been associated with this research method. For instance, it is commonly considered that case studies provide little basis for scientific generalization. The author explained that case studies are generalizable to theoretical propositions by aiming to expand and generalize theories (analytic generalization).

3.2 Multiple case study research design

Yin (2009) describes the research design as the logic that connect the data to be compiled with the initial question of the study. In other words, research design deals with: what questions to study, what data are relevant, what data to collect, and how to analyse the results. This section covers the definition of the study propositions and unit of analysis, the identification of the type of case study design and its qualitative validation conditions.

The setting of study propositions, based on the research question, aims to direct attention to something that should be analysed within the scope of the study. Besides, these propositions provide a guideline about where to look for the correct evidence. Therefore, based on sub-question 2, the following study propositions can be set:

- The application of QCL in real-life situations could be influenced by the valorization chain design proposed by each company.
- Even if some practices related to quality and logistics control are applied, it does not mean that the processing company recognize them as part of an integer system (QCL).
- There might not be a quality modelling developed for the quality prediction of waste streams. However, the setting of CQP is relevant to ensure the quality of final products specially during the processing step.
- Supply chain collaboration between suppliers and buyers considers the establishment of contracts, time windows delivery and price agreements.

These propositions reflect about some points covered by the literature review (Chapter 2) and will be a support for the data collection step.

The next point that research design covers is the definition of the unit of analysis. In this case, based on the demarcation of the study and the study propositions, the units of analysis for this study are the FVW valorization projects.

About the type of case study design, Yin (2009) defined 4 basic types based on a 2x2 matrix considering the number of different units of analysis and the number of cases studied as criteria. These are: single-case (holistic), single-case (embedded), multiple-case (holistic) and multiple-case embedded). For the present study the design selected is the multiple-case (holistic) study as three cases are developed and the units of analysis studied are the FVW valorization projects. This type of case study also allows to use a replication logic which consists on generating similar results within the selected case studies, but also, if they are not enough to obtain reliable

findings, more cases can be replicated by this design. This is a relevant fact to take into account for further research.

In addition, Yin (2009) proposes five techniques for analysing case studies: pattern matching, explanation building, time-series analysis, logic models and cross-case synthesis. For this report, the cross-case synthesis is chosen because it allows to accumulate each case knowledge, compare and contrast them and thus, producing new knowledge.

Finally, Yin (2009) described 4 criteria to judge the quality of the case study research design: construct validity, internal validity, external validity and reliability. Some tactics aiming to deal with these criteria are presented in detail in Table 3. It is important to mention that the table has been modified based on the specific tactics that will be only applied in this study.

Table 3

Case study tactics for four criteria (adapted from Yin, 2009)

Criterion	Case study tactics	Phase of research in which tactic occur
Construct validity	- Establish chain of evidence	- Data collection
External validity	- Use replication logic in multiple-case studies	- Research design
Reliability	- Use case study protocol. - Develop case study data base	- Data collection - Data collection

It is clearly seemed that the judgment of the design procedure goes beyond this section as the data collection phase is also involved. Nonetheless, for this section the external validity criterion can be applied. This deals with the previously mentioned analytical generalization where the results obtained are generalized to some broader theory. The tactic to apply for this criterion (in this specific study) is the use of replication logic in multiple case studies. Therefore, if three FVW valorization projects are the cases, they should predict similar results (a literal replication) or predict contrasting results (a theoretical replication).

3.3 Multiple-case study research preparation

This step is a link between the case study design and the data collection procedure. The case study research preparation includes the development of a case study protocol, the screening of candidate cases and the realization of a pilot case study.

The first point to cover is the case study protocol. As Yin (2009) mentions, the protocol aims to be a guideline for the researcher in carrying out the data collection from each single case, and it describes the rules and procedures to be followed when it is used. Moreover, setting a protocol is the best way of increasing reliability of the case study research.

Based on the example provided by Yin (2009, pp. 80-81), a protocol for the present study is developed and shown in the Appendix C following a structure of four sections: case study overview and purpose (research objective, theoretical framework, role of the protocol), field procedures (name of the company, data collection plan), case study questions (specific questions that the researcher must keep in mind) and the outline of the case study report (format for the data, use and presentation of information).

After development of the protocol, a screening of potential cases to be part of the study is carried out. Yin (2009) suggests to select cases that best fit in the literal or theoretical replication design. In the situation of the present study, the three cases to be studied are projects that give added value to fruits and vegetables waste streams under a recycling processing scheme previously mentioned (Chapter 2). There is no geographical demarcation for the cases but only English or Spanish data collection sources are considered. Following these criteria, a searching of potential projects via Google search, LinkedIn and professional contacts is done. Finally, project A that processes beet stems, project B that processes spent coffee grounds and project C that processes apples and pears leftovers were included in the study (appendix D).

Finally, the third point during the preparation step is to carry out a pilot case study. Yin (2009) mentions that a pilot case study helps to refine the data collection plan in terms of the contents of the data and the procedures. Moreover, it helps to develop relevant lines of questions and to provide a better clarification of the research design. For this purpose, a pilot case study is carried out with the company D which processes bakery products into animal feed. Even if the scope of this case is out of the demarcation about the use of fruits and vegetables waste streams as raw material, its facilities were visited and the application of some quality and logistics control activities in the operations was clearly observed. Therefore, applying the case study protocol and the data collection procedures for this specific case will allow to verify the possible outputs

for the planned questions. The results of these pilot case are not shown in this report but it allowed to rearrange the questions syntaxis in order to gather more accurate information from the interviewees.

3.4 Data collection methodology

The data collection methodology to gather data for the multiple-case study analysis is the semi-structured expert interview. The invitation to be part of the interview is sent via email once the experts are chosen (Appendix D). Several projects were approached but, in the end, only 3 of them accepted to participate in this study.

The detailed information on the individual experts is presented in Table 4:

Table 4

Detail information of interviewees

Organization	Expert position	Activity/ Location
Cormo alimentos	- General manager	- Production/Chile
Spaak Circular Solutions	- Researcher	- Consultancy/Netherlands
Fooditives	- Manager, food scientist	- Production/Netherlands

In accordance with the literature analysis findings presented in the conceptual framework (Figure 3) and how this is structured, the semi-structured expert interview is divided into different parts. Four parts are established, and their questions aim to obtain insights about the interrelations depicted by the arrows in the conceptual framework. With the objective to make it straightforward and unambiguous for the experts, the questions were sent to them previously to carry out the interview.

The interview used in this study is classified as a semi-structured interview. This is characterized by using open-ended questions allowing for an argumentation with the interviewee rather than a strict sequence of questions. An interview guide was developed to provide a determined structure for the interview. As mentioned, the interview consists of four sections: the introduction, the waste valorization strategy, questions about the quality and logistics activities based on the six QCL elements and the potential improvements related to the FVW valorization chains. The content of these sections is described as follows:

Interview section 1: The introduction in the interview allows the researcher the opportunity to present and explain the research background and the specific issues to the experts. Furthermore, the researcher gets to know in depth the professional expertise of the interviewee and to what extent is related with the topic.

Interview section 2: The second part of the interview include questions about the fruit and vegetable waste valorization chain strategy the expert is familiar with. Besides, insights about the raw material selection and how was the valorization process designed are also relevant information collected in this section.

Interview section 3: The third section of the interview covers detailed questions concerning the logistics and quality activities along the valorization chains of FVW streams and how they are interrelated based on the six QCL elements.

Interview section 4: The fourth section of the interview provides additional questions about potential improvements that, based on their expertise, they would implement in this kind of valorization chains in accordance to the answers they give. They also have the opportunity to ask remaining questions or other information related to the study.

The design of the interview guide and the questionnaire is presented in the Appendix E. The narrative evidence formed by the open-ended answers to the questions are presented in the Appendix F. These are considered as a part of the multiple-case study database (increasing reliability).

As mentioned in Table 3, the establishment of a chain of evidence is applied to construct validity criteria in order to increase the multiple-case study quality. This tactic aims to link the research questions, the gathered data and the conclusions along the present report in order to allow the reader to follow the derivation of any evidence.

CHAPTER 4: MULTIPLE-CASE STUDY RESULTS

In this chapter, the data gathered from the evidence sources is presented and analysed in order to validate and contrast the conceptual framework developed about the application of Quality-Controlled Logistics in FVW valorization chains.

Firstly, each case study will be analysed separately describing the results based on the four sections established in the interview guide (Appendix E). Secondly, results from the three cases will be analysed independently by applying the developed conceptual framework (Figure 3) and the cross-case synthesis technique is applied by placing the evidence within an overview table built based on six categories representing each QCP element. Therefore, relevant insights to answer sub-question 2 are provided. Finally, in order to answer sub-question 3, the main findings obtained are contrasted with the main findings of Delgado (2019) to find if there are similarities between the application scope of the QCL between fresh food and food waste supply chains.

4.1 Cormo Alimentos

Cormo Alimentos began operations as a start-up company in 2016 in Santiago de Chile (Chile). After acquiring funding from CORFO (Corporacion de fomento para el desarrollo), an agency for the Chilean Ministry of Economy, the group formed by a general manager, a food engineer, a biotechnologist and a commercial engineer started the R&D phase based on the business idea already planted. They wanted to involve the concept of circular economy on their operations as the quantity of vegetables leftovers generated daily in Santiago is huge.

Nowadays, they have a portfolio of three products: ‘Betasal’, a product considered as a reformulation of the common salt. This is mostly composed by beet steams and salt as secondary component; ‘Betaplus’, a product considered as super food which is one hundred percent composed by beet stems powder with a high content of folic acid and fibre; and ‘Keso’, a plant-based cheddar type elaborated with carrot peels still in the development phase. For the interview, it was decided to focus only in the valorization chain of ‘Betasal’.

The company has set a strategic alliance with the wholesale market ‘Lo Valledor’ as the unique supplier of raw material. The administration of the market has a specialized department called ‘Recuperacion alimentaria’ (Food Recovery) which manages the first stages of the logistics operations of Cormo. This relationship is fundamental for its operations, even though they are evaluating possible scenarios in case this is not feasible anymore. The raw material is collected

and the operational staff contracted by Cormo prepare the raw material before it is transported to the processing facility which is outsourced. The beet stems are sanitized and then dried. Finally, they are milled, cooled at room temperature and packed. The market channel of the company is still growing, but at the moment 'Betasal' is sold in different natural local fairs and small shops as the denomination of seasoning. They also want to start exporting the product to the international market.

The commercial strategy of Cormo is based on offering a natural free-gluten product, very tasty and flexible in use in the culinary sector. They are very concerned about the advantage they have over their competitors in terms of the strategic alliances they have forged not only with the wholesale market but also with different Chilean organisations that impulse the application of the circular economy in the food industry as part of a national policy.

4.1.1 Quality control activities

In Cormo alimentos, vegetables sellers from the main wholesale market in Santiago provide the required raw material which are beets stems. They have a surplus of this product in their selling sites and therefore, at certain time during the day they put it on specific bins located at strategic points along the market. The location of this bins is aiming to avoid that the raw material be in direct contact with sunlight and not to be in contact with the floor neither. The amount of collected beet stems is brought to a specific location in the wholesale market which is refrigerated in order to preserve their desired characteristics as much as possible. The application of this refrigerated condition was also established by the food engineer of the team as idoneal in order to preserve the sensorial characteristics of the raw material. There, the leaves are separated from the stems by the operational staff of Cormo obtaining the ready to use raw material. Regarding the acceptance period established, the company do not work with raw material that has been stored for around 3 days before production as they did trials that demonstrated that this is not suitable for the process basically because the raw material loses too much moisture content and the colour it presents is not in accordance with the desired final product attributes.

The ready beet stems are transported to the production facility in order to start the production process of 'Betasal'. Some quality aspects to take into account at this point are the cleanliness checking of the truck before load the raw material. For the production process, Cormo has set the colour of the raw materials as a main quality attribute for the process as is strongly related to the final quality of 'Betasal'. This is checked by the operational staff while doing the

sanitation of the beet stems. The staff separate the raw material that present a colour out of the range they set empirically as they do not use any control chart to do the segregation formally. The chemical content has been also set as quality requirement but in a more implicitly way. They found during the R&D phase that beet stems have a high salt content and a good taste once it is produced as a seasoning. However, they do not carry out any compositional or sensorial analysis to establish required target values.

Cormo outsources the production facility but it is concern about the application of quality assurance systems which deal with safety issues too. The outsourced company applies the HACCP (Hazard analysis and critical control points) and it manages all the required records to fulfil the Chilean food regulations. They have the temperature and time control during the drying process as the most important parameter to control and as the critical quality point as if these parameters are not respected, the final colour will be affected negatively. Although the outsourced company has records about the controlled operational parameters, these have not been standardized for all the incoming batches of raw material as their quality status varies between them. The application of mathematical quality prediction modelling has not been considered neither, but the interviewee argued that it would be useful for prediction of the final product quality considering its moisture content as the main quality attribute as the product is very hygroscopic. Accelerated shelf life testing was carried out in order to set a shelf life period of 6 months once the product has been packed.

4.1.2 Logistics activities

Cormo really thinks that the strategic alliance they have with the wholesale market is a competitive advantage over their market competitors. They see the market as a partner in charge of their first stage of logistics activities as it manages the collection from the bins along the market and does the transportation towards the refrigerate zone. Reliability in this partnership is fundamental in order to ensure the availability of raw material. The interviewee also mention that they decided to work with only vegetables and not with fruits by-products because in the case of fruits, these are mostly discarded as they are already spoiled and a very few quantities are discarded for esthetical reasons. This did not ensure Cormo the required volume and process standardization.

The company owns a truck with 800 kg capacity that brings the raw material from the market to the outsourced facility. The company does not have any inventory management strategy as they do not have still the resources to have a warehouse for raw material. The production is

based on the outsourced facility capacity, so the same amount of raw material is brought every time production is planned. They have never been affected by a shortage of the raw material as the quantity generated at the market is huge and they only collect one part of this. However, they have considered the idea to buy raw material directly from the vegetable sellers in case the strategic alliance does not work optimally anymore. Regarding the inventory of the final product, as the product is dehydrated, they set sometimes a safety stock in case demand grows up but it does not happen often.

Cormo has planned to increase its production and thus, they have considered to collect raw material also from big food companies that process different kind of vegetables. Besides, the processing frequency will increase as they process now three times per week and they do not want to store raw material. They consider that the most important factors to establish a relationship with this supplier are the volume and quality of the raw material. Setting of the required amounts or collection time windows are also information to consider.

4.1.3 QCL approach:

The previous information for the case-study of Cormo Alimentos is analysed by the application of the conceptual framework (Figure 3) to understand better the interaction of quality and logistics activities considering the QCL approach. Main quality management strategies applied by Cormo are the establishment of the strategic alliance with its unique supplier as they can rely on which is the incoming quality status of the raw material, and as the final product is targeted for human consumption, the application of quality and safety assurance systems as HACCP is compulsory to fulfil national regulations. This system supports activities like parameters control during the processes. Regarding logistics management decisions, by collecting from only one supplier which generates a constant surplus of raw material, the uncertainty about its availability is reduced. Besides, as the company outsources the production facility and the whole process is constrained by its known production capacity, this allows the company to plan their production in advance.

The main quality attribute required by the final customer is the color, hence, this means the raw material quality must be in accordance with this requirement. Firstly, the pre-treatment which involves the activities of leaves separation and sanitation of the beet stems requires a raw material whose period of storage be less than 3 days in refrigerated storage and also raw material that has not been in direct contact with the sunlight. The fulfillment of this criteria ensures the required quality attributes for next stages based on the obtained R&D findings carried out by

Cormo. Secondly, the processing stage also requires that the outputs from the pre-treatment fulfill the required quality attributes to be processed. Here the operational staff do the sorting of the raw material whose color is not in accordance to what is needed reducing the quality variability and ensuring a better standardized product. It is relevant to mention that for Cormo, the only CQP is the drying process at the processing stage as the required characteristics of the final product are obtained after the application of the optimal time and temperature parameters. If any fail related to raw material quality inputs and technical aspects occurs during this process, the final desired quality is not obtained.

Regarding quality measurement and prediction, Cormo does not use a standardized way of measuring the color as for instance using a color chart. Therefore, even if there exist a subjective quality control of the raw material carried out by the operation staff by sorting it visually based on its color, quality modelling cannot be developed and applied for the decision-making process without objective values. Besides, the quality measurement is carried out during the pre-treatment stage and not at the waste generations stage.

Information exchange occurs along this valorization chain. The wholesale market administration ensures the initial quality of the raw material by informing to the vegetable sellers how they must dispose it based on the recommendations provided Cormo. Besides, the company has an idea about the available amount of raw material based on the known refrigerated storage capacity and the generation rate of beet stems from the vegetable sellers. Then, information about the quality status after sorting is provided and process parameters during the processing are adjusted based on it. About transportation, as Cormo only own one truck for their operations, there is no modification or adjustments based on the available raw material. The same occurs for storage, which only occurs at the waste generation stage and its operation is not influenced by the availability of raw material. However, as the initial refrigerated storage aims to maintain the quality status on the raw material at the beginning of the chain, temperature values can be modified in order to hold optimally the quality level within the acceptance period. Henceforth, processing and storage might be dynamically influenced but the quality and availability of raw material and are presented surrounded by dashed lines in Figure 4.

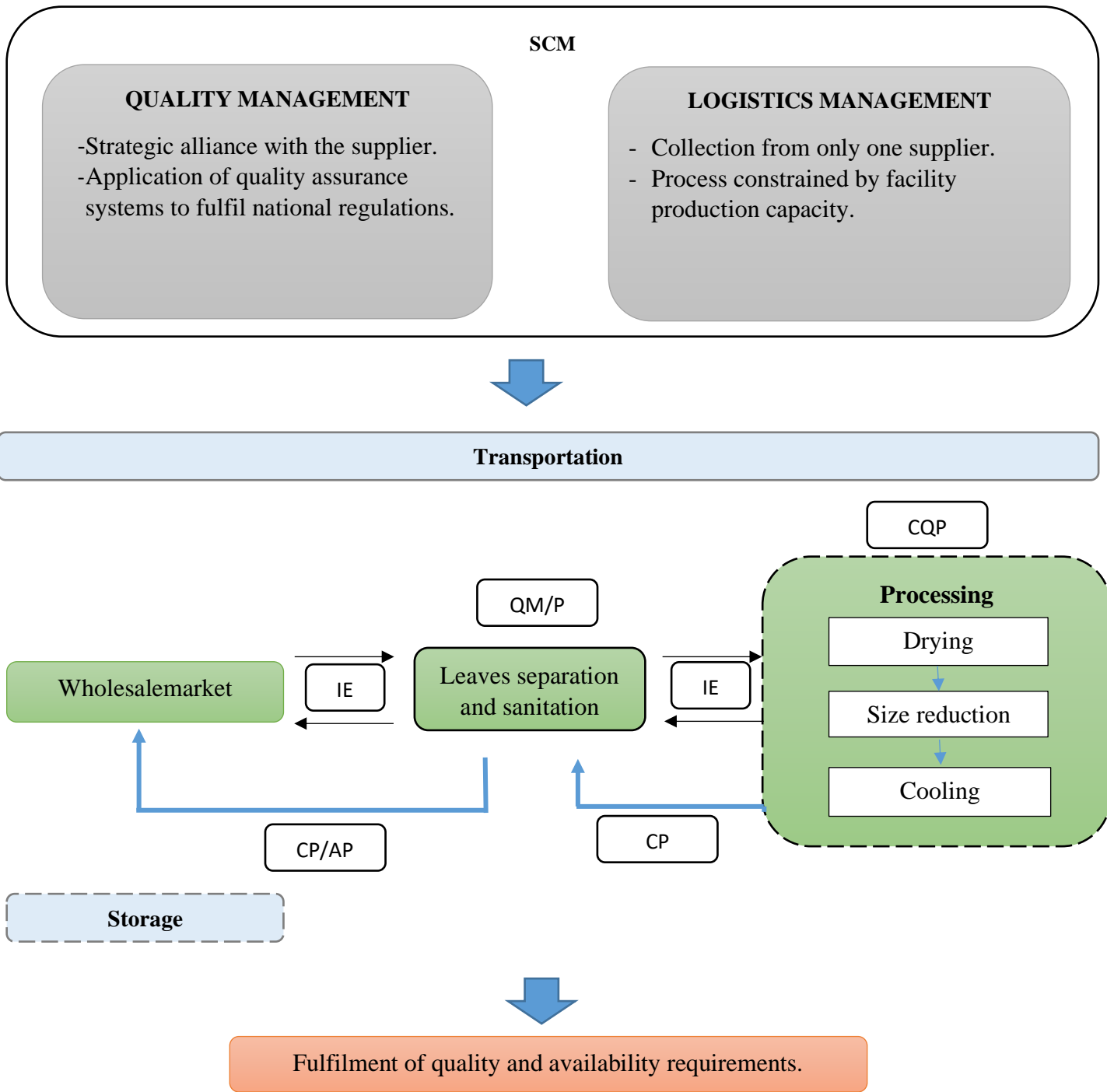


Figure 4: Conceptual framework applied to the Corno Alimentos case.

