DOES RESILIENCE REDUCE FOOD WASTE? ANALYSIS OF BRAZILIAN SUPPLIER-RETAILER DYAD

ABSTRACT

Food waste negatively impacts the three dimensions of sustainability. Environmentally and financially, it represents a waste of natural resources and increases the cost respectively. Socially, it represents an ethical issue as about 800 million people are suffering from hunger worldwide. Therefore, the purpose of this paper is to explore if and how resilience contributes to food waste reduction in fruits and vegetables distribution in the Brazilian market. Multiple case studies were conducted in the supplier-retailer dyad of four retail chains. Results have shown that resilience plays the role of both enabler and barrier to food waste reduction. On the positive side, collaboration, communication, flexibility, innovation, knowledge management, leadership, security technologies and supply chain design contributed to food waste reduction; especially during the COVID-19 pandemic. On the negative side, financial health and redundancy increased the level of food waste. Additionally, it was observed that flexibility can reduce or increase food waste. Our findings have implications for academics and practitioners as the developed framework summarizes the role of resilience to food waste reduction. As a social impact, the implementation of food waste reduction initiatives by non-governmental organizations and retailer associations can result in increased communication, knowledge diffusion, and training about how to build resilience and improve food waste reduction practices among different agents. To the best of our knowledge, this is the first empirical study that explores the relationship among elements of resilience and food waste. Thus, it advances the current literature by operationalizing resilience to reduce food waste.

Keywords Resilience; Food waste; Retail; Food supply chain; Food loss; Waste reduction.

Paper type: Original article

1. Introduction

Food waste (FW) has become a top priority on the agendas of governments and economic sectors in the pursuit of achieving the UN Sustainable Development Goals (SDGs). However, there is no common agreement on the definition of food loss (FL) and food waste (FW). Generally, FL refers to losses in the food supply chain from harvest up to (but not including) the retail level. On the other hand, FW occurs at the final stages of the chain, such as

distribution, sale, and consumption (Fao, 2019). As this study analyses distribution with a focus on retailers, the term FW is used.

Reducing FW is one of the crucial actions towards a more sustainable food system and a sustainable society. Environmentally, it implies misuse of natural resources (water, land, and energy), increasing greenhouse gas emissions, and overloading of disposal and treatment processes. Currently, in 2020, the world generated around 931 million tons of food waste (Forbes et al., 2021) and, in 2018, FW was the source of 8-10% of global greenhouse gases emissions (Mbow et al., 2019). Socially, it represents an ethical issue as about 800 million people are suffering from hunger worldwide, and another 700 million are undernourished (Fao, 2019). According to Amicarelli and Bux (2020), with particular reference to zero hunger (SDG 2) and responsible consumption and production (SDG 12), it is impossible to ensure that the global population will have access to sufficient, safe, and nutritious food without rebalancing the food system, and making it fairer, healthier and more environmentally sustainable.

The reduction of FW represents an important commercial advantage for companies (Nikolicic et al., 2021). Thus, Macfadyen et al. (2015) highlight the importance of resilience for food chains to better respond and recover from disruptions to minimize waste. In this context, supply chain resilience (SCRes) intends to develop responsive capabilities across the supply chain to deal with sudden disturbances on the flow of goods, services and/or information (Hohenstein et al., 2015; Kamalahmadi and Parast, 2016). Therefore, this concept can potentially play a role in reducing FW (Bajželj et al., 2020).

Nevertheless, literature exploring both concepts (SCRes and FW) is still sparse. Manning and Soon (2016) studied the concept of strategic business resilience to develop innovative mechanisms, which seek to identify solutions for FW. Further on, Moraes et al. (2019) explored the theoretical relationship between elements of resilience (EoR) and causes of FW. Bajželj et al. (2020) examined individual interventions of farmers to minimize FW by scoring their impact on different aspects of resilience. In this particular study, they concluded that redundancy (as an EoR) may increase FW, and stressed the need for further studies that explore if resilience can contribute to FW reduction. Recently, Magar et al. (2021) pointed out that building resilience in the agriculture sector can improve the use of land, labor and food security. To the best of our knowledge, no study has explored the relationship among EoR, food waste causes (FWC) and food waste reduction practices (FWRP). Therefore, the purpose of this paper is to explore if and how resilience contributes to FW reduction in fruits and vegetables (F&V) distribution in the Brazilian market.