4.2 Spaak Circular Solutions

Spaak Circular Solutions is a Dutch consultancy agent which provides the service of consultancy for companies that look for establishing a sustainable process for their side streams and to work in accordance to the circular economy principles. The company started operations on 2013 and was formed by entrepreneurs with different professional backgrounds in order to develop complete business cases. They work not independently but with different partners including regional governments, third-party logistics (3PL) companies and the same companies which ask for their services.

The company has already been part of one successful food waste valorization project denominated 'Care-Orange', a project aiming to recover extracts from organic residual streams by using residual heat and applying clean technology; and currently they are working together with the company CaffeInk in order to establish a joint biorefinery for the recovery of natural dyes and oils from spent coffee grounds. To achieve the best results for these projects, a business case must be developed in order to evaluate the economic feasibility, but also the technical aspects analysis and the process design are relevant steps. For the interview, it was decided to focus only in the valorization chain of the spent coffee grounds.

The technical process of this project has finished and now the researchers of Spaak are dealing with the logistics analysis and the improvement of the process. Besides, as collaboration with different stakeholders is a key factor for the business strategy of the company, they also are looking for reliable partners to support their operations constantly. The interviewee, a researcher of Spaak, is carrying out a market research for this project which involves not only commercial aspects but also retrieving samples and conducting tests to evaluate potential suppliers. At this moment, these are different cafeterias, hotels and offices. After having been collected by a 3PL partner, the raw material is brought to the biorefinery where the extraction process is carried out. The interviewee was not able to provide more information about the process flow but he mentioned that there is no any pre-treatment to conditionate the raw material previous the extraction. Moreover, he explained that after the extraction process they still have some residues and they are still doing research to find out how these can be used.

Spaak as a company has three domains which lead its activities: identification of opportunities, building of business cases and create reliable partnership with all the parties involved in its projects. Therefore, it is important to remark that Spaak does not focus on developing its own

brand but on using as much side streams as possible in order to generate the most positive impact for the environment.

4.2.1 Quality control activities

The interviewee is in charge to carry out the market research for the valorization process of spent coffee grounds. He mentioned that although the operations for this project are not carrying out currently, considerations about quality aspects and the logistics have been considered.

The main quality attribute that has been set for the collected spent coffee grounds is the age or the period of time since their generation to their collection. This is very related to the concept of the acceptance period which is approximately 3 days. If the age of the raw material is higher than this period, mold starting to grow and this would affect the final quality of the oil. This is also directly related to the moisture content of the raw material as this has 60% of moisture on average which might allow the growing of this fungus. Besides, the variety of coffee was also a factor considered during the R&D phase. It was demonstrated during the pilot test that working with spent grounds of Arabica or Robusta coffee (varieties) lead to different levels of chemical purity for the final product. At this moment, Spaak has only considered a mix of varieties to its process and try to standardize parameters to avoid quality variability.

Once the raw material is collected, this is brought to the biorefinery for the extraction process. The interviewee mentioned that although they had applied the GMP (good manufacturing practices) in the Care-orange project, these are not applicable for this one. This is basically explained by the nature of the final products (oil and dyers) which are mostly used in the cosmetic sector where safety is not much considered comparing the food and beverage industry. The company also argues that they do not want to deal with food regulations so far.

The most important quality control activity is the chemical composition analysis of the final products by setting the concentration of free fatty acids as a quality indicator. To achieve the required final quality, it is important to fulfil first the initial quality for the spent coffee grounds in order to reduce the probability to reject a batch. Regarding the process parameters controlled, temperature and time during the extraction process are the most important. They do not use any mathematical quality prediction model as they have not been awarded about this, but he agreed that its application during the production will be a good technical support.

4.2.2 Logistics activities

Spaak projects to work together with a 3PL company which will collect and transport all the raw material to the biorefinery. The transportation modality chosen are electric vehicles. It is a feasible alternative for the company as the 3PL company has all the know-how about optimizing routes as there will be different flows of raw material that will depend on the supplier's location. Regarding production capacity, after carrying out the pilot test, Spaak has decided to scale-up the production to 25000 tonnes of spent coffee ground per year and it will increase progressively.

As was mentioned, the variety of coffee is also an important quality attribute that has an influence in the final product quality. The researcher argues that to have mono-streams flows of raw materials based on coffee variety instead of a mix is not feasible at this moment as each partner will have to be used to the fact that they will have to segregate the spent coffee grounds which will make the collection process more complex.

At the biorefinery, it is also considered to establish a specific site in the biorefinery where it will be eventually possible to separate batches of raw material based on their age. To achieve this, it was thought to implement a barcode system in order to apply traceability and to know which supplier provided the least suitable raw material. This can be a sort of tool in order to take decisions about suppliers' selection.

The interviewee also mentioned that relevant information to exchange with potential suppliers are quantities of raw materials generated, the age, the variety and even the roasting type of the coffee grounds if possible. He also described that the way how they would formalize the agreements between partners (suppliers and customers) are through letters of intents and thus, establishing a reliable collaboration. In order to minimize its risk, Spaak plans to establish a fix amount of production based on customers' orders in order to not pick up more raw material than required, and this agreement will be formalized by signing a letter of intent. About the raw material price, the company is not paying for this now as the supplier partners asked them to take all their side streams by free. However, they have considered that in the future, as all the market related to circular business will increase, the raw material cost will increase too and thus, the better relations they forge with their partners the more probability to get the best market prices. In case of raw material shortage, Spaak think that drying of raw material might be a solution for this problem but the operational costs that this operation involves are too high.

Regarding the geographical location of the operations, the interviewee considers that the best location is a centralized location. In the case of The Netherlands, it should be also close to the German market. In this way, the most optimal potential location for the biorefinery would be the eastern part of The Netherlands as if a radio circle is drawn around this area, several supplier partners will be located on it and this would support the logistics in terms of raw material collection and transportation. Otherwise, other regions would present sea spaces inside this radio.

4.2.3 QCL approach

The previous information for the case-study of Spaak is analysed by the application of the conceptual framework (Figure 3) to understand better the interaction of quality and logistics activities considering the QCL approach. It is relevant to mention that for this case in specific, even if this is not already a running project, the QCL approach might be still applied.

The main quality management strategy planned is the application of a barcode system in order to trace the quality per batch of raw material collected from the suppliers based on the desired quality attributes and thus, this can act as a decision-making tool for suppliers' assesment. Regarding logistics management, one of the key strategies of Spaak is to build reliable collaboration with all the stakeholders involved in the valorization chain of the spent coffee grounds. This is demonstrated by outsourcing the transportation activities from a 3PL partner which is in charge of collecting the raw material at the waste generation points representing by hotels, cafeterias and offices. Besides, as Spaak is working of this project for an external company, the amount collected is determined by the final product demand established by this company.

Each project covered by Spaak follows a specific structured methodology where the establishment of the main quality attributes of the final product is carried out during the research & development phase. The final product main quality attribute is its chemical composition defined by the concentration of free fatty acids. To obtain this the processing stage demands from the waste generation points spent coffee grounds with no more than 3 days of generated. This fact is supported by the R&D trials carried out previously where main findings explain that the longer the period since the spent coffee grounds have been generated the most prone are to be spoiled by mold, as these are hygroscopic and will absorb moisture required for the growth of this fungus. Besides, Spaak deals with different quality levels of raw materials as their supply consists of a mix of spent coffee grounds from two coffee varieties which also

influences the chemical purity of the final product. Although the Spaak has not established a proper quality measurement activity to deal with this variability, moisture measurement should be done in the waste generation points in order to use this information together with the acceptance period to develop a mathematical model to predict the growth rate of mold per batch of raw material. Temperature conditions must to be also considered if this approach is applied.

Regarding the location of the CQP, the final fatty acids concentration is mostly affected by the performance of the chemical extraction process related to the temperature and time values applied. Therefore, any deviation of the application of these parameters during the processing stage might significate a rejection of the final product quality.

Some information exchanged between the waste generation points and the processing stage are mostly related to the amount of available spent coffee grounds, the acceptance period and the coffee variety. Besides, this information provides insights to the 3PL partner in order to carry out an optimal collection and transportation. Once the raw material is collected and delivered to the processing stage, this can be stored for a short period of time. Here, barcodes are assigned per batch of raw material and its quality status defined by its age and moisture content might influence the extraction process parameters in order to obtain the desired final quality. Besides, this information obtained by supplier might help to evaluate them and to decide if more raw material will be collected from them in the future or not. In this context, the 3PL logistics should have to modify its operations like its routing planning and fleet management. In addition, as the available spent coffee grounds' collection is established in accordance to the final product demand, decisions about storage capacity might be influenced by the demand variability. Henceforth, the chemical extraction, transportation and storage can be dynamically influenced by the quality and availability of raw materials.

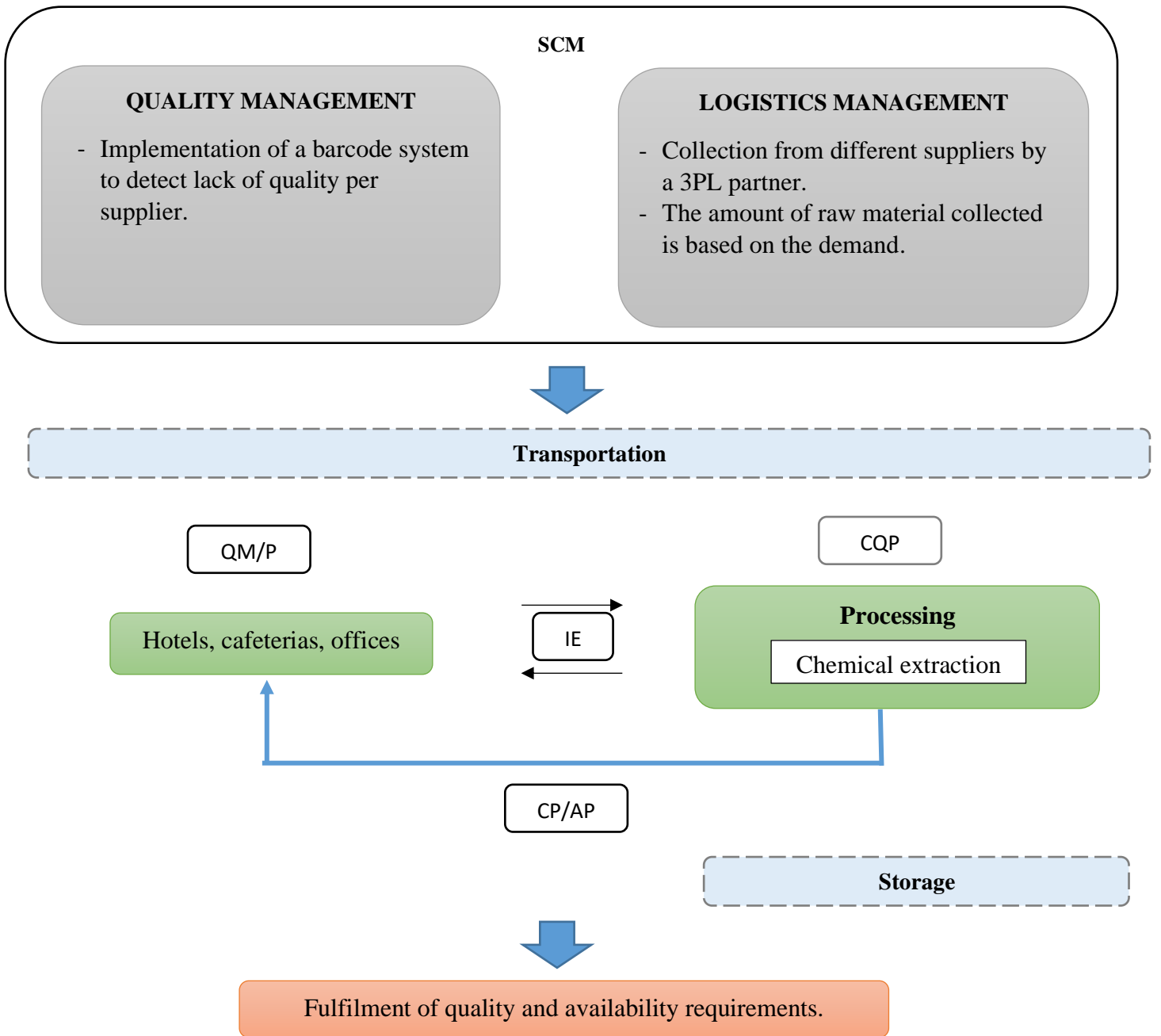


Figure 5: Conceptual framework applied to the Spaak case.

4.3 Fooditives

Fooditives B.V. is a Dutch startup that produces food additives from fruit by-products and ugly fruits in order to provide a healthy alternative for food production. The company started operations in 2018 in Rotterdam but the business idea behind had been thought around 8 years ago by its founder and food scientist, the interviewee. The company is formed for people from different backgrounds ensuring a multidisciplinary professional environment in order to cover all the operations which a company has to deal with.

The company has as its main product the Fooditives Sweetener, a zero-calorie and natural sweetener produced with apples and pears side streams supplied from different sources. Besides, there are three more products in its catalogue; a preserving agent made with side streams of carrot, a thickener produced with banana peels and an emulsifier extracted from potatoes. The R&D activities that addressed the development of these products has been described in patents and thus, technology innovation is considered part of its core business too. For the case study, the explanation of the valorization chain of the Fooditives Sweetener was chosen.

The valorization chain designed for these products starts with the supply of apples and pears leftovers from three different types of suppliers. Fruit that is still in the fields after harvest, side streams from companies that process apple or pear purees and ugly food discarded because of visual aspects from the distribution of agro-traders to supermarkets, are used to elaborate the Fooditives sweetener. These incoming flows of raw material are brought to an outsourced factory where by fermentation followed by a spray drying process the final product is obtained, packed and distributed. Among these stages, the company has established some partnerships with a 3PL company, suppliers and regional governments.

Fooditives is strongly concerned about the positive impacts of its operations in the current world. The company applies the corporate sustainability pillars in its activities. In the social aspect, it aims to provide healthy and low-calorie natural products for human consumption; regarding the economic factor, the company is always looking for contributing to establish fair relationships with its partners in terms of payments; finally, by ensuring the valorization of food side streams and using all the organic matter available avoiding any kind of waste that could be generated after the production process, the environmental pillar is fulfilled.

4.3.1 Quality control activities

The approach of Fooditives about the quality of the raw material covers from the harvest until the collection stage. They consider that the initial quality of apples and pears from the different incoming flows is really important for their process and it is a reliable indicator to know if the final product quality will be obtained. From the farms, agro-traders and food processing companies, all the raw material must be safe for human consumption. Besides, the content of sucrose is another relevant quality attribute for the fermentation process and thus, Brix degrees are measured. The company also tries to track all the incoming batches of raw material by assigning them a code and to monitor which suppliers provides the most suitable apples and pears side streams for the production. Each time the raw material is picked up, information about geographical origin, dates of production and the operational staff involved in this activity is recorded. Moreover, Fooditives considers that this traceability system is a decision-making tool for suppliers' evaluation.

About the acceptance period, the company only uses apples and pears with no more than 2 weeks since their harvest from suppliers as farmers and agro-traders, and for the apple or pears puree leftovers, it must be used the same day. The interviewee mentioned that they have never exceeded this period as their production is weekly and considers that in case this would exceed it, the initial quality required for the process might not be fulfilled.

Fooditives focuses on provide safe additives for the food and beverage production and thus, the application of the GMP is fundamental along their operations, especially to avoid the hazards represented by the possible cross-contamination from the operational staff. Among the processing stages, the company has set the raw material washing as a critical quality point in order to eliminate any physical contaminant. Besides, a great focus on the hygiene of the transportation vehicles and the process equipment to avoid cross-contamination is put into practice. There is no any mathematical quality prediction model applied, not even for the microbial growth but the interviewee believes that this would be a great tool for taking proactive actions based on the initial quality aspects of the raw material.

4.3.2 Logistics activities

For Fooditives, there does not exist suppliers or outsourced companies, but partners. They base their operations on trust between each other and rely on every partner will fulfil its function. As mentioned before, the company has established a traceability system to differentiate the incoming flows or batches of raw materials. This system is strongly supported by a logistical

partner whose main activities are assigning a code number to each batch of raw material collected and transporting it to the processing facility. This production plant is outsourced as the company still do not have enough capital to afford the building of an own one.

The company is conscious about sustainability but also about fairness and thus, the setting of prices for the raw material with all their suppliers is one element of the information exchanged system between them. Information about collection time windows and the quantity required is managed by the logistical partner, Fooditives and the suppliers jointly. The company has established contracts with all its partners as they consider that this is the best manner to ensure that everybody gets some benefit from the valorization chain.

The production process takes 5 days and thus, the production is weekly. The quantity produced varies based on the customers' demand and the raw material collected too. With this production scheme, the company tries to avoid storing any kind of organic material or final product. The company has not registered any raw material shortage situation but in case any of the suppliers do not fulfil the quality requirements or the availability of raw material is not enough, two other alternative suppliers per each original one are considered.

The transportation activities carried out by the logistical partner are done with electrical vehicles to be in accordance with the sustainability approach of the company. The partner also set the collection routes.

4.3.3 QCL approach

The previous information for the case-study of Fooditives is analysed by the application of the conceptual framework (Figure 3) to understand better the interaction of quality and logistics activities considering the QCL approach. The quality management strategy established by the company involves the application of quality assurance systems in their processes by taking care a lot the cleanliness along all the stages of the valorization chain. Besides, the traceability system applied to trace each batch of raw material collected and the recording of relevant information for the production process during the collection are also important for decision-making process. About logistics management, Fooditives' business strategy is very influenced by the partnerships set with different stakeholders that supports their logistics and operations optimally. This occurs with a logistical partner in charge of the transportation activities of the company. In addition, although there is a surplus of the raw material at the waste generation points, they collect the raw material based on the final product demand in order to avoid an excessive production that might imply an increasement in storage costs.

The pre-treatment process in this valorization chain is the sanitation. During this stage the raw material is washed and disinfected in order to reduce the risk of presenting any physical or microbiological hazard. This stage requires from the waste generation points fruits with no more than 2 weeks in storage after their harvest. By its part, the processing stage requires fruits with the suitable Brix degrees for the fermentation process and fruit in a good sanitized condition (no microbial spoilage). The company sets the sanitation process as the CQP as if the safety hazards that might be presented in the incoming raw material flows are not reduced or mitigated, the final quality attribute related to the safety of the products for human consumption is not fulfilled.

Regarding quality measurement and prediction, Fooditives has established the Brix degrees as a quality parameter to characterize the raw material flows and this control is done at the waste generation stage. They have not applied any mathematical quality prediction which uses this parameter to obtain insight about how quality might evolve on time.

Several information is obtained from the suppliers. This information regarding the amount of available raw material, its date of production, operational staff involved and other regarding raw material primary production, allows Fooditives to develop a traceability system to track all the incoming batches of raw materials characterizing them based on the Brix degrees they present. This is considered by the company as a decision-making tool for suppliers' evaluation by replacing the suppliers that not provide the required quality for raw material with other alternatives ones. Therefore, the logistic partner might also change their operations as routing planning and collection time windows if a new supplier is considered in the valorization chain. In addition, this traceability system allows the fermentation process to know in advance the which are the inputs and based on this adjust their process parameters to comply with the final quality required. Consequently, the processes dynamically influenced by the quality and availability of raw material are the processing and transportation. About storage, the company tries to avoid any kind of storage along their operations and this is only presented at the waste generation points which is managed by the suppliers and thus, out of the scope of the company.

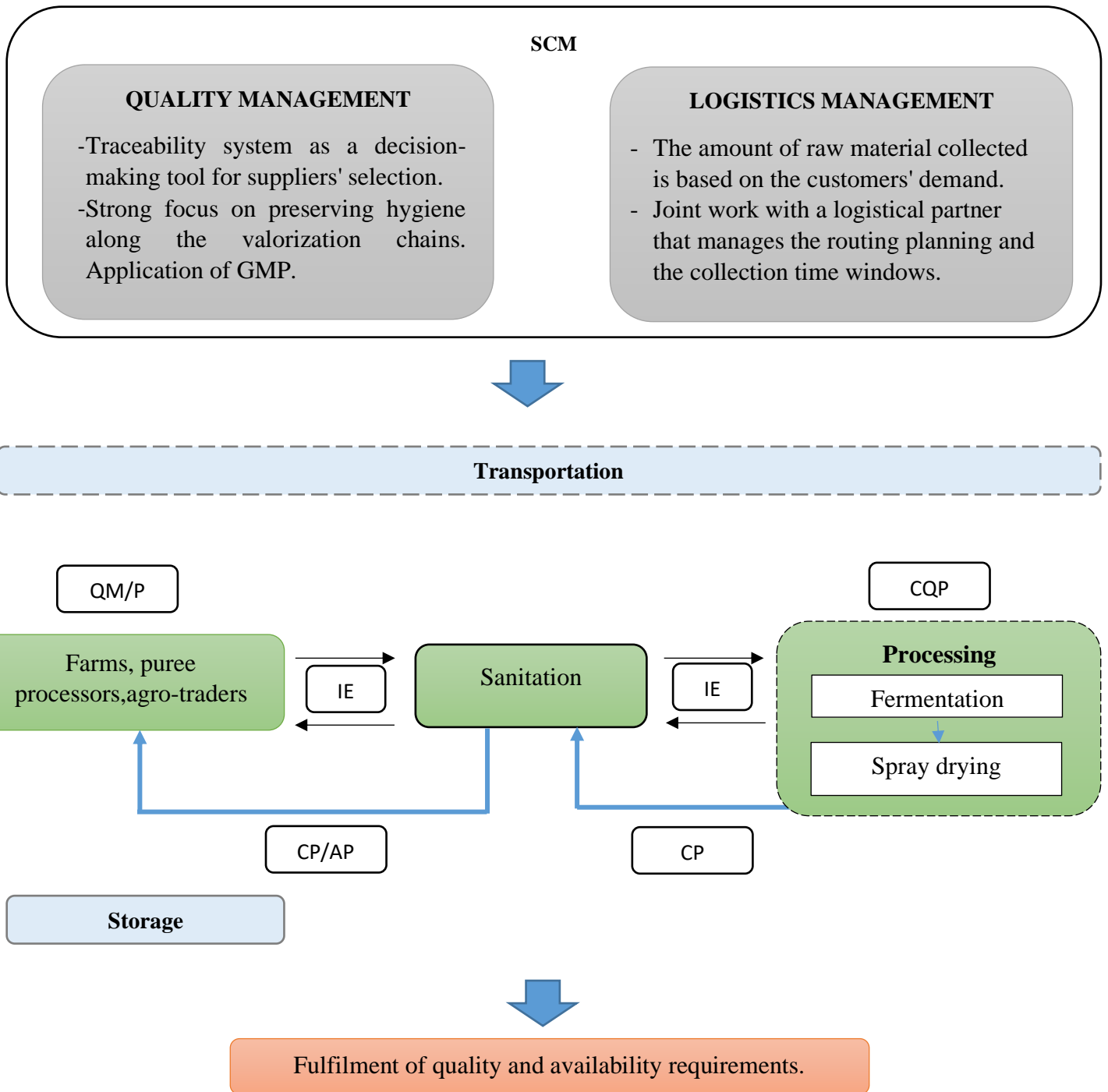


Figure 6: Conceptual framework applied to the Fooditives case.

4.4 Cross-case Synthesis

In this section, the empirical evidence about the interaction between the quality and logistics activities described by the previous section applying the conceptual framework to each case is contrasted case vs case by using the six QCL elements as categories. After discussing each element, an overview table is depicted to sum up the analysis. This analysis answers the sub-question 2 about how the QCL elements are deployed in real life FVW valorization chains.

A. Consumer preference and acceptance period of product quality attributes

Between the three cases, this is the element with the highest applicability as all the interviewees understood clearly which was the meaning behind this without any previous explanation. Besides, as they are all start-ups, the fulfilment of customers' requirements is an obligation to obtain an optimal performance. The totality of the quality attributes established by the companies are intrinsic. Corno Alimentos perceives the colour (sensory) of the beet stems as a main quality attribute in order to obtain the best characteristics for their final product. For this reason, it tries to avoid any external condition that would affect this attribute as the direct contact of the stems with the sunlight. For its part, Spaak considers the age (shelf life) of the spent coffee grounds or the time period since their generation as a main attribute. This is because this raw material is prone to mold growth due to their high moisture content. Moreover, the company has also established the variety of the coffee (sensory) as a quality attribute that will influence the chemical purity of its final products. Finally, Fooditives establishes two main quality attributes for the apples and pears side streams, their physical hygiene (safety) and their sucrose content (sensory) that contributes to an optimal fermentation process. Overall, the empirical evidence matches at some points from what was explained about the main by-product's quality attributes for valorization chains (moisture content, particle size and chemical composition). Even if the explanation in the literature review is more focus on the quality requirements for the process stage itself and do not necessarily from a consumer perspective, which is the main driver to define the attributes in real life situations, the application of both approaches need to be well established in order to obtain a good performance of the final product quality.

About the acceptance period, the three companies defined an accurate period of time where the quality attributes of the side streams are still acceptable for their purposes. Corno does not work with beet stems with more than three days under refrigerated storage conditions based on the results obtained during some trials. For Spaak, the age as quality attribute is at the same time

the acceptance period established. The company does not use spent coffee grounds with more than 3 days since its generation because of their perishable nature. Fooditives has established a longer acceptance period compared to the other cases. The company does not process any fruit which has an age of more than two weeks from its harvest in case it comes from farmers or agro-traders. For the apples or pears puree processors, the raw material must be used the same day as it is very prone to be spoiled. It is concluded that the acceptance period can be empirically determined by trials or previous observation about how the by-products behave in the processing stage and if the final required quality is obtained.

B. Critical quality points

The theoretical review raises that most of the time, the critical quality points are located at the pre-treatment stage, but as it is visualized among the cases, this stage is not always present in the valorization chains. Besides, there was mentioned that the drying, sorting and grinding are pre-treatments also considered critical quality points as if its technical parameters are not controlled efficiently, an unavoidable negative impact in quality will occur. Therefore, the empirical evidence contrasts this statement not only because of the consideration of the pre-treatments as critical quality points but also because of the type of process. For Cormo, the drying process is not considered as a pre-treatment but a critical quality point in order to obtain the required colour for its products as the control of temperature and time has been set based on this purpose. This control is also carried out under the HACCP plan in order to ensure the final product safety. For its part, the expert of Spaak did not provide much information about its process but he mentioned that temperature and time control during the extraction process is fundamental to ensure the final content of fatty acids of its product, which is the most important quality attribute for its customers, so this process is considered the critical quality point. Finally, Fooditives is more focus on the safety of its products by setting the raw material washing as the critical quality point in order to avoid any physical contaminant although the expert did not provide more details about the parameters controlled. The implementation of the GMP is the best way to control this based on the expert's opinion.

Overall, the location of the critical quality point can be flexible based on the valorization chain design and the process method applied by the companies. Quality assurance schemes as the HACCP plan and the GMP are also important to ensure quality along the processes, especially when the final destination of the products is human consumption as are the cases of Cormo and Fooditives. Furthermore, even if technical processes that determine the final quality are

presented in the valorization chain, the approach of the company about quality assurance can influence the definition of a critical quality point as Fooditives does by considering the raw material washing as the most relevant process rather than the fermentation.

C. Product quality measurement and prediction

The results from the empirical evidence about this element show that though quality measurement of the relevant quality parameters is done at different stages of the chain, the development of mathematical models for quality prediction is not used in real life situations.

However, Cormo Alimentos would consider to implement quality prediction models but to determine how the quality of its final product is modified on time by setting the moisture content as the main quality attribute to develop the model. In Spaak, they were not aware about the function of this tool but in case they would implement any model, it would be do it to set the most optimal parameters during the processing stage based on the incoming quality level of the raw material defined also by its moisture content which influences on the mold growth. Fooditives also argues that these mathematical models would be a good technical support for its processes considering the Brix degrees as the main quality parameter.

To conclude, it seems that the application of mathematical models for quality prediction is not applied for all the three companies in this research. Nevertheless, this is not necessarily a strict fact as these are start-ups, and as the experts mentioned during the interviews, they are still trying to improve their operations and are more focused on commercial rather than technical issues. It might be possible that companies that use much higher volumes of FVW streams apply some models to keep track the quality along the valorization chain and to set the most suitable conditions for processing operations as explained in section 2.3.1.

D. Logging and exchange of information

The evidence collected from previous studies establishes that logging and sharing information are fundamental in order to reduce uncertainties about the availability of raw materials and other factors between the partners presented along the valorization chains. This statement is supported by the evidence collected from the interviews where all the three experts share different kind of information with their partners.

The three companies are still developing in terms of process improvement, new market sector searching and product quality assurance. For this reason, working with different partners that have a better understanding of auxiliary operations as transportation or the required processing

installations is fundamental to growth as a business. In Cormo Alimentos, the strategic alliance with a wholesale market as the unique supplier of raw material allows the company to manage directly the initial quality by informing the required conditions during the collection stage to the partner in charge to carry out this activity. They also outsource the processing facility where by-products are processed and the partner is asked to share information about the certifications regarding the fulfilment of all sanitary regulations required. Another kind of information is presented in the case of Spaak, where different suppliers are considered. They consider that to know the available amount of spent coffee grounds prior the collection is relevant, but also information about the variety of the coffee and how these by-products were generated. Spaak also has planned to establish a partnership with a 3PL that will be in charge of raw material collection and thus, the company need to be able to provide information about its supply points. The main means that Spaak uses to formalize all the agreements with its partners are the letters of intents. For Fooditivities, the allocation of other activities that are not related to its core business is a fact as they consider that working with partners that have a better know-how about certain operations is the most efficient way to work for a company that is still growing. They establish formal contracts with the suppliers where agreements about the quality, volume and prices are set. Besides, they outsource its logistics operations by working with a logistical partner that knows in advance the exact quantity of side streams to collect and also the suppliers' locations that allow to develop the most optimal routing plan. One of the main business strategies that Fooditivities puts into practice to deal with quality assurance is the implementation of a traceability system that allows to track all the incoming flows of raw materials and make decisions about suppliers' performance based on the quality criteria.

To sum up, the logging and exchange of information as depicted in Figure 3, occur along the different stages of the valorization chain and between all the partners involved on these. However, the type of information and the means through this is shared might vary depending on the business strategy and to what extent the company would like to share private data. All the information shared brings the setting of formal agreements to fulfil the independent interests of each partner and at the same time, to create a reliable environment of collaboration.

E. Local dynamic/adaptive logistics and quality control

As explained in the literature review, this element considers the customer requirements and the quality and availability aspects to adapt the quality control and logistics operations throughout the chain. Four of the stages along the valorization chain depicted in Figure 3 are considered to

be dynamic or adaptive: the pre-treatment and processing (quality control), storage and transportation (logistics).

Cormo Alimentos established its required process technology based on the results from an intensive research carried out prior starting of its operations. They take into account the colour of the raw material as a main quality attribute and thus, the process parameters are adapted to keep this characteristic. In Spaak the situation is similar as they have just finished with the R&D phase where the most suitable process parameters have been established based on the raw material variety as a quality attribute. They are currently working with a mix of two varieties of coffee, but it is desired to work with separate flows of raw material's varieties. This would signify the production of products with higher chemical purity but also the adjustment of parameters of the current process. Fooditives has also allocated lots of resources in the R&D phase to establish the most suitable technology for their production process. Its main process is the fermentation and to obtain the desired outputs of this process, the fruits side streams need to comply with the sucrose content required (Brix degrees), so the process parameters are linked to the initial quality of the raw materials. Overall, the empirical evidence demonstrates that the diverse processes that are applied in the valorization chain must be adapted based on the quality attributes of the raw materials in order to set the most suitable process parameters but also considering the desired outputs.

Regarding the storage management, it is important to notice that the three projects try to avoid any kind of storage because of the perishability nature of the FVW streams and they do not have the economical capability to deal with providing the most optimal storage conditions neither. However, Cormo Alimentos does the sorting of its raw material based on visual checking of the colour at the refrigerated storage location of its supplier. In Spaak, they are considering to work with other kind of suppliers which higher supply capacity. Therefore, they are concern that if this agreement succeeds, they will need to establish a storage location for the different batches of raw material coming which have different quality levels. For this reason, the implementation of the planned traceability system would allow the company to sorting the raw material batches stored in terms of their age (quality attribute) and to adjust any parameter for their next process if it is required. The traceability system is also applied by Fooditives, but they use this tool in order to evaluate their suppliers in terms of the quality provided. The company does not have any inventory of raw material nor final product.

The transportation management in the valorization chains context is a relevant operation that deals with a trade-off between distances and efficiency. Between the three companies, it is possible to observe different scenarios in terms of the transportation operations. For Corno Alimentos, there is only supplier in the chain and the transportation modality selected is a truck with enough capacity to transport the required amount of raw material for the weekly operation of the company. The company considers the supplier's location as a key point for its processing operations as raw material do not travel long distances and it is not spoiled before processing. For its part, Spaak plans to outsource the transportation operations to a 3PL partner whose main activities are the collection of raw material and the setting of its optimal routes to cover with all the suppliers' locations. Nowadays, as they are still working in the market research of the project, they are concern about the location of the biorefinery and the potential near suppliers in order to establish the best scenario in terms of transportation and availability of raw material. The chosen transportation modalities are electric vehicles. A similar partnership with a 3PL partner is put into practice by Fooditives who also is aware about the hygiene conditions of the vehicles in order to prevent any kind of cross contamination. The company have three kind of suppliers but any special conditions, except for sanitation of the vehicles, are applied during the transportation of the raw materials from their locations to the production facility as they are produced the same day. Electric vehicles are also used and the 3PL partner is provided with information about suppliers' location and collection time windows. Therefore, transportation along the valorization chain deals with distances from the suppliers' locations to the processing plants. The shorter these distances are, a better management of quality of the raw material is carried out as spoilage is avoided as much as possible. Moreover, there is a trend for these kinds of companies to outsource the transportation operations as it is more efficient and economically feasible to allocate these activities to specialized partners.

F. Supply chain management

The theory behind this element is analysed from different perspectives by previous studies which covered fresh food supply chains. For this research the approach of this element is addressed to analyse the decisions made at the three strategic levels referred to the logistics and quality management.

Regarding logistics management, important decisions has been taken by the three companies in order to fulfil its requirements of raw material quantities. About strategic decisions, one of these is the selection of suppliers that has already been widely explained in the previous sections. The

strategic alliance of Cormo and the main Chilean wholesale market as its unique supplier is a good example of collaboration of different stakeholders involved in the valorization chain. The agreement of Spaak and its suppliers is another type of supplier selection based on their closeness in relation to the potential biorefinery location. For its part, Fooditives presents a better supplier selection method by implementing a traceability system to track the incoming flows of raw material per supplier and their quality conditions. About the establishment of the collection method and technology applied by these companies, all of them have made a great effort during the R&D phase to find the most optimal and suitable processes to collect and obtain their final products complying their consumers' requirements. Finally, the decisions related to the location of their operations differs between them. For Cormo, the location of its operations is totally influenced by the closeness to the location of the wholesale market as a unique supplier. Spaak and Fooditives consider that the geographical location of their operations must be a centralized location which ensures them enough suppliers for a long-term period and allows to build a professional network with different partners.

Besides, some tactical and operational decisions are also covered by valorization chains. For instance, production planning differs between the companies. On the one hand, Cormo has the production capacity of the outsourced production facility as the main constraint for its operations. The company collects and processes three times per week and the amount of raw material used is always the same. On the other hand, Spaak and Fooditives establish their production capacity based on customer' demand and as a consequence they do not collect more raw material than required to fulfil this. About decisions regarding transportation, while Cormo covers a unique transportation route and there is only one truck, Spaak and Fooditives prefer to assign these decisions to 3PL partners with a specialized know-how which have an electrical vehicle fleet and the necessary resources to carry out the most optimal routing planning.

Decisions for quality management in valorization are mostly related to how the company cope with the limited shelf life due to perishability and the variability of the FVW streams. As was already explained in previous sections, Cormo Alimentos relies the wholesale market as a strategic partner whose capacity to manage the initial quality of the raw material by delaying the quality decay using refrigerated storage conditions, represents a great advantage for the company. For their part, the traceability system applied by Spaak and Fooditives allows them to manage the quality of the different flows of raw material coming from different suppliers. Therefore, the traceability system is considered a tool to deal with quality assurance issues of the whole chain, not only about the raw materials flows but also about the final products,

providing the customers with valuable information about what they are acquiring. Another point about quality management described by the literature review is the establishment of a correct equipment maintenance in order to avoid any inconvenient during the production that might have a negative impact in the final product quality. In this context, all the three companies, considered start-ups, do not have their own production facilities and to outsource this service is more economically feasible for them as a business. This action allows the companies to allocate the decision-making process to these outsourced facilities in terms of the establishment of an equipment maintenance program and also the fulfilment of sanitary regulations for FVW streams processing.

An overview of the empirical evidence results considering the QCL elements as categories is depicted in Table 5.

Table 5

Overview of the application of the QCL elements in real life valorization chains

QCL element	Cormo Alimentos	Spaak Circular Solutions	Fooditives
Consumer preference and acceptance period of product quality attributes	<ul style="list-style-type: none"> - Colour as the main intrinsic quality attribute influences the final product acceptability. - Acceptance period established during the R&D phase. 	<ul style="list-style-type: none"> - Raw material variety impacts in the final product characteristics. - The acceptance period is considered as quality attribute. High moisture content means high perishability. 	<ul style="list-style-type: none"> - Hygiene as an intrinsic quality attribute. Sucrose content influences the performance of the processing stage. - Acceptance period established during the R&D phase.
CQP	<ul style="list-style-type: none"> - Drying. 	<ul style="list-style-type: none"> - Chemical extraction. 	<ul style="list-style-type: none"> - Raw material sanitation.
Product quality measurement and prediction	<ul style="list-style-type: none"> - No model applied. Potential use to measure moisture content of final product to evaluate quality decay on time. 	<ul style="list-style-type: none"> - No model applied. Potential use to establish the best process parameters. 	<ul style="list-style-type: none"> - No model applied. Brix degrees are a potential quality parameter for model developing.
Logging and exchange of information	<ul style="list-style-type: none"> - Initial raw material quality, certifications, process parameters. 	<ul style="list-style-type: none"> - Volume, varieties, processing, suppliers' locations. 	<ul style="list-style-type: none"> - Quality, volume, price, suppliers' location, collecting time windows.
Local dynamic/adaptive logistics and quality control	<ul style="list-style-type: none"> - Adapted process parameters based on initial quality attributes. - Sorting of raw material based on visual checking. - No special transportation conditions. One route. 	<ul style="list-style-type: none"> - Raw material variety influences the process parameters. - Traceability system to sort batches of raw material based on their age. - 3PL partner manages the collection activities. Different suppliers provide low volumes and different characteristics of raw material. 	<ul style="list-style-type: none"> - Adapted process parameters based on initial quality attributes. - Traceability system to track the incoming quality level of raw material per supplier. - 3PL partner manages the collection activities. 3 types of suppliers provide fixed amounts of raw material. Control of hygienic conditions.
Supply chain management	<ul style="list-style-type: none"> - Strategic alliance with its unique supplier. Production planning constrained by the production capacity of the outsourced production facility. 	<ul style="list-style-type: none"> - Selection of suppliers based on location. - Production based on demand. Outsourcing of production facility. 	<ul style="list-style-type: none"> - Constant evaluation of its suppliers based on quality. Centralized geographical location. - Production based on demand. Outsourcing of production facility.