According to FAO (2018), 35% of the food produced in Latin America is wasted yearly, whilst in Brazil (the world's fourth-largest food producer) 17% (23.6 out of 140 million thousand tons) are lost through the entire food supply chain (ABRAS, 2019). For instance, the total amount of food wasted in 2014 would be enough to feed 11 million people (Benítez, 2015). Unfortunately, this situation ends up being more critical given the COVID-19 pandemic scenario, in which 59% of households were in a situation of food insecurity (Galindo et al., 2021). Thus, Amicarelli and Bux (2020) highlight that studies in developing countries, such as Brazil, should focus on the storage and distribution of this type of food.

In retail, F&V waste represents 5.25% of retail revenue. One of the reasons for this waste is that 28% of Brazilian supermarket chains do not have a department focused on loss prevention, as they do not see value in it (ABRAS, 2021). Nevertheless, as supermarkets have access to research and technologies, they could bring changes by leading innovation, education, and information sharing to mitigate FW along food supply chains (Teller et al., 2018). Retailers are at the center of food systems and can significantly influence FW throughout a chain, making them a crucial food chain link to be studied (Gruber et al., 2016). They can impact significantly the cost of fruits and vegetables (F&V) chains, where the quality standards emphasize appearance over nutritional quality (Brancoli et al., 2017; Gruber et al., 2016). For these reasons, the unit of analysis chosen was the retail-supplier dyad.

To do so, multiple case studies were conducted through four supplier-retailer dyads to identify a set of FWC and FWRP, and then to explore if and how EoR can impact them. After 12 interviews with experts to identify appropriate sources of data, 47 individuals were interviewed in the supplier-retail link. The results were analyzed to identify EoR that helped reduce FW (enablers), and EoR that increase FW (barriers). To increase data reliability, findings were validated with further interviewees during the COVID-19 pandemic.

This paper extends the literature of EoR and FW by presenting and characterizing the relationship between these constructs based on empirical data and by specifically considering the impact of the COVID-19 pandemic. The pandemic has highlighted the importance of food system resilience and the need to reduce FW (Bajželj et al., 2020).

In the following sections, we present a structured literature review considering the role of SCRes in reducing the FWC through FWRP. This is followed by the research design. We then discuss the results and develop a framework to summarize the contribution of supply chain

resilience to FW. Finally, managerial and social implications for researchers and managers, as well as limitations and future opportunities are highlighted in the conclusion.

2. Literature Review

2.1 Supply Chain Resilience (SCRes)

Disruptions in the flow of goods, services and/or information are sudden and unexpected events that can lead supply chains to fail in their mission to deliver value added activities to their customers. Resilience is defined as the capability of supply chains to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level (Ponomarov and Holcomb, 2009). It is therefore seen as a way to manage and improve supply chain performance when facing different types of disruptions (e.g. internal, external and environmental) (Karl et al., 2018; Werner et al., 2020), and to develop reactive and proactive actions to adapt effectively operations to unexpected changes (Kamalahmadi and Parast, 2016). Ali et al. (2017) summarized all key concepts discussed in the supply chain resilience literature and developed a concept mapping framework, which classifies resilience into phases, strategies, capabilities, elements, and resilience practices. For this study, we focused on the key elements of resilience (EoR), which are listed in Table I and summarized in Appendix A.

2.2 *Causes of food waste (FWC), practices for the reduction (FWRP) and elements of resilience (EoR)*

Food waste increases the environmental impact of food production across the entire supply chain. Thus, reducing waste while maintaining current production levels can help meet the global food needs (Thyberg and Tonjes, 2016). In this regard, previous studies on FW have focused on measuring it and identifying its causes (Mena et al., 2014; Balaji and Arshinder, 2016; Holweg et al., 2016; Teller et al., 2018). Few have discussed the practices for its reduction (Thyberg and Tonjes, 2016; Strotmann et al., 2017; Diaz-Ruiz et al., 2019; Huang et al., 2021) or have advanced in actions that anticipate and/or prevent its occurrence (Bajželj et al., 2020; Costa et al., 2021). Therefore, exploring the relationship among causes, practices and elements of resilience is an opportunity to advance the debate on FW.

Most of the discussions presented in the literature do not reflect the reality of the retailers from developing countries (FAO, 2019) and, consequently, do not consider issues related to their interface with suppliers, which could mislead proper actions (Teller et al. 2018, Moraes et al. 2020). Additionally, these studies do not focus on analyzing the relationships between resilience and FW, and, to the best of our knowledge, Manning and Soon (2016) study is the only one that affirms that creating supply chain resilience can positively impact the reduction of food waste. Therefore, there is a gap in the empirical analysis of how resilience can contribute to reducing food waste.

In this research, we identified 33 FWC, 22 FWRP and 15 EoR through a structured literature review at the retailer level. The relationships between these constructs are seen in Table 1. The set of numbers in front of each FWC and FWRP indicates the authors who have discussed such constructs. A complete list of them is in Appendix B that also highlights FWC and FWRP that did not show any relationship in the current literature.

Table I - Interrelationship among EoR, FWRP and FWC adapted from author in appendix B

EoR	FWRP	FWC
AGILITY	Upstream coordination and communication [10;13;15]	Lack of coordination and information sharing [2;14]
COMMUNICATION	Integrated logistics system [4;15;18;19]	Poor logistics network design [2;12]
		Short shelf life [7;14;22]
	More accurate labelling information (expiry date) [11;15;21]	Inadequate packaging [2;17]
		Short shelf life [7;14;22]
	Downstream communication [18;19]	Lack of coordination and information sharing [2;14]
INNOVATION	Development and adaptation of packaging [4;11;18;19]	Inadequate packaging [2;17]
		Short shelf life [7;14;22]
		Inappropriate storage [16;17;21]
KNOWLEDGE MANAGEMENT	Upstream coordination and communication [1;10;13;15]	Lack of coordination and information sharing [2;14]
	Downstream communication [18;19]	
	Training for waste reduction/prevention [1;5;20;18;19]	Lack of training [2;3;11]
		Lack of knowledge [2;3]
	Employee awareness of waste [18;19]	Lack of training [2;3;11]
		Lack of knowledge [2;3]
LEADERSHIP	Management autonomy [11;18;19]	Lack of coordination and information sharing [2]
		Strict standards of F&V appearance and shape [10;16;21]
		Inappropriate work procedures [2;3;9;16]
		Lack of operational control [4;16;17;19]
	Quality policies in the organization [3;4;19]	Lack of coordination and information sharing [2]
		Strict standards of F&V appearance and shape [10;16;21]
		Inappropriate work procedures [2;3;9;16]
		Lack of operational control [4;16;17;19]
SECURITY TECHNOLOGIES	Technologies to check food conditions [13;16;19;21;22]	Discontinuities in cold chain [2;7;17]
SENSING AND INTERPRETATION	Technologies to check food conditions [13;16;19;21;22]	Discontinuities in cold chain [2;7;17]
	More precise demand forecast [4;5;14;16;22]	Inadequate demand forecasting [2;16;22]
VISIBILITY	Development and adaptation of packaging [4;11;18;19]	Inadequate packaging [2;17]
FLEXIBILITY	Secondary markets [19;21]	Poor logistics network design [2;12]
		Lack of stock rotation [5;11;12;22]
	More precise demand forecast [4;5;14;22]	Excess production [4;16;17;19]
		Inadequate demand forecasting [2;16;22]
		Sudden changes in orders [4;18;19]
REDUNDANCY (BARRIER)	Inventory policy [13;20;21;22]	Poor inventory control /management policy [4;11;12;22]
COLLABORATION	Retail-supplier collaboration [4;5;19;20]	Lack of information sharing [2;14;18]
		Lack of coordination and information sharing [2;14]
	Upstream coordination and communication [1;10;13;15]	Lack of coordination and information sharing [2]
FINANCIAL STRENGTH (BARRIER)	Inventory policy [13;20;21;22]	Poor inventory control /management policy [4;11;12;22]
	Technologies to check food conditions [13;16;19;21;22]	Weak logistics infrastructure [3;7;16;21]
	Training for waste reduction/prevention [1;5;20;18;19]	Lack of training [2;3;11]
		Lack of knowledge [2;3]
		Lack of commitment [11]