4.5 QCL in fresh agri-food supply chains and food valorization chains

In order to answer sub-question 3, this section aims to contrast the main results of this study with the main results obtained by Delgado (2019) who studied the implementation of QCL in fresh food supply chains in order to find similarities between both.

Delgado (2019) analysed the QCL implementation in 4 cases, 2 fresh agri-food producers and 2 wholesalers. Whereas describing all the quality and logistics activities, the author defined 4 type of strategies that the fresh supply chains apply and act as a guideline for the optimal managing of the quality control and logistics activities (supply chain element). These are a volume-oriented strategy, characterized by managing a great variety of products that are allocated to match consumers` demand and a low level of information exchange between stakeholders; a supply chain oriented strategy with an integrated control at the upstream stages that allows the chain to cover both volume and quality requirements informed by customers and an extensive information exchange by receiving feedback from the customers; a market-oriented strategy strongly focused on information shared by customers and suppliers in order to predict demand and extent product shelf life respectively; and a quality-oriented strategy aiming to have a diversity of product qualities available to fulfil different customers` needs. Overall, although these 4 strategies apply the QCL elements in different ways, all of them aim to orient their activities to satisfy consumers` requirements concluding that the fresh supply chains studied by the author are demand-driven.

Regarding the cases analysed in the present study, it is possible to argue that they are also demand-driven supply chains as all of them have already established final product quality attributes for the target markets. However, valorization chains in theory are supply-driven supply chains as once the waste streams are generated, the supply chain must be designed from this point, establishing forward stages to add value to these streams. This is something that might mostly occur in low hierarchies strategies of food valorization as incineration or energy recycling but for recycling strategies, as the waste streams are now considered raw materials for producing added-value products, specific target markets` demand, volume, quality and even safety requirements must be reached, turning the supply-driven valorization chain into demand-driven supply chains. Moreover, this change might also be influenced by the results obtained during the research and development phase of the projects as based on the outputs from the first pilot trials, they could establish the most suitable raw materials` characteristics for their processes and thus, providing insights for reaching the best potential suppliers. Therefore, it is

possible to make an analogy of the strategies used by Delgado (2019) in the three cases studied. The strategic alliance of Cormo Alimentos with its unique supplier allows the company to get some control over the initial quality of the raw material and the required volume to fulfil its production planning and satisfy consumers' demand. This control over the upstream stages is mainly associated to the supply chain strategy. In the case of Spaak, the associated valorization project is still not operating but the empirical evidence would suggest that the volume-oriented strategy is applied in this case as many raw material flows with different qualities are supplied, and by means of the explained barcode system, it is possible to adjust the most suitable process parameters to fulfil the final product quality requirements. Finally, Fooditives applies a market-oriented strategy as they plan their production based on customers' demand, and based on this information they are also allowed to contact their suppliers to get insight about the raw material availability and to manage its collection. The traceability system applied by Fooditives also aims to provide reliable information among all the stakeholders in order to create a reliable collaboration

Regarding the consumer preference and acceptance period, it might be that the main similarity with the results of Delgado (2019) is that all the cases are oriented to fulfil customers' requirements even if they do not receive them directly. It means that it does not matter where the organization studied is located, upstream or downstream in the supply chain, the overall aim will be always satisfying the customer. Besides, the author mentions that the quality requirements for agri-food products are characterized by different parameters as colour, firmness and Brix degrees, but the main quality aspect to consider is the shelf life. This is considered also as the acceptance period of the product and whereas in the fresh food supply chains the not fulfilment of this period might significate revenues losses, for the valorization chains it is more a technical aspect issue as the raw material that does not comply with the acceptance period established might not be suitable for the valorization process. Overall, fresh food supply chains align all their effort to provide the required quality attributes to the client ensuring an enough shelf life to be delivered, and valorization chains applied this QCL element more in a technical way in order to fulfil the operational requirements and thus, to obtain the desired final quality attributes.

About CQP, Delgado (2019) located these points at the supply, production and distribution stages of the supply chains. Some CQP points are described during primary production in order to control the initial quality proactively once the product be harvested based on the customers' requirements. Other CQP are located during the storage of the products ensuring the well

function of the cooling and ripeness condition in case be required. In contrast, valorization chains studied locate their CQP mostly in their processing operations. This can be explained that the cases studied by Delgado (2019) only cover primary producer and wholesalers whose main business are producing, buying and selling but not processing. Therefore, it can be state that the commercial objectives of the companies or projects influence directly the location of the CQP along both chains.

There is also a distinction about the main activities of the companies related to the quality measurement and prediction modelling. The author argues that for primary producer's quality measurements focus on the compliance of the good agricultural practices while for wholesalers, measuring quality aims to extends the product shelf life and holding the product quality. Accepting sampling by visual control of the products, Brix degrees measurement and monitoring of the temperature during the storage at cooling cameras and during transportation by means of data loggers are some of the quality measurements described in the cases. In addition, the author states that obtaining temperature records is relevant to predict fresh product quality on time. Therefore, even if no mathematical model was developed for quality prediction, some cases monitored the quality of the product under specific temperature conditions for certain days in order to get insights about the quality decay. Nor models are also applied in the cases studied in this research but there are quality measurements activities similar to these mentioned as Brix degrees measurements and a visual sorting of the product based on sensory attributes. Nonetheless, the fresh food supply chains present a strong focus on ensuring the right temperature conditions along the chain which is something that is not fully considered by the valorization chains where no temperature conditions during storage or transportation are applied, except for the case of Corno where refrigerated storage of raw material is implemented by its supplier. This can be explained by the short time that the waste streams are manipulated and the avoiding of any kind of storage before their processing and the additional cost that the implementation of the required cooling systems represent.

Regarding the information exchange, Delgado (2019) mentions that most relevant information for fresh agri-food supply chains are related to the customer demand by means of purchase orders established in advance in order to ensure a correct supply, and the temperature history records along the chain which act as indicators for the product shelf-life. Besides, during transportation, the use of thermographs to track information on real time about temperature but also geographical location, supports the traceability of the product which is relevant in case any customers' claims is presented. The author concludes that while logging of information is

fundamental for an optimal quality control system, information exchange is an optional practice. This can be argued based on the empirical evidence of the present study as some information as the know-how of the main valorization processes were not completely shared during the interviews as is the case of Spaak. However, the cases show that information exchange in valorization chains is more important than logging information. On the one hand, all of the cases established any kind of collaboration with other stakeholders in order carry out their operations optimally, and to do this they had to share information about their valorization processes, required quantity and specifications of the raw material, and suppliers' locations. On the other hand, although logging of information is presented in a less relevant way than information exchange, as described by the cases of Cormo and Spaak where it was only focused on the process parameters records, Fooditives, apart from the recording processes parameters, is also aware about recording several information about the quality and geographical information during the waste stream collection to support its traceability system and thus, to offer a better service to the customer by providing reliable information when it is requested.

Finally, the local dynamics logistics and quality control element is also described along fresh agri-food supply chains. Main adaptive practices are related to the change of the inventory distribution methods, for instance from FIFO (first in, first off) to HQFO (high quality, first off) based on customers' requirements. This is presented as some of the cases store products with different qualities. Besides, some cases all have the adaptability to allocate the final product on different markets based on the its quality status. Other flexible activity is the establishment of the optimal storage parameters as temperature and oxygen concentration at the cooling cameras based on the final product characteristics requirements. Finally, in the case of wholesalers, they deal with different sources of products that change based on the demand and thus, they need to be flexible in managing their transportation including decisions as the selection of transportation modalities. On the other hand, valorization chains align their logistics and quality control activities to supply the most suitable raw material for the selected valorization process and obtain the desired final product quality. Some adaptive actions are the adjustment of processes parameters based on the incoming quality of the waste streams and the evaluation of suppliers based on the delivered quality of their waste streams. This last action influences directly some transportation decisions as routing and fleet planning. Overall, this element has the same objectives at both supply chains which is adapt their logistics and quality control activities to obtain the final desired quality, but while fresh agri-food supply chains do not produce the raw material and thus, these activities are directly related to fulfil optimally the

delivery of the final products to the client based on its specifications; valorizations chains adapt these activities to focus on satisfy the technical requirements for the valorization process.

CHAPTER 5: CONCLUSIONS AND DISCUSSION

In this chapter, the final conclusion of this research is outlined. Henceforward, the main results of the study are emphasized in order to answer the research questions. Besides, some remarks about the research methodology limitations and future research opportunities are presented.

5.1 General conclusions

This research aims to analyze how the implementation of Quality-Controlled Logistics approach along the FVW valorization chains might support the fulfilment of the expected quality and availability requirements. The first step of analysis was carried out by gaining insights about how the FVW valorization chain are designed, concluding that three main stages are presented: waste generation, pre-treatment and processing. Moreover, storage and transportation activities support the optimal interaction between them. Although these stages are extensively mentioned in previous studies, the empirical evidence suggests that this distribution might be flexible depending on the recycling valorization process selected, but also on to what extent the chain requires to implement storage and transportation activities. These insights about FVW valorization chain design together with information retrieved from previous studies about the application of the QCL approach allowed to build a conceptual framework about how the QCL elements are deployed in FVW real-life valorization chains.

Three FVW valorization projects were selected as cases to analyze more in depth the QCL application in real-life situations. The information compiled from semi-structured interviews was contrasted with the conceptual framework concluding that all the six elements can be implemented in accordance to the objective of fulfilling quality and availability requirements. However, there is not a standardized manner to present the elements along the valorization chains as their design is not always in accordance to that one proposed in the conceptual framework. For instance, the pre-treatment stage is not always applied because the established valorization strategy does not require it. Besides, storage is mostly avoided because the valorization projects tried to process the waste streams as soon as possible or to collect only the required amount based on customer´ demand. Therefore, these different distributions of stages and activities influence the interaction of the QCL elements.

Finally, this interaction between QCL elements is better detailed by comparing the results of Delgado (2019) about the application of QCL elements in fresh agri-food supply chains with those retrieved from the present study. The overall approach is starting by establish the main quality attributes that must be ensured in order to provide an acceptable final product quality and also the acceptance period during this quality is able to be hold. Then, once these attributes are identified, the critical quality points, where any quality deviation will result in failing to obtain the final desired quality, are located along the chains. To get insights about the status of these attributes and make decision based on this, the quality measurement and prediction element is applied. Once this information is obtained, together with other shared and recorded information compiled along all the stages and stakeholders of the chains, it is possible to adapt both quality control and logistics activities to obtain the desired outputs. Lastly, both fresh agri-food supply chains and FVW valorization chains set general strategies that cover all the decisions regarding quality and logistics management that the companies or projects must consider. These strategies are covered by the supply chain element.

Although the explained similarities about the general QCL approach addressed by both chains, fresh agri-food supply chains focus a lot on the temperature conditions control and record during storage and transportation in order to deal with the perishability factor. The application of devices as data loggers and thermographs seem to be very useful for this purpose. On the other hand, to deal with this issue, valorization chains try to avoid the excessive collection of waste streams and their further storage considering consumers' demand and thus, their production planning. In addition, although the temperature is also a relevant parameter to control during the valorization chains, it is more related to the optimum valorization process performance and not to the storage or transportation conditions. This statement is also supported by the fact that the supply chains described by Delgado (2019) do not present any production process, except from primary production, while valorization chains must ensure the optimal recycling process conditions to obtain the desired outputs.

5.2 Limitations of the study

The main limitation presented is regarding the application of the case study as the empirical methodology selected in order to create knowledge and contribute to the literature. The use of this methodology provides results that are not allowed to be generalized. In this case, the three projects studied are start-ups and they are still developing as companies by looking for process optimization methodologies and the fulfilment of customers' satisfaction. Therefore, the actions

taken by these companies might differ from those taken by companies whose valorization process is higher in scale and have allocated the required resources to be capable to optimize them. However, the conceptual framework presented is still applicable as this does not make any distinction between small or big companies. Besides, this study focuses on fruits and vegetables waste streams recycling valorization strategies and thus, it would not be suitable to apply the same approach, or even the same conceptual framework, to valorization chains that use other kind of organic raw materials or food valorization hierarchical strategies.

Regarding semi-structured interviews, although the interview guide and case study protocol were applied, some established questions were not asked during the interviews because some of them were not applicable for all the projects, but also because the interviewee was not allowed to provide confidential information that answer those questions. In addition, the data gathered from the interviews is the only source of empirical evidence and this goes against the criteria established by Yin (2009) to assess the case study research quality as this promotes the collection of relevant evidence from different sources and not only one. Besides, this study only applies 3 of the 4 criteria and not all the strategic tactics proposed by the author are applied. Consequently, it might be concluded that the reliability of the empirical research should be improved.

5.3 Future research opportunities

Based on these conclusions, future studies could address research by validating the presented conceptual framework in other companies than star-ups whose production capacity is bigger. Besides, the demarcation of fruits and vegetables waste streams can be also changed in order to generalize the framework for other kind of organic waste streams. For this purpose, the hierarchal valorization strategy studied must be also taken into consideration as the operations involved in the processing stage might vary. Finally, the implications of the practical implementation and assessment of the framework by setting suitable key performance indicators in the overall performance of a specific valorization chain might increase the study reliability.

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APPENDICES

APPENDIX A: LITERATURE ANALYSIS SEARCH STRATEGY

<p>Literature search 1: How is the fruit and vegetable waste valorization chain designed and which logistics activities are involved.</p>	<p>Literature search 2: To what extent Quality-Controlled Logistics elements might influence the achievement of the logistical matching in fruits and vegetables waste valorization chains?</p>
<p>Databases: WUR Library database, Scopus and ScienceDirect</p>	<p>Databases: WUR Library database, Scopus and ScienceDirect</p>
<p>Search terms:</p> <p>Fruit* OR vegetable* AND ('waste' OR 'by-product*' OR 'byproduct*') AND ('valorization strategies' OR 'valorization strategies')</p> <p>Fruit* OR vegetable* AND ('waste' OR 'by-product*' OR 'byproduct*') AND supply chain</p> <p>Fruit* OR vegetable* AND biomass AND supply chain</p> <p>Fruit* OR vegetable* AND ('waste' OR 'by-product*' OR 'byproduct*') AND logistics</p>	<p>Search terms:</p> <p>'quality-controlled' OR 'quality controlled' AND logistics AND fruit* AND vegetable*</p> <p>Biomass supply chain AND quality control</p> <p>By-product AND pre-treatment AND fruit* AND vegetable*</p> <p>By-product AND quality AND prediction AND fruit* AND vegetable*</p> <p>Industrial symbiosis OR biomass supply chain AND information AND exchange</p> <p>Industrial symbiosis OR biomass supply chain AND transportation AND storage AND logistics</p> <p>Industrial symbiosis OR biomass supply chain AND decision-making process</p>
<p>Initial body of literature: 66830</p>	<p>Initial body of literature: 5533</p>
<p>Secondary body of literature after screening: 13</p>	<p>Additional reference identified by a manual research in the reference lists from the retrieved articles:12</p>
<p>Secondary body of literature after screening: 27</p>	<p>Additional reference identified by a manual research in the reference lists from the retrieved articles: 12</p>
<p>Final body of literature after screening: 25</p>	<p>Final body of literature after screening: 39</p>

APPENDIX B: MAIN FINDINGS

Author(s)	Title	Main findings
Ayala-Zavala, et al. (2011)	Agro-industrial potential of exotic fruit byproducts as a source of food additives	<ul style="list-style-type: none"> – Fruit industry deals with a large percentage of by-products (peels, seeds). – The economics the tropical crops processing could be improved by developing higher-value products for their by-products. – By products of tropical fruits contain: high levels of health enhancing substances, and dietary fibre.
Kowalska et al. (2017)	What's new in biopotential of fruit and vegetable by-products applied in the food processing industry.	<ul style="list-style-type: none"> – Million tons of FVW with potential utilization are produced every year. These have a negative impact in the use of water and energy. – FVW have high content of bioactive components and are a natural raw material for recovery of valuable nutrients. – Apple pomace is a rich source of pectin, carbohydrate, crude fibre and minerals. – Dried mango by-products contain significant amount of pectin. – Sustainable economic development may be obtained by valorization of low value by-products. – Blueberries bagasse is dried in an oven at 60°C and ground to produce flour for beverage production.
Garcia-Garcia, et al. (2019)	Opportunities for waste valorization in the food industry - a case study with four UK food manufacturers	<ul style="list-style-type: none"> – Waste valorization is the process of converting waste into more useful products. – Waste materials are usually available in vast materials. – Food supply chains need significant changes o implement valorization strategies (set up biorefineries) – 4 valorization chains studied. All waste streams were analysed to understand their properties. – Key aspects for valorization chains design: quantities and types of biomass, patterns of generation, qualitative and quantitative characteristics of the waste, variability of waste generation.
Sagar et al., (2018).	Fruit and vegetable waste: Bioactive compounds, their extraction, and possible utilization	<ul style="list-style-type: none"> – Fruits and vegetables processing operations generate about 25 to 30 % by weight of waste. – Quantity and type of waste varies depending of commodities and morphological components. – FVW are susceptible to bacteria spoilage and thus these should be processed using thermal or

		non-thermal technologies to reduce contamination risk.
Alzate et al., (2017)	The profile of bioactive substances in ten vegetable and fruit by-products from a food supply chain in Colombia	<ul style="list-style-type: none"> – By-products disposal represents a growing problem because of their environmental impact. This is also prone to microbial spoilage. – The cost of drying, storing, and transporting by-products are economic obstacles for their use in low added value outputs. – Factors that economically limit the by-product valorization strategies: microbiological quality, chemical characterization, high cost of drying, storage and transportation. – Acceptance quality limit (AQL) tables were used to as a part of the quality control sampling procedure. – Carotenoids and polyphenols were analysed.
Banerjee et al., (2018)	Valorization of pineapple wastes for food and therapeutic applications	<ul style="list-style-type: none"> – Fruit and vegetable processing industries are the largest segment of food waste which is produced worldwide. Disposal of the waste involves high capital investment. Mostly transportation costs. – High content of carbohydrates of pineapple by-products (55%) makes it an appropriate substrate for high-added value chemicals. – Incineration is not feasible strategy for fruit waste processing because of their high-moisture content. – There is an insufficient understanding of fruit waste nutritional and economic value. – Valorization of pineapple waste is influenced by its chemical composition. Seasonality, maturity period and location of cultivation affect are factors involved. – Valorization strategies: bromelain extraction, polyphenols, organic acids. – Valorization process plant can be set up in the vicinity of pineapple processing facilities (suppliers).
Mirabella et al., (2014).	Current options for the valorization of food manufacturing waste: A review	<ul style="list-style-type: none"> – The large amount of food waste produced worldwide increases serious economic and environmental problems. – The application of industrial symbiosis represents a feasible alternative to food waste valorization. – The majority of the studies reviewed focus on pilot-scale laboratory experiences. – There is a lack of research about the logistics concerns of industrial symbiosis. – The promotion of industrial symbiosis is possible only upon evaluation of materials potential quality and quantity.