In retail, FW originates from a wide range of internal and external causes (or a mix of them) (Moraes et al., 2020). The internal causes are controllable aspects that occur in any part of the retailer process from inbound logistics to storage and display. It can be related to problems with the equipment employed at these processes, lack or wrong work procedures, workforce mistakes, non-compliant quality products or problems with packaging. Additionally, part of the retailer FW is generated by external pressures from a set of stakeholders, which are more difficult to control; these are weather conditions, seasonality, consumer behavior, NGOs' pressures, competitors' practices and governmental laws (Mena et al. 2011; Halloran et al. 2014; Ghosh et al., 2015; Huang et al., 2021).

Regarding FWRP, development and adaptation of packaging is one of the most discussed reduction practices in the literature, which include the change in package layout to protect fresh products and to increase their shelf life (Jedermann et al., 2014; Verghese et al., 2015). Additionally, more accurate labeling information (expiry date, e.g.) can influence consumer to discard less food at home, since there is a confusion among the terms "best before"; "expiration date"; "edible until"; "use-by date" (Gruber et al., 2016; Verghese et al. 2015). Training for waste reduction/prevention is mainly aimed at raising awareness among employees and consequently increasing their commitment to reducing waste. Macfadyen et al. (2015) point out that retail is more capable of disseminating information throughout the chain, as well as coordinating the communication processes of it. In this sense, Liljestrand (2017) adds that coordination includes joint decisions, rules and prices that must be used between producers, wholesalers, suppliers and supermarkets. Therefore, upstream coordination and communication, as a FWRP, can reduce costs and waste considerably throughout the supply chain.

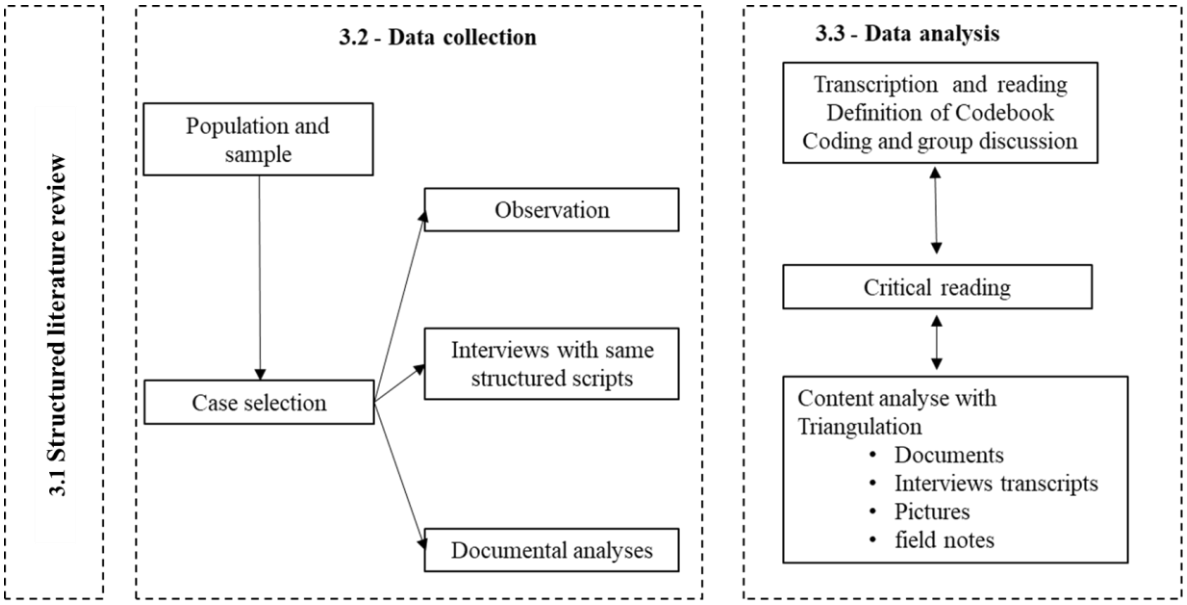
To ensure efficient food distribution, it is necessary to promote FWRP and minimize FWC. This can be done with internal retail measures to manage product surplus through simple actions, such as unsold product donations (Bilska et al., 2016; Tostivint et al., 2017; Amicarelli et al. 2021b). There is also a need to understand the FWC in an integrated perspective of the supply chain so to identify solutions and then prioritize practices for the prevention and/or reduction of waste (Garrone et al., 2014; Derqui et al., 2016). Additionally, part of the retailer FW is generated by external pressures from a set of stakeholders, which are more difficult to control. These pressures come from seasonality factors, consumer behavior, NGOs' pressures, competitors' practices and governmental laws (Mena et al., 2014).