Plazzotta et al., (2017)	Fruit and vegetable waste management and the challenge of fresh-cut salad.	<ul style="list-style-type: none"> – FVW present high biodegradability. – Different management strategies can be applied to FVW. – Food by-products: biomass can be properly treated and transformed into valuable products. – Fruit and vegetable waste are the inedible parts of vegetables that are discarded during collection, handling, transportation and processing. – Waste management: collection, transport, recovery and disposal of waste. – Waste management strategies as classified hierarchically. – Partial drying is required to reduce water content of biomass for reusing purposes as it is prone to microbiological contamination. – Recycle of FVW: major modifications of waste materials. Offers more possibilities than reuse. – Intrinsic FVW characteristics: high water and fibre content, low protein content. – Production of FVW flour is viable if high-value added products are obtained. – Bio compounds: High initial investment . – Rational 4 step procedure to select the most effective valorization strategy: waste characterization, output definition, process design, feasibility study. – Cost of the valorization strategy is directly proportional to waste transportation.
Anwar et al., (2019)	The potential of utilising papaya seed oil and stone fruit kernel oil as non-edible feedstock for biodiesel production in Australia—a review.	<ul style="list-style-type: none"> – Local availability and cost-effectiveness are key parameters during selection of biomass feedstock. – Continuous supplying of feedstock is an obstacle to circular practices. – Storage of feedstock can be challenging as they are biodegradable.
Galanakis, C. (2012).	Recovery of high added-value components from food wastes: Conventional, emerging technologies and commercialized applications.	<ul style="list-style-type: none"> – Food biomass represent a cheap source of valuable bio compounds. Besides, they have high organic load. – Scientist are focusing on the recovery of functional compounds obtained from agricultural by-products. – Waste produced at final stages of the supply chain present difficulties during their collection as more effort is needed because of the different collection points. Biological stability is also an obstacle. – FVW processing wastes are the mostly waste streams studied as present different types of

		<p>antioxidants and dietary fibres. A simultaneous extraction can be done.</p> <ul style="list-style-type: none"> – Five distinct recovery stages are set for high added-value products production from fruits and vegetables waste: macroscopic pre-treatment, macro and micro molecules separation, extraction, isolation and purification, and product formation. However, sometimes some steps can be eliminated or oversubscribe each other. – More research should be done in achieving successful scale up of valorization strategies without affecting functional properties of the final output. – Functionality of final product is altered based on biomaterial specification. – Scale up is usually accompanied with complex concerns as extensive handling a continuous production.
Prosman, E., & Wæhrens, B. (2019)	Managing waste quality in industrial symbiosis: Insights on how to organize supplier integration	<ul style="list-style-type: none"> – Waste quality management by supplier integration. This is an industrial symbiosis capability. – Involving the right individuals is important for waste quality manging in an industrial symbiosis context.
Spatafora, C. (2012)	Valorization of vegetable waste: Identification of bioactive compounds and their chemo-enzymatic optimization	<ul style="list-style-type: none"> – Waste upgrading is a potential source of incomes. Source of high-added value products. – Two strategies for valorise vegetables by-products: identification and isolation of bio compounds (antiproliferative constituents from almond hulls), and chemical and enzymatic modification of the compounds. – There exists a growing interest in food biomass recycling though extraction and upgrading.
Demirbas, A. (2011)	Waste management, waste resource facilities and waste conversion processes	<ul style="list-style-type: none"> – Waste management is the collection, transport, processing, recycling and monitoring of waste materials. – Waste management system: Collection, transportation, pre-treatment and processing. – Recycling is the process of extracting valuable resources from waste – Re-introduction of suitable groups of biological material into production cycles as secondary feedstock is one goal of waste management. – It is relevant to understand the local factors such as waste characteristics and seasonal variations. – Waste management strategies are categorized into four areas: minimization of waste, recycling of waste, energy recovery, land filling.

		<ul style="list-style-type: none"> – Minimization of waste has the top priority. Recycling has the second priority as it is the recovery of materials that are able to be used as raw materials for other purposes. – The quantity and type of waste generated by a company reflect the nature and size of waste management operations. – Waste hierarchy (prevention, minimization, re-use, recycling, energy recovery, disposal) refers to make more sustainable use of waste to reduce environmental impacts. Waste hierarchy is the cornerstone of most waste minimization strategies. – Waste and recycling management plans must be developed previously starting of operations.
Topi, C. & Bilinska, M. (2017)	The Economic Case for the Circular Economy: From Food Waste to Resource	<ul style="list-style-type: none"> – Isolation of high value material is a major challenge when trying to apply food waste management strategies. – A case studied about the application of the circular economy principles to the chain of coffee is presented. Spent coffee ground waste was reused to produce high quality compost. The main finding was that this sustainable practice was attractive to investors. – Logistics aspects are considered under 4 scenarios by providing insights about the warehousing and transportation activities of Spent coffee ground waste.
Henríquez et al., (2010))	Development of an ingredient containing apple peel, as a source of polyphenols and dietary fibre	<ul style="list-style-type: none"> – The production of a new powder ingredient produced from apple peels waste is presented by this study. The stages of the procedure from collection to production is presented. – The drying technology did not affect significantly the nutritional quality of apple peel. – The by-product used has a high potential to as ingredient in the formulation of foods by presenting high levels of antioxidants and dietary fibre.
Górecka et al., (2010)	Raspberry pomace as a potential fibre source for cookies enrichment	<ul style="list-style-type: none"> – Drying process was required to facilitate distribution of raspberry pomace from a fruit processing plant.
Benítez et al., (2011)	Characterization of industrial onion wastes (<i>Allium cepa</i> L.): dietary fibre and bioactive compounds.	<ul style="list-style-type: none"> – Onions were cut to obtain different sections similar to those generated in industrial peeling. – Onion skin could be potentially used as a functional ingredient rich in dietary fibre and in total phenolics and flavonoids, with high antioxidant activity.

Djekrif-Dakhmouche et al., (2006)	Application of a statistical design to the optimization of culture medium for α -amylase production by <i>Aspergillus niger</i> ATCC 16404 grown on orange waste powder	<ul style="list-style-type: none"> – Orange peels generated from the juice processing industry are collected to produce a microbial substrate. It was concluded that this by-product is a good source of carbon for this purpose. – ‘The wastes are dried in the open air, and then, grounded and sifted (0.250 nm) and preserved in hermetically sealed boxes.’
Panouillé, M et al., (2009)	Recovery and reuse of trimming and pulps from fruit and vegetable processing	<ul style="list-style-type: none"> – Apple pomace and citrus peels are very prone to be spoilage by microorganisms in their wet state. They are usually dried for shipment or warehousing because the pectin production might be located in a different place apart from the by-product physical source or the production can be realized in different periods (seasonality).
Ajila et al., (2010).	Mango peel powder: A potential source of antioxidant and dietary fiber in macaroni preparations	<ul style="list-style-type: none"> – Mango peel was spread in trays and dried at 50 ± 2 °C using a crossflow drier. Afterward, the peel was powdered using a hammer mill and passed through a 150μm sieve.
Asif et al., (2016)	Therapeutic potentials of bioactive compounds from mango fruit wastes.	<ul style="list-style-type: none"> – Mango waste is mostly presented as peels and seeds. – Composition of mango seed kernel varies according to the variety.
Majerska et al., (2019)	A review of new directions in managing fruit and vegetable processing by-products	<ul style="list-style-type: none"> – Pomace contains above 80% of moisture content and thus considered perishable product. – Pomace is easily contaminated by microbes and this implies various problems during its storing. – Limiting storage space in processing plants and inadequate securing of pomace (environmental impact) – Type of preliminary treatment influence the final quality output (quality of dried apple pomace ,polyphenolic compounds depends on the drying method used) – Fruit and vegetables processing plants should take into account the space and infrastructure for pre-treatment of by-products.
Abdulrazik et al., (2017)	Multi-products productions from malaysian oil palm empty fruit bunch (efb): Analyzing economic potentials	<ul style="list-style-type: none"> – Oil palm empty fruit bunch valorization is motivated by its abundance, cheapness and production feasibility of different products. – Biomass supply chain modelling as a decision tool for determining valorization strategy.

	<p>from the optimal biomass supply chain</p>	<ul style="list-style-type: none"> – 3 collections points, intermediates processing plants, transportation networks (trucks and train) and storage facilities are considered in the model. Besides, biomass costs, production costs and transportation costs are used to calculate annual profit. – Waste generation yield is considered in the model. – There was a demarcation about the processing facilities location.
<p>Raimondo et al., (2018)</p>	<p>Making virtue out of necessity: Managing the citrus waste supply chain for bioeconomy</p>	<ul style="list-style-type: none"> – Distance of between waste generators and by-products processing plants is one of the main criteria for selecting the right valorization strategy. – Circular economy action plan recognizes bio economy as the pillar of circular economy. – Industrial adoption of innovation for valorization processes require collaborative R&D schemes and financial investment. – Contract mechanisms are considered as an effective way to achieve cooperation and coordination along supply chains by delivering flexibility. Besides, the risk of investment is sharing. – Stable relationships among stakeholders is a critical step for overcoming supply chain fragmentation. – Horizontal coordination helps the value chain to reach efficient and effective goals. – 4 coordination mechanisms: supply chain contract, information sharing, joint decision making, collective learning. – Biogas yield depend of different factors (citrus variety, pH, microbiological characteristics of the biomass) – Citrus by-products disposal represents a high cost activity. – Contract design: price of biomass, length of the contract, options for renegotiation and minimum product volume. – Return from citrus by-products in pectin is lower than from biogas production. – Energy required for waste drying can be an obstacle for the overall competitiveness of the valorization chain.

Author(s)	Title	Main findings
Sharma et al., (2013)	Biomass supply chain design and analysis: Basis, overview, modelling, challenges, and future	<ul style="list-style-type: none"> – The performance of supply chain depends on the degree of coordination and integration. – Pre-processing refers to any operation performed to ease transportation and storage. Pre-treatment can occur at different stages depending on the equipment requirements and location. – Biomass supply chains requires year-around and reliable supply. It deals with uncertainty and biomass availability. – Sources of variability: weather uncertainty, seasonality, geographical distribution, low bulk density of biomass. – Strategic decisions: design of efficient supply chain. Involve ensuring effective and efficient delivery of biomass, ensuring of biomass availability, collection and production technology selection, supply and demand contracts (terms of delivery and payments), number of locations and capacity of sites. – Tactical decisions: provide cost-benefit by planning production (alternative biomass suppliers), inventory planning (inventory policies), fleet management (transportation resources) and logistics management (information exchange, efficient flow of biomass) – Operational decisions: fulfilling demand in the best possible way. Delivery of biomass in the right quantity and in time. – Information exchange: entities, biomass types and end-products. Biomass availability, production capacities and production rates.
Akhtari et al., (2019)	Impact of inventory management on demand fulfilment, cost and emission of forest-based biomass supply chains using simulation modelling.	<ul style="list-style-type: none"> – Main key barriers for application of biomass supply chains: cost of biomass, feedstock availability, biomass quality. – A simulation model analyses two inventory systems: order up-to-level and fixed order quantity by comparing demand fulfilment, cost, and emissions for both. – Transportation cost has the highest contribution to the total cost in both systems. – Grinding operation is the second highest sourcing of expenses.

		<ul style="list-style-type: none"> – Biomass is bulky and its handling is challenging., requires pre-treatment, deals with seasonality. Disturbances (machine breakdowns) interrupts processing operations. – ‘Continuous feedstock supply avoids interruptions in production and therefore improve demand fulfilment of the supply chain. – Keeping too much biomass allows to avoid a shortage but increases handling costs. (biomass inventory management) – In case of the biomass substitution, procedure is based on biomass quality attributes. – Supplier factors: Monthly amount generated, production schedules, productivity. – Conversion site factors: biomass types demand, inventory management, inventory control parameters, moisture content, product yields. – ‘Total amount of biomass transported depends on the order quantity and the number of orders per year’ – ‘Fixed order quantity system has the better demand fulfilment.’ There is a greater amount of biomass that would be stored compare to the order-up-to-level situation. Less probability of shortage.
Castillo-Villar et al., (2017)	Integrating biomass quality variability in stochastic supply chain modeling and optimization for large-scale biofuel production	<ul style="list-style-type: none"> – An optimization model is presented that quantifies and control the impact of biomass quality variations on supply chain decisions and technology selection (strategic and tactical levels) – Biomass quality is represented by the moisture and ashes content. It also depends on the particle morphology. – Results indicate that overall cost increase as much as 27-31% because of the low quality of biomass (it requires of quality control activities) – Research if feedstock quality is still not covered and most traditional models focuses mainly in driving down logistics cost without consideration of the biomass quality impacts in the supply chain. – ‘A proper assessment if the optimization model is presented that quantifies and control the impact of biomass quality

		<p>variations on supply chain decisions and technology selection.</p> <ul style="list-style-type: none"> – Ignoring quality may lead to costly results only noticed after conversion processes. – Some important biomass supply chain decisions: biomass availability, transportation cost, conversion yield, technology selection, inclusion of pre-processing and quality control. – Moisture content impacts the biomass transportation costs.
Macheka et al., (2017)	Exploration of logistics and quality control activities in view of context characteristics and postharvest losses in fresh produce chains: A case study for tomatoes	<ul style="list-style-type: none"> – Interaction of logistics and quality control activities to prevent postharvest losses in fresh agri-products supply chains. – Four context characteristics proposed: product (inherent properties of raw materials), process (process parameters), organisation (administration conditions), and supply chain environment characteristics (relationships with other companies) – Inadequate logistics control: poor demand forecasting, inefficient inventory control systems, lack of supply chain coordination. – Inadequate quality control: insufficient temperature, humidity and atmospheric conditions, poor product quality control. – 6 core logistics (planning quantity to process, determine the mode and type of transportation, vehicle scheduling and routing) and 10 core quality control activities (deciding on grading standards, storage practices, maintenance of measuring equipment, monitoring environmental conditions) were found. – Managing logistics control activities is based on information about actual demand and product quality requirements. – Quality control activities are managed based on the use of scientific knowledge, standardised equipment, procedural method and systematic activities.
Van der Vorst et al., (2007)	Quality controlled logistics in food supply chain networks: integrated decision-making on quality and logistics to meet	<ul style="list-style-type: none"> – The Quality-Controlled Logistics approach provides a means to optimize product quality and availability in specific target markets. – Product quality prediction enables the control of supply chain processes optimally. – Supply chain management refers to matching supply and demand. It deals with

	advanced customer demands	choices regarding the distribution networks design, transport and production infrastructures, inventory management and information flows.
Macheka (2010)	<i>Using quality controlled logistics concept to reduce food losses in fresh agri-produce supply chains</i>	<ul style="list-style-type: none"> – ‘A high level of control quality controlled logistics which is characterised by the integration of quality control and logistics control will result in less defective produce and minimal losses and waste in the fresh agri-product supply chain through use of product quality information and predictive models to direct logistics activities’.
Heising et al., (2017)	Options for reducing food waste by ‘quality controlled logistics’ using intelligent packaging along the supply chain.	<ul style="list-style-type: none"> – The application of intelligent packaging (IP) can reduce food waste generation when it is used in quality-controlled logistics systems. – IP allows food quality monitoring throughout the whole chain. – Quality of raw materials and environmental conditions strongly influences the final product quality. – The interaction between actual quality and logistics decision-support models can applied to improve supply chain performance. – QCL: leads to obtain knowledge about quality status at its last destination. – ‘QCL is based on variation in product quality, developments in technology, heterogeneous needs of customers and the possibilities to manage product quality changes.’
Delgado del Río (2019)	Implementation of quality controlled logistics in the fresh food supply chain: A multiple case study research on global food supply chains	<ul style="list-style-type: none"> – A multiple case study was developed in order to analyse to what extent the six Quality-Controlled Logistics elements are engage to real life supply chains. – Quality control and logistics are dynamic as they use real-time product quality information to fulfil customers’ requirements. – ‘Traditionally issuing policies are driven by storage time but new rotation systems are product quality driven.’ – Despite the supply chain configuration, the six elements can be implemented but with different specific activities among them.
Van der Vorst et al., (2011)	Towards a diagnostic instrument to identify improvement opportunities for	<ul style="list-style-type: none"> – Identification of six element required to implement the Quality-Controlled Logistics approach in a specific supply chain.

	quality controlled logistics in agrifood supply chain networks. <i>International Journal on Food System Dynamics</i> , 2(1), 94-105.	<ul style="list-style-type: none"> – Supply chain configuration can be influenced by the relationship between the information about the chain conditions and the dynamic behaviour of the quality attributes. – Product quality measurement and prediction provides information to supply chain actor in order to make proactive decisions. – Information about demand, inventory and supply can be exchanged in the supply chain.
Luning & Marcelis (2009)	Food quality management: Technological and managerial principles and practices.	<ul style="list-style-type: none"> – A model proposed involves intrinsic and extrinsic quality attributes. It argues that quality perception depends on noticeable product attributes which can be split in intrinsic (safety, health, sensory, shelf life, convenience) and extrinsic (production system characteristics, assigned quality by marketing/communication) attributes. At the same time, these are influenced by physicochemical properties of raw materials and intermediate products, technological factors and legislation. – A definition of Critical Quality Point is defined as a point in the supply chain where variations in the quality attributes results in irreversible deviations not desired by customers. – Logistics management is complex for food supply chains as deals with variability and short shelf life of the products. Therefore, specific conditions must be considered to maintain the desired quality level. – Food quality management covers both, production systems and dynamic behaviour of people towards quality.
Moschopoulou et al. (2019)	Food Quality Changes during shelf life	<ul style="list-style-type: none"> - Quality attributes are classified in intrinsic and extrinsic. Different elements are set inside these groups: pH, water activity, microflora, enzymes and redox potential as intrinsic factors while processing, storage conditions and packaging practices refer to extrinsic attributes.
Spatari et al., (2014)	Uncertainties in life cycle greenhouse gas emissions from advanced biomass feedstock logistics	<ul style="list-style-type: none"> – Pre-treatment sites densify and stabilize the biomass feedstock in order to ease the long-distance transportation and delivery to final processing sites.

	supply chains in Kansas	<ul style="list-style-type: none"> – Logistics activities consist of harvest, collection and storage, biomass transportation from collection sites to pre-treatment depots, pre-treatment operations and transportation of biomass to final processing sites. – Biomass storage activities are constrained in their ability to address biomass quality issues (moisture content, ash content).
Malladi et al., (2018)	Development of a decision support tool for optimizing the short-term logistics of forest-based biomass	<ul style="list-style-type: none"> – Biomass logistics is complex and involves interdependent decisions related to storage, pre-treatments and transportation. – There exist more studies focus on medium-term decisions than short-term planning decisions. – A mixed integer model was developed to determine pre-treatment scheduling and the number of vehicles for different types of biomass on daily operations. – Direct delivery of biomass from suppliers to conversion sites could result in cost savings. – Collection of biomasses can be supply or demand-driven. – Storage of biomass decisions: quantity to be stored and location, – Pre-treatment: size and quality requirements. – Challenges during storage: storage space availability, additional pre-processing, equipment availability, operation scheduling. – Transportation challenges: capacity, the setting of time windows. – Pre-treatment and transportation decision taken based on supply and demand quantities. – Input data: daily truck availability, daily biomass supply, daily biomass demand.
Kaderides & Goula (2017)	Development and characterization of a new encapsulating agent from orange juice by-products	<ul style="list-style-type: none"> – Fruits wastes are an important source of natural fibres. – Chemical composition and water holding capacity were considered orange by-product quality attributes.
Henriquez et al., (2014)	Kinetic modeling of phenolic compound degradation during drum-drying of apple peel by-products.	<ul style="list-style-type: none"> – Apple peel presents a high total phenolic content (TPC). These compounds are highly thermosensitive and unstable. TPC degradation exhibited first-order kinetics. – Drying causes physical, chemical, structural and biological changes that affect by-product quality attributes.

		<ul style="list-style-type: none"> – Long-term drying processes affect antioxidants properties. – Kinetic simulation of water transfer allows to control and optimize the drying process.
Withouck et al., (2019)	Evaluation of the impact of pre-treatment and extraction conditions on the polyphenolic profile and antioxidant activity of Belgium apple wood	<ul style="list-style-type: none"> – Apple wood has a high moisture content and is considered unstable and easily degradable. – The exposure to oxygen during oven-drying process influence the chemical composition. – Total phenolic content is evaluated as a quality attribute. – Pre-treatment process influence the phenolic composition of the biomass.
O’Shea et al., (2015)	Physicochemical assessment of two fruit by-products as functional ingredients: Apple and orange pomace.	<ul style="list-style-type: none"> – Apple pomace flour produced viscous pastes because of its high content of pectin. – It is relevant to understand the individual components functionality of raw material to fully utilize their activity in food applications. – By-products generated from citrus processing have the advantage of being gluten and lactose free and thus represent ideal ingredients for diverse food applications. – Cultivar is a factor that influence the functionality and nutritional properties of the final flours.
Gómez & Martínez (2018)	Fruit and vegetable by-products as novel ingredients to improve the nutritional quality of baked goods.	<ul style="list-style-type: none"> – Utilization of fruits and vegetables by-products (FVB)in bakery products deals with loss of customer acceptability. This is mostly due to lack understanding of physical structure and chemical composition of the waste streams and their effect in the final product quality. – Organic dry matter is influenced by the origin of fruit or vegetable, degree of ripening and the manufacturing process. – Only small quantities of FVB should be utilized in cereal-based products otherwise loss quality is occurring. Dough structure is affected, and sensory attributes are negatively impacted. – Interaction between FVB and other components in the dough depends on the intrinsic factor as composition, physical properties (water binding, capacity, gel-formation activity, particle size). – Bakery products quality loss is based on the reduction in bread volumes and increasing of crumb hardness (appearance).