Finally, Bajželj et al. (2020) highlight that resilience can increase or reduce FW. While short-term resilience (such as redundancy) can amplify FWCs, investments in building long-term resilience (financial incentives, for instance) can reduce waste. Still, according to Bajželj et al. (2020), trade-offs should be recognized so that they can be adequately addressed and compensated for, and thus, chain players can choose the right actions to improve resilience and reduce FW.

3. Research Design

The qualitative case study is defined by Barrat et al. (2010, p.329) as "an empirical research that primarily uses contextually rich data from bounded real-world settings to investigate a focused phenomenon". Case study is therefore considered a relevant method that focuses on the understanding of the dynamic environment within some desired settings (Eisenhardt, 1989; Meredith, 1998; Stuart et al., 2002), besides being able to explore, explain and describe the phenomenon of interest (Ellram, 1996; Voss, 2008). This research is qualitative, as it seeks to examine the context of resilience and food waste by exploring the context of retail-supplier dyad (Ketokivi; Choi, 2014). We designed it by dividing it into the literature review, data collection and data analysis (Figure 1).

Figure 1 - Research phases



3.1 Structured literature review

This paper started with a structured literature review conducted to identify EoR, FWCs and FWRPs, alongside the relationships between them at the retail level. To perform this review, we established three research questions and related strings as portrayed in Table II.

Table II - Elaborated by the authors

Questions	Strings
What are the elements of resilience?	((("supply net*") OR ("value chain*") OR ("supply chain*")) w/3 (resilien* OR risk* OR vulnerabilit*))
What are the main causes of food waste?	((("supply net*") OR ("value chain*") OR ("supply chain*")) AND ((food) W/5 (wast* OR surplus OR los*)) AND (cause* OR source* OR fount* OR origin* OR generat* OR minimi* OR prevent* OR avoid* OR reduct* OR diminution* OR decrease* OR manag* OR practice* OR strateg* OR act* OR proce* OR police* OR initiative))
What are the main food waste reduction practices?	((("supply net*") OR ("value chain*") OR ("supply chain*")) AND ((food) W/5 (wast* OR surplus OR los*)) AND (minimi* OR prevent* OR avoid* OR reduct* OR diminution* OR decrease* OR manag* OR practice* OR strateg* OR act* OR proce* OR police* OR initiative))
How the elements of resilience can contribute to minimize food waste in supply chains?	((("supply net*") OR ("value chain*") OR ("supply chain*")) w/3 (resilien* OR risk* OR vulnerabilit*)) AND ((food) w/5 (wast* OR surplus OR los*))