		<ul style="list-style-type: none"> – ‘Many fibres presented in FVB are hydrophilic and have a natural affinity for water.’ – Nutritional improvement is obtained by enrichment of bakery products with FVB flours. – Astringent polyphenols can reduce the acceptability of breads. Particle size of FVB influences also the volume and hardness characteristics. – FVB that contain high fibre content present a difficulty to mill and thus coarse particles are obtained. – Strategic selection of FVB with optimal composition and physical properties that do not affect the quality of bakery products must be done prior manufacturing (process conditions) – Use of additives can be considered to minimize the impact on quality and increase acceptability.
Keizer et al., (2017)	Logistics network design for perishable products with heterogeneous quality decay	<ul style="list-style-type: none"> – Duration of logistics operations and environmental conditions impact the overall performance of fresh agricultural products network logistics activities. – Lead time and product quality should be considered in the decision-making process. – Different level of quality decays means different network structures. – Information about quality decay can be used to optimise stock rotation systems. – Trade-offs between delivery lead time, location, transportation and inventory costs address the decision-making process. – Product quality decay is mostly implemented at the tactical and operation levels. – In closed loop supply chains, multiple quality levels are due to the final strategy proposed. – Product quality decreases with each logistics operation considering operational characteristics and decay rate. Use of quality decay function (based on a time - temperature model)
O'Shea et al., (2012)	Dietary fibre and phytochemical characteristics of fruit and vegetable by-	<ul style="list-style-type: none"> – Fruits and vegetables by-products have a high nutritional value. Their use as a food ingredient due to their functional abilities

	<p>products and their recent applications as novel ingredients in food products.</p>	<p>such as gelling and water binding is a potential valorization strategy.</p> <ul style="list-style-type: none"> – Drying is the most favourable by-products pre-treatment in order to maintain their chemical stability.
<p>Malladi & Sowlati (2018)</p>	<p>Biomass logistics: A review of important features, optimization modeling and the new trends</p>	<ul style="list-style-type: none"> – Biomass logistics: harvesting and collection, storage, pre-processing and transportation. There exists a high level of inter-dependence among logistics operations. – Biomass: seasonal available, scattered geographically and has quality variations. – Biomass logistics decisions are made at the strategic and tactical planning level. – Biomass collection: procurement of the required quantities of biomass from supply points. Medium (selecting suppliers, determine quantity of biomass) and short-term (scheduling of collection resources) planning level. – Demand-driven collection: Only the required quantity of biomass is collected in order to fulfil customer’s demand. Result in leaving some biomass at the supply sites and thus requires storage space there. – Supply-driven collection: the entire quantity of feedstock is collected, and it is constrained by time windows. Storage space has a limit at the supply points. – Biomass quality deterioration: different supply points means biomass with different characteristics. The total quantity of biomass depends of its quality. Quality does not affect supply-driven collection of biomasses (all biomass is collected). – Operational level transportation planning: Multiple modes of transportation are used. Short-term planning decisions cover with allocating biomass from suppliers to buyers and planning routes. – Storage: decisions involve quantity to be stored and type of storage (covered or open-air storages). Driven by logistical matching. Storage of biomass can be presented at different locations. At intermediate locations, there is a trade-off between the handling of high volumes of biomass and the transportation and handling costs involved.

		<ul style="list-style-type: none"> – Pre-treatment planning: sorting, grinding, drying and densification. It increases transportation efficiency and biomass quality. Decisions are related to quantity to be processed and scheduling of operations. – Variations in biomass quality influence collection and transportation operations in the short-term.
Gianico et al., (2013)	Ultrasonic and thermal pretreatments to enhance the anaerobic bioconversion of olive husks	<ul style="list-style-type: none"> – Factors that affect pre-treatment are residence time, temperature, chip size and moisture. – The pre-treatment effects are linked with substrate features and mechanisms.
Bchir et al., (2009)	Original article: Osmotic dehydration of pomegranate seeds: Mass transfer kinetics and differential scanning calorimetry characterization	<ul style="list-style-type: none"> – The increase of temperature favoured the increased of water loss, weight reduction, solids gain and effective diffusivity during the osmotic dehydration process of pomegranate seeds.
Marques et al., (2018)	Planning woody biomass supply in hot systems under variable chips energy content.	<ul style="list-style-type: none"> – ‘The higher the moisture content of wood chips, the lower its net caloric value and therefore, a larger amount of chips is needed to meet the contracted demand’ – A mathematical model was developed for biomass supply planning at the tactical level by considering the moisture content of biomass.
Rong et al., (2011)	An optimization approach for managing fresh food quality throughout the supply chain.	<ul style="list-style-type: none"> – ‘Quality prediction of food products is a complex task, due to the range and dynamics of product characteristics and storage conditions’ – ‘For a given product there is normally one leading quality characteristic that can then be used in quality prediction models’
Dekker et al., (2014)	Predictive modelling of vegetable firmness after thermal pre-treatments and steaming	<ul style="list-style-type: none"> – Texture is a relevant product property that affects quality evaluation of processed vegetables. – The effect of time and temperature of thermal pre-treatment on the rate constant of softening is evaluated by mathematical modelling. – The model can be applied to improve other quality attributes (multi-criteria optimization). – The temperature effect on the rate of softening is described by the Arrhenius equation.

Zhang et al., (2012)	Development of a simulation model of biomass supply chain for biofuel production	<ul style="list-style-type: none"> – Key supply chain activities: biomass processing, transportation and storage. – Cost and complexity of biomass supply chain activities represent an obstacle for biomass utilization. – Biomass supply chain is driven by daily demand and daily biomass recovery.
De Meyer et al., (2016)	A reference data model to support biomass supply chain modelling and optimisation	<ul style="list-style-type: none"> – A mathematical model for decision support that covers biomass types and handling operations is developed. – Uncertainties of biomass supply chains: weather variability, policy conditions, market fluctuations. – Transportation and handling costs are the main economic barriers for implementation of biomass supply chains. – A reference data model must be applicable to different types of biomass and cover with the three different levels of decision making (strategic, tactical and operational). – 6 key operations: biomass production, harvest, collection, pre-treatment (adapt its properties, physical size reduction and densification), storage, conversion. – Two types of data: spatial (locations of biomass production, storage pre-treatment and conversion facilities, operation options, capacity, transportation mode) and non-spatial (possible sequences, mutual relationship between stages)
Fraccascia & Yazan (2018)	The role of online information-sharing platforms on the performance of industrial symbiosis networks	<ul style="list-style-type: none"> – Match between waste supply and demand is an important condition to carry out industrial symbiosis practices. – ‘This match is hampered by lack of information among companies.’ – Waste generators companies are not aware of the waste demand. – Information regarding geographical location, type and quantity of produced and required biomass. – Waste treatment, transportation and transaction costs are additional costs apart from discharge and purchasing. – Information exchange increases the trust between companies, but it is also a fact of revealing private data about formulation of products. – Industrial symbiosis needs basic information about available and requested amount of

		<p>biomass, waste quality, waste content (physical and chemical characteristics), potential treatment costs and transportation issues.</p> <ul style="list-style-type: none"> – ‘Waste treatment costs depend on the technical substitutability between wastes and inputs)’ – Companies are willing to cooperate only if they find benefits from this practice. – Sharing information via online platforms supports the economic and environmental performance of the industrial symbiosis network. – Information exchange recues uncertainties and implements a trustful network.
Herczeg, et al., (2018)	Supply chain collaboration in industrial symbiosis networks	<ul style="list-style-type: none"> – ‘Logistical integration is characterized by exchanging explicit information between companied, such as production plans and inventory levels.’ – ‘The availability of industrial waste is the result of a push process, meaning that surplus or shortage can occur due to the variability in supply and demand, and the different seasonal characteristics in different industries.’
Zema et al., (2018)	Logistics in the Biomass Supply Chain of Bio-energy Plants in Southern Italy	<ul style="list-style-type: none"> – Cost of biomass supply chains must be properly calculated and optimized to enhance competitiveness. – Key problems are related to timely and availability of biomass, scattered geographical distribution, storage operations. – The most important KPI for supply chain efficiency is the total cost. – Biomass physical and chemical characteristics depends on the processing technology applied.
Prosman & Wæhrens (2019)	Managing waste quality in industrial symbiosis: Insights on how to organize supplier integration	<ul style="list-style-type: none"> – Waste materials present often low quality. Therefore, production issues may occur. – Supplier integration: information exchange by means of reports, calls, e-mails and visits. It aims to align waste quality with production requirements. – High internal manufacturing complexity may lead to complex relationships between waste quality and operational parameters. – Aligning waste quality and requirements may involve waste fraction separations and mixing with another feedstock.

Rentizelas et al., (2009).	Logistics issues of biomass: The storage problem and the multi-biomass supply chain.	<ul style="list-style-type: none"> – Larger fraction of the overall cost in the biomass supply chain come from the logistics activities. – Using storage facilities located in the processing sites accelerates the drying process of the biomass (using of heat produced). – Pre-processing improves handling efficiency and the quantity delivered. – Collection of large volumes of biomass requires equipment and workforce. – Low-density materials: increase storage space, may need customized collection equipment.
Gleissner & Femerling (2013)	<i>Logistics : Basics -- exercises -- case studies (Springer texts in business and economics</i>	<ul style="list-style-type: none"> – Logistics has become more complex over time; from the simple view of transporting, handling and warehousing activities towards a management-oriented perspective of global value chains.
Domenech, et al., (2019)	Mapping industrial symbiosis development in Europe, typologies of networks, characteristics, performance and contribution to the circular economy.	<ul style="list-style-type: none"> - The geographical scope within industrial symbiosis schemes depends on the type of waste stream, transportation costs and market value of secondary materials.
Sosa et al., (2015)	Controlling moisture content and truck configurations to model and optimise biomass supply chain logistics in Ireland	<ul style="list-style-type: none"> – A linear model was developed to optimize biomass supply chain cost by considering moisture content as a driving factor. – Impact of moisture content and truck configurations. – ‘Minimizing transportation costs is considered an essential aspect on supply chain optimization’ – Control of biomass moisture content is a beneficial activity when planning logistics. This provides relevant information about the biomass volume and the time this can be stored. It also supports the quantification of truckloads to deliver the biomass.
Oo et al., (2012)	Assessment of Business Case for Purpose Grown Biomass in Ontario: A Report for Ontario Federation of Agriculture.	<ul style="list-style-type: none"> - ‘Transportation cost for biomass is a function of distance, density of the biomass and mode of transportation.’

Abdulrazik et al., (2019)	A model-based approach for biomass-to-bioproducts supply chain network planning optimization	<ul style="list-style-type: none"> – An optimization model was developed considering multiple cost sources including biomass resource acquisition cost, production cost, and transportation cost.
Santibañez et al., (2015)	A mixed-integer dynamic optimization approach for the optimal planning of distributed biorefineries	<ul style="list-style-type: none"> – Biomass supply chain: selection of processing technologies, portfolio of products, feedstock selection. – Issues: Various biomass suppliers, availability and seasonality of biomass, potential geographical locations, locations of storage facilities, and transportation modes. – Biomass supply chain considers the flow of raw material and products and the flow of information among different stages. – A mathematical model has been proposed to get the optimal configuration of a biomass supply chain. The model allows to select the processing technologies, processing facilities location, manufactured products and utilized raw materials.

APPENDIX C: CASE STUDY PROTOCOL

CASE STUDY PROTOCOL

A. Overview of the case study research (Take into account for Appendix D)

1. Introduction:

Fruit and vegetables waste (FVW) streams processing companies deal with the biological characteristics of their feedstock which hinder the proper transport, storage, and preservation activities, as these features are associated with increased risk of microbial contamination and thus their degradation along their valorization chain. In this context, research is needed to analyse how the Quality-Controlled Logistics approach implementation might deal with this problem and to ensure the optimal delivery of these waste streams from the waste generation point to the demander point in terms of quality and availability.

2. Case study purpose and question:

The purpose of this case study research is to gain empirical insights about the application of the QCL practices in real life situations. This will allow to support, validate or contrast the conceptual framework developed. Therefore, the following research question is set:

- How are the Quality-Controlled Logistics elements deployed in the real-life fruits and vegetables waste valorization chains?

B. Field procedures

1. Name of the person of contact and organization:

- ##### 2. Expected preparation prior data collection:
- ask for recording permissions, data protection (confidentiality) to the interviewee. Check for all the materials required (laptop, voice recorder, pen and paper)

3. Data collection plan:

Role of the interviewee in the organization:

Type of evidence expected: oral testimony about the quality control and logistics activities in the processing of FVW streams. Application of the 6 QCL elements explained in the literature review in empirical situations.

Documents to be reviewed: if possible, get access to the documental procedures or records about quality control or contracts formats the company uses.

***Include here Appendix E**

C. Case study questions:

1. The fruit or vegetable waste valorization chain design

- a. Describe the stages of the processing chain for a specific raw material, including parameters, if any.
- b. How has the valorization chain been designed? Which factors have delimited the selection of the raw material?
- c. To what extent is the collaboration with your suppliers supporting your operations?
- d. Which are the main objectives of the valorization chain based on a customer perspective?

2. The application of QCL in real life valorization chains

- a. Which are the main quality attributes for the process?
- b. Have quality control activities been implemented? Which stages are implied? If any.
- c. Describe the quality control activities in detail considering the person in charge and documents recorded, if any.
- d. Describe which type of information is exchanged with the suppliers.
- e. Which are the main logistics aspects in the company? Describe in detail inventory management and transportation management activities.

D. Outline of case study reports

1. Background of the company
2. Designing of the fruit or vegetable waste valorization chain. Depicting of the processing flowchart, if possible.
3. Outcomes from the application of quality control and logistics activities.
4. Overview.

APPENDIX D: INVITATION SENT TO EXPERTS

English version:

Dear Sir/Madam,

My name is Max Yanac, a Food Quality Management master student at the Wageningen University & Research in the Netherlands. Currently, I am researching about the implementation of the concept of Quality-Controlled logistics in fruits and vegetables waste valorization chains. This approach deals with linking quality control and logistics activities in order to deliver raw material with the specific quality requirements and to ensure its availability. For the empirical part of my research, I need to interview people related to this kind of industry in order to use the information gathered to contrast the theoretical framework I have developed. All the data compiled will be uniquely used for my study and will be anonymized for confidentiality reasons. I will be pleased to sent you the final results of the study if you are interested in.

I would be very thankful if you could accept to participate in this exploratory research. I would like to know about your time availability for an interview in the period of the 27th of January till the 21th of March . If you are not able, I would be glad to know if you can contact me with a colleague who would like to participate, please let me know.

Thanks in advance.

Kind regards,

Max Yanac

MSc student Food Quality Management

+31657651258

Spanish version:

Estimado Sr./Sra.

Mi nombre es Max Yanac, estudiante de maestría en Gestión de la Calidad de los alimentos en la Universidad de Wageningen en los Países Bajos. Actualmente, estoy realizando una investigación acerca de la implementación del concepto de Quality-Controlled Logistics a lo largo de la cadena de valorización de residuos generados de la industria de procesamiento de frutas y verduras. Este enfoque trata de relacionar las actividades del control de calidad con la logística con el propósito de entregar la materia prima con los requerimientos de calidad necesarios, asegurando también su disponibilidad mediante una óptima logística. Para mi investigación necesito de la opinión de expertos quienes tengan experiencia laboral o de investigación en este tema. En este contexto, me gustaría por ende tener la oportunidad de entrevistarlo/a. La información recopilada es únicamente usada para mi estudio y será anónima por motivos de confidencialidad. Estaré complacido de enviarle los resultados finales del estudio si es de su interés.

Les estaré agradecido si aceptara participar en este estudio exploratorio. Me gustaría saber acerca de su disponibilidad de tiempo para llevar a cabo la entrevista dentro del periodo comprendido entre el 27 de Enero hasta el 21 de Febrero en caso se encuentre dispuesto. Por favor, si usted no está disponible para la entrevista me gustaría saber si podría contactarme con algún colega que le gustaría participar.

Muchas gracias de antemano.

Saludos cordiales,

Max Yanac

APPENDIX E: INTERVIEW GUIDE AND QUESTIONNAIRE

First of all, thank you to be part of this exploratory research. Before we start, I would like to ask you:

- Do you have any questions about anonymity and confidentiality regarding this study?
- May I record the interview via audio recorder? After results are analysed, I commit to delete it.

The aim of this interview is to validate a theoretical framework developed about the implementation of Quality-Controlled Logistics in fruits and vegetables valorization chains. The results will provide relevant insights for fruit and vegetables producers for ensuring effectiveness and efficiency along this circular economy strategy of waste valorization while increasing also their profitability and reducing its environmental impact.

The interview consists of 4 parts, an introduction, questions about the valorization strategy applied, questions about the quality and logistics activities and how they are related each other, and proposing of potential improvements.

The interview length will be around 30 to 40 minutes. Do you have any question?

Date of the interview:

Interview section 1: Introduction questions

1. How much time of experience do you have in the food waste processing industry/research field?
2. Which are the main responsibilities in your current professional activity? Which is the specific department you are working in?
3. Have you ever heard about the Quality-Controlled Logistics approach? If not, what is the first idea that comes to your mind about this concept?
4. To what extent the application of circular economy strategies is relevant in your professional environment?

Interview section 2: Questions about the valorization strategy

1. Which type of waste streams are involved on the valorization strategy you are familiar with? (Select the main raw material)
2. Can you explain briefly about the valorization strategy process of the main raw material you are working with? (Mention the processing stages or describe the flowchart)
3. Which is the sourcing process or stage of your raw material generation? (In which stage of the supply chain it becomes waste)
4. Does the company have any information about the process parameters or conditions during waste generation at the supplier facilities?
5. Do you consider economically feasible to apply this circular economy practice in your organization?

Interview section 3:

Next questions are regarded to the implementation of the Quality-Controlled Logistics in real life situations:

1. Which quality attributes has the company established to evaluate raw materials acceptability before entering to the process? (e.g. moisture content, particle size)
2. Does the company communicate to its suppliers of any changes in these quality attributes based on your production requirements? How does the company deal with it?
3. Does the company use procedures and/or records to analyse quantitatively these quality attributes? Can you explain what kind of information is recorded? (e.g. source, quantity)
4. Has the company established an acceptance period for its raw materials in terms of quality acceptability for your process? (i.e. the maximum amount of time in which the quality of your raw material is still acceptable for processing) How does the company set this point? (i.e. the criteria)

5. Has the company established a quality assurance or control system along the production?
Which one?
6. Are there some critical quality points along the process? (a point in which a not fulfilment of quality attributes results in irreversible deviations of the quality specifications for the process) In case they are implemented, can you mention the name of the process stage in which they are located? In case they are not, in your opinion, which can be considered critical quality points?
7. Which are the quality control activities carried out in the critical quality points? Which parameters are involved?
8. Does the company apply any mathematical quality prediction modelling tool? In case it is not applied, would you consider its implementation useful in order to take proactive decisions about quality?
9. Are processing conditions (e.g. temperature or process time) recorded in a formal format? If yes, in which processing stages?
10. Which type of information does the company exchange with its suppliers? (e.g. time windows picking, raw material price and quality, amount of raw material)
11. Has the company established any kind of contract of agreement with its suppliers? In case yes, is the collaboration working optimally or are there some complications?
12. Does the company provide its suppliers information about the inventory of raw material it manages? (quantity of raw material in stocks) How often?
13. Has the company established order sizes, order dates and/or delivery dates to manage the inventory of raw materials? How does the company set these factors?
14. Does the company collect raw material based on its demand or take all what is available in the supply point?

15. Has the company set a fixed inventory level for its operations?
16. What does the company do in case of a raw material shortage?
17. What does the company do in case of a raw material surplus? (e.g. additional storage)
18. Which factors does the company consider to select a supplier? Is there any kind of formal procedure? (e.g. checklist)
19. Which is the pre-treatment applied to the raw material? (e.g. size reduction, drying) How has it been established? (e.g. pilot tests)
20. Is there any quality control activity during the pre-treatment stage? Which processing conditions are applied?
21. Which are the transportation modalities used by the company? (e.g. trucks, train) Is there any environmental condition controlled during transportation of raw materials?
22. Does the company take into account the distances from the suppliers during transportation management decision-making process?
23. Does the company establish routing planning for the collection of raw materials? In case it does not, how is the raw material collection procedure designed?
24. In case there exist different flows of raw materials, does the company set different transportation conditions for each one?
25. How has the company established the technology applied for the processing of food waste? (e.g. pilot tests, formula optimization)
26. How has the company decided about the location of the facilities? Are there any relevant factors?

Interview section 4: Potential improvements

1. Would you consider that the implementation of Quality-Controlled Logistics would support the company operations? In which terms?
2. What is your opinion of the application of this kind of circular economy strategy? Do you consider it profitable to your organization?
3. Would you suggest any improvements for this research or questionnaire?
4. Do you have some questions regarding the present study?

APPENDIX F: INTERVIEW TRANSCRIPTS

INTERVIEW TRANSCRIPT: CORMO ALIMENTOS

Interviewee: Maria Silva

Date: 09/02/2020

First of all, thank you Maria to be part of this research by participating in this interview. Before we start, I would like to ask you:

- Do you have any questions about anonymity and confidentiality regarding this study?

It is a pleasure. I don't any problem if you mention the name of the company.

- May I record the interview via an audio recorder? After the results are analysed, I promise to delete it.

Yes of course.

The aim of this interview is to validate a theoretical framework developed for the implementation of Quality-Controlled Logistics in fruits and vegetables valorization chains. The results will provide relevant insights for companies that use fruit and vegetable waste or by-products as raw material about how the quality control and logistics activities can support the logistical matching, i.e. getting the correct quality and the necessary quantity for this raw material.

The interview consists of 4 parts: an introduction, questions about the valorization strategy applied, questions about the quality and logistics activities (and how they are related each other), and proposing of potential improvements.

Section 1: Introduction questions

1. How long have you been in the food waste processing industry/research field?

We as a group started with the idea in 2016 and in 2017, we formalized Cormo as a company. This started as a business idea and then as a Start-up.

2. How did this idea of using by-products emerge as raw materials?

We won a fund from CORFO (Corporación de Fomento de la Producción) which is part of the Ministry of Economy of Chile. With this money we started to develop and do research about the most suitable processes which use vegetable by-products as raw materials as here in Santiago it is possible to observe that a huge amount of this organic matter is generated daily.

3. What are the main responsibilities in your current professional activity?

I founded Cormo and currently I am the general manager in charge of all the administrative activities. There is also a food engineer, a biotechnologist and a commercial engineer in the team but they do a part-time job.

4. To what extent is the application of circular economy strategies relevant in your professional environment?

In Chile, the generation of vegetable by-products is a transversal problem. Regarding the feasibility of this strategy, at least for us, it is more reliable to work with vegetables than working with fruits by-products here in Santiago. This is because fruits here are discarded because they are very ripe and there is a very little quantity that is discarded because of esthetical reasons and this does not ensure us the required volume and process standardization. On the other hand, working with vegetables represent working with raw material still fresh. We consider them as any other fresh raw material. This is like buying fresh vegetables for a restaurant but instead of buying the main part of the vegetable, you go for the by-product.

5. Has this decision made based on the shelf life of the raw material too?

Indeed, for that reason we have decided to work with vegetable by-products which on our opinion are less perishable than fruit by-products.

Section 2: Questions about the valorization strategy

1. Which type of (material) waste streams, that are involved in the valorization strategy, are you familiar with? (Select the main raw material)

Currently we have two products in the market and a third one in the development phase as we are still carrying out analysis to determine which preservatives to use. The most popular is 'Betasal' and the other is 'Betaplus'. 'Betasal' is a product considered a reformulation of the common salt. This is mostly composed by beet stems and salt as a secondary ingredient. We found out during the development phase of this product that the beet stems have a high salt content and they are very tasty, especially if they are aiming to be used as seasoning. We took advantage of this property to create this product. Besides, 'Betaplus' is a product that is only composed as beet stems but produced with less temperature values during the drying process in order to maintain the required properties. We are trying to characterize this as a super food as it has huge content of folic acid and fibre. The last product is a 'type cheddar cheese' produced with carrot peels.

2. Can you briefly explain the valorization strategy process of the main raw material you are working with? (Mention the processing stages or describe the flowchart)

I am going to explain to you the process of 'Betasal'. We have a strategic alliance with the wholesale market of 'Lo Valledor'. We think this is a very fundamental factor for our company as we think that in other country this would have been more difficult to establish this collaboration. This market has a department called 'Recuperacion alimentaria' (Food Recovery). This department manages a specific space (a refrigerated container) where the beets stems and other by-products are stored. They also provide bins at different strategic sites along the market where vegetables sellers put all the by-products during the day. These bins are the same as those ones used for collection of organic matter but cleaner and conditioned. They also bring these bins with the beet stems in the food recovery zone where our personal does the first operation which is taking out the leaves from the stem. The raw material then is stored under refrigeration until a required quantity is reached. Then this is transported to the production facility which is outsourced as we are still growing up as a company and we do not have our own processing plant so far. At the plant, our personal sanitizes the raw material and there is a visual checking in order to separate the stems that do not fulfil the required characteristics as colour. These stems are put in trays and brought to an air oven dryer for the dehydration process.

Once they are ready, they are milled in a hammer mill and then cooled to room temperature. Finally, they are packed manually or stored in big glass recipients.

3. For the refrigerated container, do you have any knowledge about the its parameter conditions? Is this important for you?

I do not have the accurate temperature value but it is important to consider it. We did lots of trials at the beginning in order to know the behaviour of the beet stems regarding their initial temperature, i.e. if they were fresh or refrigerated. The food engineer checked all the parameters and established that it is better to work with refrigerated values as this helps to hold the required colour.

4. Do you consider it economically feasible to apply this circular economy practice in your organization?

It depends, as in our case we did a very strenuous research before starting operations about the discarded by-products concluding working with vegetables by-products as the best alternative as raw materials. However, it is important for us considering the logistics too in order to establish an optimal transport. We have the ease to be supported also by the wholesale market administration and maybe this favours our process a lot. We consider that the recycling culture is a key factor for our company as all the stakeholders in this chain are concerned about it. This makes our project feasible but I will not be sure if this would be the case without this alliance. Of course, we had a plan B in case the alliance with the market would not have worked. We planned to buy the raw material directly from the vegetable sellers at the market as they have a lot of free time during their activities and this would represent a new source of incomes for them.

5. Have you set a price for the raw material?

At the beginning we wanted to set a price for the raw material but currently we do not pay for it. We started selling in little fairs and natural food stores. But as we are going to start to increase our production, we are planning to buy it directly for the vegetable sellers too. Nowadays, we contract people that go and separate the leaves from the stems but the idea is to buy the ready raw material from the sellers so they will have to separate the leaves in advance.

Section 3: Implementation of QLC elements

1. Which quality attributes has the company established to evaluate raw materials acceptability before entering the process?

Firstly, we have to be sure that the raw material has not been in contact with the floor and it must not have received the sunlight directly. We did lots of trial using different initial conditions of raw material and all of them showed different final outputs in the final product in terms of quality. A stem that has been too much time in direct contact with the sunlight will show different colours. For us quality is based on hygiene and visual properties.

2. Then, would you say that you as a company has not a direct control over the initial quality of the raw material?

Not at all, but we rely in the food recovery department activities. They locate the collector bins strategically in order to avoid direct contact with the sunlight and the floor.

3. Do you use any control chart to evaluate the colour of the raw material?

We do not. There is no a big range of colours for the beet stems. However, there are some that present little white stripes and they are separated. Actually, it is a very low percentage.

4. Does the company use procedures and/or records to analyse quantitatively these quality attributes? Can you explain what kind of information is recorded?

This is done by the wholesale market based on the strategic alliance we have. We consider that they manage the first stage of our logistics. They secure the hygiene of the raw material and also the operation in the food recovery department refrigerated space.

5. Has the company established an acceptance period for its raw materials in terms of quality acceptability for your process? How does the company set this point?

We have established a maximum 3 days. Nowadays we are working very fast so there is no raw material that exceed this period. In case this exceeds these 3 days, the stems start getting dry gradually and then, they are not suitable for the production. Our objective is to produce daily as we do it three times per week currently.

6. Has the company established a quality assurance or control system along the production? Which one?

I know about the application of the HACCP plan which is managed by the outsourced company. We are planning to move our operations to another facility but we are still evaluating different factors, among them, if they have any kind of certification.

7. Are there some critical quality points along the process? In case they are implemented, can you mention the name of the process stage in which they are located?

For our process, the temperature control during the drying process is really important. This is because the colour of the product is very influenced by this parameter. For the Betaplus, this is a product that attracts a lot to the consumers because of its pretty pink and purple colour. Besides, the colour is also an indicator of the amount of antioxidants and if they are still in the product. If we exceed the required temperature, the colour changes and then the final quality of the product is affected negatively.

8. Does the company apply any mathematical quality prediction modelling tool? In case it is not applied, would you consider the implementation of such a tool useful in order to take proactive decisions about quality?

The food engineer only has established the required temperatures and times for the process and there is no any mathematical model used. He has established a relationship between the temperature applied and the final colour required for the product. Once the product is ready this is packed immediately because is very hygroscopic and there can be a risk of spoilage. So, moisture content is also important for the quality of the final product.

9. Which is the shelf life for Betasal?

This is powder of beets stems mixed with salt. The food engineer has set a shelf life of 6 months based on accelerated shelf life tests. This is enough time to deal with the delivery of the product in case we decide to export it.

10. Is this wholesale market the only supplier you are considering in this moment to work with?

By the moment yes, for the Betasal and Betaplus. However, for the last product we are planning to work with a big company that generates carrots peels as waste stream. They also work with beets. By now it is not necessary because the available raw material generated is enough for us. The raw material available exceeds our production capacity.

11. In case you establish a relationship with the supplier, would you consider to do it by establishing a contract or formal agreement?

In case working with the big company yes but not with the vegetables sellers as there is no any formality with them. The big company has their own standards and they are very rigorous.

12. Which type of information do you consider important to exchange with your suppliers?

For us, it is relevant to know information about the volume and quality because signing a contract with a company that do not ensure us the required volume. We do not want to deal with uncertainty about the volume and for us as s starting company this is fundamental.

13. Does the company provide its suppliers with information about the inventory of the raw material it manages?

As we a are a small company we do not have a great production and then we don't have problems of stock shortage or similar challenges. As these are considered as fresh vegetables, the idea is work as soon as we have the raw material. Just in some cases we store a little bit in the refrigerated container.

14. In case you buy the raw material from the big company, would you establish order sizes, order dates and/or delivery dates to manage the inventory of raw materials?

Yes, these factors are talked with the company. This big agroindustrial company, as the wholesale market, generates a lot of quantity of by-products. If we worked with this company for sure we would establish recovery dates.

15. Does the company collet raw material based on its demand or take all material that is available from the supply point?

By now, we have not been in this situation. There is a lot of raw material available generated so we do not rush in collecting all. However, there are months which very low primary production of beets that maybe would affect their availability for the production. Maybe in the future, as our product is dehydrated, we will collect more raw material independently of the demand and thus, we would store the final product as a safety stock in case of low availability of raw material. Of course, this is very least likely.

16. What does the company do in case of a raw material surplus?

We would consider to work with a surplus of raw material to deal with seasonality by producing more.

17. Have you set a fixed inventory of your final product?

We are still considering this because we are looking for a new outsourced company to work with. This new alternative has a dryer with higher production capacity and we are calculating the required storage space for this new production capacity.

18. What are factors that the company considers in order to select a supplier? Is there any kind of formal procedure?

Quality and volume. Before deciding we go and talk with the potential suppliers about their productive process and their facilities. In the case of the big agroindustrial company, safety is also a factor to consider. The food engineer is the person in charge to check also the certifications our potential suppliers have.

18. Do you consider the distance from the supply point to the processing plant a factor too?

Indeed. At the beginning we outsourced our production outside Santiago and now we are working with another one which is very much closer to the wholesale market. This represents for us saving time and money by easing the logistics.

19. What are the transportation modalities used by the company? (e.g. trucks, train) Is there any environmental condition control during transportation of raw materials?

We work with only one truck with 800 kg capacity. There are no special conditions during the transportation as the travelled time is about 20 minutes.

20. Have you thought about using the beets leaves to produce any product?

Not so far. Leaves are not generated in big quantities and we have not done any research about this raw material.

21. At the wholesale market, are there any people that collect the raw material manually?

As I already mentioned, there are some bins where the vegetable sellers put the beet stems. Besides, if they do not do this, they will receive a fine by the market administration department. This is a must for them and a great advantage for us. The vegetable sellers also accumulate some quantity of beets stems in their locations and then put them in the bins. Then the market administration staff uses a mechanical equipment to transport these full bins.

22. I have noticed that you consider the research and development phase of your product as a fundamental activity. How has the company established the technology applied for the processing of beet stems?

This was a very long and hard process as we did not any kind of bibliography about the use of this raw material. We did not have any knowledge about its behaviour. Then we started characterizing the raw material by analysing and doing trials or pilot tests. We considered different initial conditions for the raw materials and they did not show the same physicochemical behaviour and the taste neither. The pilot tests were not only based on define the raw material behaviour but also to obtain an attractive product for the consumer. We could sell the final product as beet stems powder but this is not attractive for the consumers. We had to deal with technical and commercial issues.

23. Do you deal with any kind of regulation regarding the food industry at Chile?

The outsourced processing plan is inspected by the sanitary authority. The food engineer makes sure that the plant has all the equipment required and the updated certifications.

Section 4: Potential improvements

1. Would you consider that the implementation of Quality-Controlled Logistics would support the operations of food waste valorization strategies?

Of course. However, we try to get away of the concept of waste and consider our raw material as a by-product. This is safe as it does not have contact with the floor. Beet stems are considered fresh products for us.

2. To what extent the Chilean government support the application of the circular economy in the food industry?

In Chile there a lot of available funds designated to entrepreneurship related to the application of the circular economy in the product development. Chile is looking for integrate this purpose as part of its national development strategy in order to provide healthy and functional foods. Using of by-products is a plus and there are subsidies for this. The ministries of economy, agriculture and production are part of this strategy.

INTERVIEW TRANSCRIPT: SPAAK CIRCULAR SOLUTIONS

Interviewee: Andes Vreeken

Date: 11/02/2020

Good evening Andes. First of all, thank you so much for accepting to be part of this interview

Andes: Hello. there is no problem. I am very curious about your questions. I am happy to be part of your empirical research.

- Do you have any questions about anonymity and confidentiality regarding this study?

It is a pleasure. I don't any problem if you mention the name of the company.

- May I record the interview via an audio recorder?

Yes of course. there is no problem at all.

Well, as a I mentioned to you, I am doing a research about how the quality assurance and logistics activities are in Bournemouth in the validation chains that use food waste or by-products as raw materials. the questions are very related to these both aspects and I already know that you have a technical background in biology which can contribute with a new point of view for my research.

Andes: Indeed, I studied Future Planet studies at the University of Amsterdam. More of the studies were related to the concept of sustainability combined with air sciences. Afterwards I did a master in Biology. That was the main subject that I was most interested in, but besides that my main field interest is sustainability.

To give you a brief context, the aim of this interview is to validate a theoretical framework developed for the implementation of Quality-Controlled Logistics in fruits and vegetables valorization chains. The results will provide relevant insights for fruit and vegetable producers in order to ensure effectiveness and efficiency for a circular economy strategy for waste valorization while also increasing profitability and reducing environmental impact.

The interview consists of 4 parts: an introduction, questions about the valorization strategy applied, questions about the quality and logistics activities (and how they are related each other), and proposing of potential improvements.

Interview section 1: Introduction questions

1. How long have you been in the food waste processing industry/research field?

Spaak Circular Solutions is kind of a consultancy agency. We consult parties that have an assignment for us in the sense that they want to have a certain stream of their process in a more circular scheme. I have been working there almost 1 year and a half. I also wrote my thesis there. It was a part-time job for me at the beginning but not I have been working full-time for a year.

2. What are the main responsibilities in your current professional activity? In which specific department you are working?

Mainly, I am a project worker. We as a team have lots of different project working at the moment and I contribute with the knowledge I gained during the bachelor regarding sustainability in order to provide an interdisciplinary approach. For example, I am leading a market research of a project that uses coffee ground as raw material. Next week, I will be doing some practical tests for the project of orange peels that we have too. I will be actually conducting tests and retrieving samples and sending them to the third party that does the analysis. It is very broad. I do not have a strict area that I always conduct. I also feel that I am learning, so I also want to acquire some skills about how to get funding so I have been in the funding team for a project to apply for subsidies or things like that. It is a learning ground for me. It is very flexible and there is a multidisciplinary environment in the office with everybody with different backgrounds.

3. To what extent is the application of circular economy strategies relevant in your professional environment?

I would say that we cannot always apply it in one hundred per cent but is always in the back of our heads. For example, the coffee project we are working now is aiming to extract coffee oils and colorant from spent coffee grounds and in order to build a biorefinery for this we have to make a business case. First, we are going to extract these compounds and then we are going to analyse if we can still extract some other compounds from the residues of the process. We aim to maximize our impact by using as much waste stream as we can.

Interview section 2: Questions about the valorization strategy

1. Which type of waste streams, that are involved in the valorization strategy, are you familiar with?

I would say the coffee grounds. This is a project that at this moment is very relevant for me. I also conducted a logistical test to see how you could do the collection of this coffee grounds. Also analysing the quality of the raw material. With this we can get an idea about we can expect about the logistical structure in the future.

2. Can you briefly explain the valorization strategy process of the main raw material you are working with?

Well, I cannot give you much information about it but the collection starts from different partners that discard coffee grounds and then our logistical partner uses electrical vehicles to collect the raw material. Then the raw material will go to the biorefinery where in our process line we will conduct extractions of the coffee oil and colorants. After that we get the residues. We are still doing research to know how we can use this waste. Finally, we sell business to business. We are able to sale coffee oil to other companies but not to make our own brand. We are process engineers and not exactly a brand so we do not want to make Spaak Circular Solutions soaps or colorant which implies to build a biorefinery which can handle as much spend coffee ground as possible in order to have the major positive impact for the environment.

3. Which is the final use for the oil extracted?

That is what I am going to start to analyse with the market research. We see a lot of potential in cosmetics or even in paints. There is a wide variation that the coffee oil can give us. We still need to do the market research on what could actually be the first market we would like to enter.

4. What is the sourcing process or stage of your raw material generation?

It depends. For the pilot test, I approached some hotels in Amsterdam and also coffee bars and cafeterias. Also, offices. I tried to get as much as different places that I can get to see if there are some different on the quality of spent coffee ground that I can expect from hotels compare to office and compare to cafeterias.

5. Do you also analyse the economic feasibility of the project?

Absolutely. That is how we started this. We saw that the coffee oil is a useful product and there are some applications for it but we also wanted to see which could be the best entry market for us. We wanted to learn more about the market and also see if we can, together with the people of certain markets, build a product together that is useful for them as well because they have to want our product and we have to see if we can achieve a certain quality or certain form of products that they can actually apply in their industry.

6. Would you consider the final product quantity also a factor to establish this relationship?

Yes, at this moment we are in the R&D phase and we are looking for a pilot scale. The potential biorefinery has been theoretically built with a process capacity of 25000 tonnes of spent coffee ground a year as a beginning and if all goes well, it will increase. The more we produce the more impact we will have.