The search was conducted in five databases (Web of Science, Scopus, EBSCO, Scielo, and Spell), since combining sources provide better research results (Chadegani et al., 2013). Web of Science and Scopus are renowned and updated databases that contain a wide breadth of coverage on most scientific subjects (Boyle & Sherman, 2008). EBSCO/Academic Premier was considered because it is one of the most extensive databases in the field of management studies (Thomé et al., 2012). Finally, Scielo and Spell were included as they provide specific information regarding emerging economies, such as Brazil. The study considered articles published between 2000 and 2020, recognizing that publications dealing with both supply chain resilience and FW began to be published at the earliest 2000 (Ali et al., 2017). The results were used as the theoretical base for this empirical study, contributing to developing the research protocol and the initial codebook for the content analysis.

3.2 Data Collection

Considering the scarcity of empirical studies on this topic, the case study method was chosen (Eisenhardt, 1989), as aforementioned. The empirical part of this research was based on a case-based study carried out by Vanpoucke, Vereecke e Boyer (2014) and Pereira et al. (2020). We focused on the F&V waste in distribution between retailer-supplier. To select the cases, we considered the food supermarket chains featured in the 2017 ABRAS (Brazilian Supermarket Association) index, as it ranks the top 50 largest chains operating in Brazil (Abras, 2017). To choose among these retailers, we searched for secondary data sources (reports, websites and sustainability reports) to identify the ones that took actions related to FW reduction. Then, we conducted 12 exploratory interviews with FW specialists (consultants, retail association representatives or academics) as well as associations or NGOs of food donation (for details, see Table III - we refer to them as "experts"). These interviews helped in identifying the leading Brazilian retailers in FWRP in order to appropriately collect data to explore the purpose of this research.

Table III - Informant Interviews

Companies	**Respondents**	**Interview's length (min)**
Agricultural research company	Consultant A	61
Food waste consulting company	Consultant B	53
Loss prevention consulting	Consultant C	68
Cooperation network of companies, government institutions and civil society on waste	Consultant D	51
Retail Consultant	Consultant E	64
	Consultant F	55
	Consultant G	53
CEASA (the Brazilian state-owned fruit and vegetable distribution center where multiple private suppliers operate)	Consultant H	59
NGO (food donation)	Nutritionist	33
	Sustainability Director	34
	Responsible for contact with retailers	82
Retail Association	Supermarket Services Manager and Sustainability Manager	20

As a result of this phase, 12 retail chains out of the 50 largest ones were selected. After several contact attempts, four retailers agreed to participate in this study. All of them are among the 40 largest networks operating in the Brazilian market; 3 of them are privately held (two

have stores in the state of São Paulo, while the other has in the state of Santa Catatina) and one is publicly traded (which has stores spread across the country). Later, we selected suppliers (producers and/or wholesalers) that directly supplied these four retailers – categorized as suppliers of a) short shelf-life products, such as strawberries, bananas, tomatoes and lettuce, and b) medium/long shelf-life products, such as apples, citrus fruits, onions, potatoes, and broccoli (Mena et al., 2014). The interviewees held positions such as managers, coordinators, directors and supervisors from areas such as sustainability, quality management and food safety, loss prevention, commercial, supply, logistics, store management and nutrition. The search for multiple interviewees from different levels and areas is because FW is treated in an integrated manner, involving several areas of the organizations. In total, 47 individuals were interviewed. Details about each case are given in Table IV.