Interview section 3: Implementation of QCL elements

Next questions are regarded to the implementation of the Quality-Controlled Logistics in real life situations:

1. Which quality attributes has the company established to evaluate raw materials acceptability before entering the process?

The main is absolutely age. After 3 or 4 days molds start growing and this is important to consider for the quality of the oil. The type of coffee is also important. There are different on the final outputs depending on using Arabica or Robusta coffee variety. We have to think about it, ok, maybe it would be better to have a mono stream of one certain coffee type but it is not feasible at this moment because each partner that you will collect spent coffee grounds still have to get use to the fact that they have to separate their spent coffee grounds and just not throwing them away as a general waste and then also asking them to put their specific Robusta blend in a separate plastic bag and the Arabica blend at another one in order to get a perfect mono stream for us. At this moment we just only want to see if the general mix of spent coffee grounds is also suitable for our process in order to perceive a certain quality of oil and that is what we will show to the companies that will buy the oil from us eventually.

2. Which is the reason why both coffee varieties influence the final oil quality?

Yes. I can imagine that once the biorefinery has been build, they will start to work with mono streams of a certain type of coffee grounds in order to make a higher quality oil because is purer in terms of chemical composition.

3. Would you say moisture content is also a relevant quality attribute?

Yes, as the spent coffee grounds have a 60% of moisture on average and then, because of this moisture the mold can grow. We are looking into to see if we can dry them for transportation. You have to think about the logistical system that you put behind if you want to have fresh spent coffee grounds for a maximum of 3 days. All the coffee ground should be transported to the biorefinery within 3 days so you do not get the mold and the quality decay.

4. Would you say that the company has established an acceptance period for its raw materials in terms of quality acceptability for your process?

Yes, approximately 3 days. We still have to figure it out during the phase we are in now. But we can imagine that we will still have to transport the raw material to the biorefinery because a truck driver will not be able to assess a batch of the coffee ground in terms of age at the collection points. We need to have some sort of facility in the processing plant where we can eventually say this batch is too old and will impact the final oil quality so we cannot use this. We will need to think about another process to use this spent coffee grounds that are too old.

5. Does the company use procedures and/or records to analyse quantitatively these quality attributes?

When I did the logistical pilot, I was thinking to establish a barcode system for every place where raw material is collected. In that way, when our logistic partner collects the raw material, they scan the barcode so we know which container is coupled to the specific partner. If the partner provides very bad raw material several times you can track that partner and say that collection cannot be done anymore because their spent coffee grounds provided are not useful for us. I have not been tested it yet but it could be a good way to do traceability.

6. Has the company established a quality assurance or control system along the production? Which one?

I know about the good manufacturing practices. We worked with it for the orange peels project but not for the spent coffee grounds one. We are not going to use the final product in food or beverages and that is why we want to stay out this market as there are different regulations that become difficult to acquire. We want to stay more at the industrial level so we do not have to deal with that requirements at the moment.

7. Are there some critical quality points along the process?

That is a very interesting question. For us, that would be the composition of the oil. Every batch of oil produced needs to be tested and we need to evaluate the certain amount of free fatty acids required. We qualify the batches of products to establish if they are ready for export or not.

8. Have you set any control or preventive measure to deal with possible variations?

We have been doing lots of tests to see what influences the quality measures. So those are things that we try to prevent by looking at the raw material input quality. If the initial quality

requirements are fulfilled then the probability of a batch to be declined will be very low. Then we try at the input level to ensure the quality and of course we have to deal with other circumstances as contamination too. We try to diminish the risk.

9. Which parameters are controlled during the production?

Temperature, time, heat and the moisture content. The contamination too.

10. Do you carry out any microbiological analysis?

I do not think so. This is because cosmetic producers say that a lot of organic waste streams has been already used and they are not all GMP (good manufacturing practices) certified. It is not necessary because they are used in such big volume that possible contamination is diluted and not perceived.

11. Does the company apply any mathematical quality prediction modelling tool? In case it is not applied, would you consider the implementation of such a tool useful in order to take proactive decisions about quality?

No, we do not use them. But I consider it will be useful by contributing a higher quality of product. I was simple not aware about the models. What we are trying now is to get a minimum variable product and see if with the most basic form of coffee ground collected, we can get a sellable product. Then I think we can set more quality standards.

12. Maybe I missed but, the biorefinery you were talking about is a property of Spaak?

We are building the concept now. We do not own it as we do not have an investor yet. We do not have the money but in the end, it would be great to have enough capital to build our own factories. At this moment we are still in the starting phase. We sell the concept and we look for partner that would like to build it. What we mainly do is round up all the stakeholders that are required to set a biorefinery with the circular idea behind it. We are trying to process organic waste into different products and this represent a new way of thinking. We would like to work with all the possible stakeholders.

13. Which type of information do you consider important to exchange with your suppliers?

Well, obviously quantities, also the age of the coffee grounds. If they can give us also the information about the type of coffee used and the roasting type as these are small factors that can influence the oil so the more we know the better.

14. Do you consider relevant to establish any kind of contract or agreement with your suppliers?

Yes. We have planned to write letters of intent to our suppliers but also with companies that are going to buy our product. We are not very super competitive as we do not want cash as soon as we can. We are more an ideological company. We think it will work better by sending letters of intents with the sign of all the partners that are required for successful process lines establishment.

15. Have you establish a price for the spent coffee grounds?

At this moment we have not but we have gotten so many offers to ask if we can collect their coffee grounds. We have more than enough in terms of supply but in our business case we are going to take into account the scenario where the circular economy gets more acceptance. Then people will be concerned about it and the raw material could represent also a cost.

16. Has the company established order sizes, order dates and/or delivery dates to manage the inventory of raw materials based on your capacity production?

We aim for 25000 tonnes of yearly production but it has not been calculated based on the amount of raw material we want to make. So, we are just looking for the capacity of the year. We have to process a certain amount of spent coffee grounds in order to make profits. The cost of all the operation should be intentionally not be higher than the cost of getting the raw material. That will define the minimum production capacity.

17. Does the company collect raw material based on its demand or take all material that is available from the supply point?

It is hard to say. If we set the facility capacity based on letters of intents from people that want to purchase our products, then if they say that they cannot do anything with this product, the amount of raw material that we acquire will go down. I think, preferably for us, we prefer to sign a document that establish a fixed amount of production that guarantee the amount of coffee we are going to pick up. If another company is also interest in the product, we will analyse it to find more inputs. As I said, I am not very afraid about the availability of the raw material.

18. What would the company do in case of a raw material shortage?

We think starting paying for the raw material. In the orange peel project, which I was also involved, it is common to see that the raw material has a set price because it is also used as cattle feed. Then I can imagine that at the time that we do not have enough raw material we will need to talk with a company that does have raw material but we can pay for it. In that way we can secure more raw material. We also can set relationships with partners to access other markets for raw materials.

19. Have you thought to store raw materials?

If you want to store raw materials you have to dry it otherwise mold will grow and it will get spoiled. At this moment, also because there is enough raw material, we are not looking for storage it yet. It is not necessary for our logistical system which is relatively quick. I will be a huge additional cost to our process if you have to dry all these tonnes of spent coffee ground for using then a couple of weeks later. We still need to think about it as we do not want to be blind for this situation regarding availability.

20. Is it drying a stage of the whole process?

You could dry the raw material in order to store it but I do not know the effect it will have when entering the process several weeks later. Maybe this storage will require to add additional processes.

21. Is there any pre-treatment applied to the raw material?

Not necessarily. It is a very common extraction. It is a very direct process. It is a very fast process. If we were at the operational stage of the project, we would get several batches of product. Maybe the day before and then the factory will run for a day. It will depend on the age of the material that we get. If we get raw material from Friday and it is produced on Monday that will be the maximum age allowed. Then we need to consider if the factory will be also opened during the weekend. This is all a bit on the back of the envelope.

22. What are the transportation modalities used by the company? Is there any environmental condition control during transportation of raw materials?

Our potential logistics partner will use electric cars. Our prefer way of transport will be electrical but I do not know if it is feasible when we get the operational stage of the product. I hope that the logistical sector become electrical very far but I doubt it. Anyway, probably trucks will be our way of transport.

23. Would the company consider the distance from the supplier to the biorefinery a factor for supplier selection?

Yeah. I think this will be very depending on our logistical partner. They will have to decide if the route that we can give them or the group of hubs where coffee ground will be collected are efficient enough for them to work with us. I think we already have quite a lot of contacts in the waste sector and some of them can give us the correct partnerships that can help us in this logistical activity. For big coffee industries that produce huge quantities, it would be more efficient to send only one big truck to the factory and bring it back completely full. It is a big part of the operational costs.

24. How has the company established the technology applied for the processing of food waste?

We basically start with the idea of setting an interesting potential raw material. Then we do scientific research. We look at the most optimal and efficient extraction technologies and after that we go to the R&D stage to see if there any other variables that have influences on the yield for example and we carry on this extraction ourselves and validate the literature findings. What we do is lab work and if the pilot test has a high enough yield, we escalate the process up. We evaluate the quality of the product in the lab and large scale. Then we look for partners than would like to invest on us to actually build the process line.

25. Would you say that working with different stakeholders is relevant for Spaak?

Yeah. In the case of the coffee project, it has been subsidized by the North Holland province so we did an application for subsidy and it was granted. Until now we are still subsidised by this institution but still look for other funding alternatives. Perhaps an investor or someone that want to be our partner that would like to do more R&D with us to eventually build a solid business case and also the biorefinery for the spent coffee ground. We just always look for the best possibilities for the project.

26. How has the company decided on the location of its facilities? Are there any relevant factors?

Geographically, I would say that the best location is the best centralized place. In case of the Netherlands it should be also be closed to the German market. The eastern part of the Netherlands is more convenience. If you would place a facility in Amsterdam and you draw a radio circle around Amsterdam you will get a lot of part of sea space which is not going to produce enough coffee ground. So, if you draw the same circle in the east part of the Netherlands, there is a larger operating area. It is a dense area with lots of offices and coffee plants. Even thought, near to an international port as Amsterdam or Antwerp is also interesting because you also have easy access to international lines of transport. As long is more efficient possible will be great.

Interview section 4: Potential improvements

1. Would you consider that the implementation of Quality-Controlled Logistics would support the company operations? In which terms?

I find difficult to say as we have not considered these issues too much. We trust that there will be enough quality raw material that can be distributed on time. But I can imagine that the framework will be interesting to contrast what we are thinking now.

2. Would you suggest any improvements for this research or questionnaire?

It will be a good idea to run your theoretical framework in our business case and in that way give you some feedback.

INTERVIEW TRANSCRIPT: FOODITIVES

Interviewee: Moayad Abushokhedim

Date: 17/02/2020

First of all, thank you Moayad to be part of this research by participating in this interview. Before we start, I would like to ask you:

- Do you have any questions about anonymity and confidentiality regarding this study?

No at all.

- May I record the interview via an audio recorder? After the results are analyzed, I promise to delete it.

Yes of course.

The aim of this interview is to validate a theoretical framework developed for the implementation of Quality-Controlled Logistics in fruits and vegetables valorization chains. The results will provide relevant insights for companies that use fruit and vegetable waste or by-products as raw material about how the quality control and logistics activities can support the logistical matching, i.e. getting the correct quality and the necessary quantity for this raw material.

The interview consists of 4 parts: an introduction, questions about the valorization strategy applied, questions about the quality and logistics activities (and how they are related each other), and proposing of potential improvements.

Section 1:

1. How long have you been in the food waste processing industry/research field?

I have been already working in this field for around 8 years. I have a background in food science which I did in Jordan, and I did also my master in hotel management in Switzerland. I think is important once you want to do business to have different academic skills.

2. What are the main responsibilities in your current professional activity? In which specific department you are working?

I am the founder of Fooditives and developed the process which we apply for side streams. I had the idea 8 years ago and it was a very hardworking. We as a company are aiming to provide natural products by presenting new alternatives to the food industry and at the same time to apply the concept of circular economy in our business idea.

3. Would you say that you work in a multidisciplinary environment?

One hundred percent. We have a very diverse team with people with different backgrounds as for business we need knowledge about finance for instance. It is very flexible too as everybody is learning.

4. Have you ever heard about the Quality-Controlled Logistics approach? If not, what is the first idea that comes to your mind about this concept?

I would say that both quality and logistics are relevant for the use of side streams. I have not heard about this concept but I am pretty sure that your research will be a good support for the operations related to valorization chains of side streams.

5. To what extent is the application of circular economy strategies relevant in your professional environment?

It is always in the back of our heads as a team. We are looking for to create an impact by using raw materials that are not considered useful anymore and applying innovation in order to improve our processes. We also try to do lots of partnership and working with these partners in order to get a mutual benefit.

Interview section 2: Questions about the valorization strategy

1. Which type of waste streams, that are involved in the valorization strategy, are you familiar with?

We have now in our product catalogue three products. The most important one is a sweetener made with a mix of apples and pears leftovers which is very natural and low in calories. We also have a preserving agent made of side streams of carrots and a thickener elaborated with banana peels. I would say let's talk more about the sweetener which is our main product by now and has the volume produced.

2. Can you briefly explain the valorization strategy process of the main raw material you are working with?

Well, we work with different partners that supply the raw materials which can be whole apples and pears from farms, apple or pear puree from companies that produce these products and also from agro traders that export products and sometimes they have fruits that do not fulfill the quality requirements for the supermarkets where they distribute the fruit. Then we try that monitor all our incoming flows by assign them a batch number to ensure the traceability. We also have a logistical partner that goes to these places to pick the raw material. It transports the raw material to our outsourced processing plant where raw material is sanitized and then mixed for the fermentation process. Our process takes 5 days so we produce weekly. Then the product is spray dried and packed.

3. What is the sourcing process or stage of your raw material generation?

As I mentioned, we work with apples and pears that are on the field and are still useful for our process. Also, with the common called 'ugly food' generated during the distribution of fruits to the supermarkets. We ensure of course the safety of the raw material by doing traceability. It is more a commitment with our customers and with ourselves than a requirement.

4. Do you consider it economically feasible to apply this circular economy practice in your organization?

Absolutely. The application of the circular economy in this kind of processes are growing up progressively and in the future most of the companies will have this in the back of their heads.

Interview section 3:

Next questions are regarded to the implementation of the Quality-Controlled Logistics in real life situations:

1. Which quality attributes has the company established to evaluate raw materials acceptability before entering the process? (e.g. moisture content, particle size)

For the fermentation process as soon as the raw material is safety is enough. However, we also consider the content of fructose of raw material by measuring the brix degrees as this gives us an idea about the final production of the sweetener. We use also the side streams from apple or pear puree production so we also do not care about the shape or form of the raw material.

2. Does the company communicate to its suppliers any changes in these quality attributes based on your production requirements? How does the company deal with it?

We do not have control over this but we do the traceability in order to know which raw material is not suitable for our production and then take decisions based on it about not working anymore with this partner.

3. Does the company use procedures and/or records to analyze quantitatively these quality attributes? Can you explain what kind of information is recorded?

When picking up the raw material we try to record everything. The geographical origin, dates of production, who was working there as we consider that people is a source of hazard because of contamination. We try to make all the measurements as a proactive action. Brix are not measured here but in the factory.

4. Has the company established an acceptance period for its raw materials in terms of quality acceptability for your process?

We mostly try to work with raw material that does not have more than 2 weeks since it was generated as side stream. We produce weekly so we have not dealt with this situation before. We set this time as we do not ensure the initial quality of the raw material any more for our process.

5. Has the company established a quality assurance or control system along the production? Which one?

Well at the factory we try to use the GMP (good manufacturing practices) to avoid contamination from the employees.

6. Are there some critical quality points along the process? In case they are implemented, can you mention the name of the process stage in which they are located?

In order to ensure the safety of the product I think the the time of washing of the whole apples and pears in order to avoid whatever physical contaminant and the overall cleanliness of the factory are really important. As I told you, we provide the employees the required uniform to avoid cross-contamination and thus avoid the hazard.

7. Would you said that the time and temperature during fermentation process are also important?

Yes. Those values are recorded by the outsourced company which we consider also a partner. It gives us an idea about what can be wrong in the process in case final quality is not achieved.

8. Do you have a professional in charge to check the production?

No by now. We are still not so big to collocate a person to control the production but I am one hundred percent that in the future will be really necessary. We are also planning to work with another factory to increase our production.

9. Does the company apply any mathematical quality prediction modelling tool? In case it is not applied, would you consider the implementation of such a tool useful in order to take proactive decisions about quality?

We do not apply any mathematical model for this purpose. Not even for the microbial growth. We rely in our partners about the safety of the apples and pears. However, I would say that it can be helpful as you said to take proactive actions.

10. Which type of information does the company exchange with its suppliers? (e.g. time windows picking, raw material price and quality, amount of raw material)

We as a company worried about the sustainability also care about fairness, so we set a fair price of the raw material with the farmers. Others aspects about the raw material collection are managed by our logistic partner. We only indicate to them where do they have to go, the quantity we establish to produce and when do we need it at the factory. So, they set the collection schedule. I really find the idea of working with this logistical partner very important as they have all the know-how about it and we want to work always with the best elements.

11. Has the company established any kind of contract or agreement with its suppliers? If yes, is the collaboration working optimally or are there some complications?

We strongly consider that reliability is fundamental in our business. We have contracts with all our partners because we think is the best manner to ensure that everybody gets some benefit. By now all is working very well with them

12. Has the company established order sizes, order dates and/or delivery dates to manage the inventory of raw materials? How does the company set these factors?

We do not set a formal order size as it depends on the demand we have.

13. Does the company collet raw material based on its demand or take all material that is available from the supply point?

We do not want to store raw material. As I mentioned to you, we produce weekly but based on order from our customers so we only pick up the required amount of raw material to fulfil this demand. Then we do not have any final product inventory.

14. What does the company do in case of a raw material shortage?

Well, we have not been in this situation but if a supply partner does not fulfil our requirements or there is no availability of raw material, we have other two alternatives for each one so we avoid the shortage.

15. What does the company do in case of a raw material surplus?

We do not want to be in this situation. We are just very careful about the amount we produce.

16. What are factors that the company considers in order to select a supplier?

As I told you, reliability is very important for us. Also, by applying the traceability of the raw material we can be sure that our partners provide the most suitable raw material for us.

17. What are the transportation modalities used by the company? Is there any environmental condition control during transportation of raw materials?

Our logistic partner only uses electric vehicles which is in accordance with our sustainable approach. They do not need to have any special conditions but they have to be very clean in order to prevent contamination. We produce a sweetener that is used for food production so we should be care about the quality and safety of the raw material from the harvest.

18. Does the company consider the distances from the suppliers during the transportation management decision-making process?

Yes. We try to work with local farmers and The Netherlands is one of the major producers of apples and pears in the world and there are a lot of opportunities for businesses as ours here. There is an ease in transportation activities too.

19. Does the company establish route planning for the collection of raw materials? In case it does not, how is the raw material collection procedure designed?

The logistical partner does it. This is not our core business. We just set the place where they should go to collect the raw material.

20. How has the company established the technology applied for the processing of food waste?

We realized lots of pilot test to develop the current process. We patent it and we are still trying to improve it. This is something that we are always looking for. It was a very hardworking road but at the end we feel proud of what we have got.

21. How has the company decided on the location of its facilities? Are there any relevant factors?

Well, as I mentioned, locating our operations in The Netherlands represents for us a strength for us as this country provides lots of opportunities for business as ours by providing funds and subsidies. The professional contacts and partners that we could find here are also an advantage for us.

Interview section 4: Potential improvements

1. Would you consider that the implementation of Quality-Controlled Logistics would support the company operations? In which terms?

We have always tried to maintain the quality in our operations. By doing traceability to our raw material and always trying to fulfil our customers' requirements. We do not do additional activities to fulfil requirements. I always say that you do not business because you have to but because you want it to do it.

2. What is your opinion on the application of this kind of circular economy strategy? Do you think it could be profitable to your organization?

It is profitable. I mean, this are the new kind of business the world needs. In the future most of the companies will take this into account and they will have to work in accordance to the circular economy.

3. Would you suggest any improvements for this research or questionnaire?

No but I am very happy that students do research about this kind of topics. Me as a scientist too, would say that all what we learnt in the books is not what you find in the real world, so it is important that your research be applied.