Table IV - List of data sources carried out with retailers and suppliers

Case	Company	Interviewee, Job function and Identification	Interview length (min)	Code	Information source
Case A	Retailer A	F&V purchasing manager	104	RetA_PurcManag	Face-to-face, Visit, Photo
		Logistics manager	41	RetA_LogManag	Face-to-face
		Store manager	38	RetA_Manag	Face-to-face, Visit, Photo
		Distribution center F&V leader	20	RetA_DCLeader	Face-to-face, Visit, Photo
		Distribution center loss prevention leader	16	RetA_DCLosPrev	Face-to-face, Visit, Photo
	Supplier A1	Owners/Producer	34	SupA1_Owners	Face-to-face, Visit
	Supplier A2	Owners/Producer	No record allowed	SupA2_ Owners	Face-to-face, Visit
Case B	Retailer B	Manager of food safety and quality and Environment coordinator	56	RetB_SafManag	Skype
		Distribution center perishables supervisor	No record allowed	RetB_DCPeris	Face-to-face, Visit
		Distribution center operations manager	33	RetB_DCOManag	Face-to-face, Visit
		Perishables supply manager	40	RetB_PerisManag	Skype
		Distribution center risks and prevention manager	65	RetB_DCRisck	Face-to-face, Visit
		National loss prevention manager	15	RetB_LossPrev	Skype
		Small size store manager	36	RetB_StorePManag	Face-to-face, Visit, Photo
		Small size store supervisor	36	RetB_StorePSuper	Face-to-face, Visit, Photo
		Hypermarket store manager	No record allowed	RetB_StoreGManag	Face-to-face, Visit, Photo
		Medium size store director	40	RetB_StoreMDirec	Face-to-face, Visit, Photo
	Supplier B1	Distributor (Commercial manager and food engineer)	69	SupB1_Comerc_FEng	Face-to-face, Visit, Photo
	Supplier B2	Distributor (Quality manager)	20	RetB2_ QualManag	Face-to-face, Visit
Case C	Retailer C	Sustainability coordinator	104	RetC_SustCoord	Face-to-face, Visit, Photo
		Joint interview with Prevention manager, Store manager, Perishable´s product technician, Fruit and vegetable leader, loss prevention coordinator.	62	RetC_JointInterview	Face-to-face, Visit, Photo
		Commercial manager	30	RetC_ComercManag	Skype
		Supply manager	30	RetC_SupplyManag	Skype
		Store manager	35	RetC_StoreManag	Face-to-face, Visit
		F&V leader	No record allowed	RetC_F&VLeader	Face-to-face, Visit
		Nutritionist	15	RetC_Nutricionist	Skype
	Supplier C1	Distributor (Salesman)	15	SupC1_Salesman	Face-to-face, Visit, Photo
	Supplier C2	Distributor and producer (Manager)	15	SupC2_Manager	Face-to-face, Visit, Photo
Case D	Retailer D	Joint interview: store manager (hypermarket), nutritionist, inventory control leader, and Fresh Fruit and Vegetable leader	61	RetD_JointInterview	Face-to-face, Visit, Photo
		Joint interview: store manager (hypermarket), nutritionist and purchasing leader	20	RetD_Store_Nutric	Face-to-face, Visit, Photo
		Environment and work safety coordinator	24	RetD_Safety	Skype
		Buyer of fruits and vegetables of distribution center	16	RetD_Buyer	Skype
		Risk and Loss Manager	18	RetD_RiskLoManag	Skype
	Supplier D1	General manager	32	SupD1_Manager	Skype
	Supplier D2	Salesman	23	SupD2_Salesman	Skype

Face-to-face Visit Photo Skype

A research protocol that included semi-structured scripts was used to ensure rigor and reliability (Eisenhardt, 1989; Yin, 2010). The questions addressed the structure and main indicators of the chain, types of waste, causes and practices to reduce it, key disruptions faced, the impacts in terms of FW, and finally how EoR helps mitigate FW. A pilot test was performed with one retailer and one supplier (Yin, 2010; Voss, 2008). Whenever possible, two researchers conducted the interviews to increase internal validity. Interviews were recorded (when authorized, see Table IV) and transcribed for further analysis.

To complete the analyses, we triangulate data by using different data sources (Miles, et al., 2014), documents, such as companies' websites, internal documents, reports, companies' newsletters and documents related to training, storage when available, interviews and observations (field diary and pictures from the visit to stores, distribution centers and stock/warehouse areas). The field diary helped to validate the findings, based on multiple sources and modes of evidence (Miles et al., 2014). The use of multiple sources of evidence allowed the researchers to understand the different views and pieces of evidence about EoR, FWRP and FWC through the cases.

3.3 Data analysis

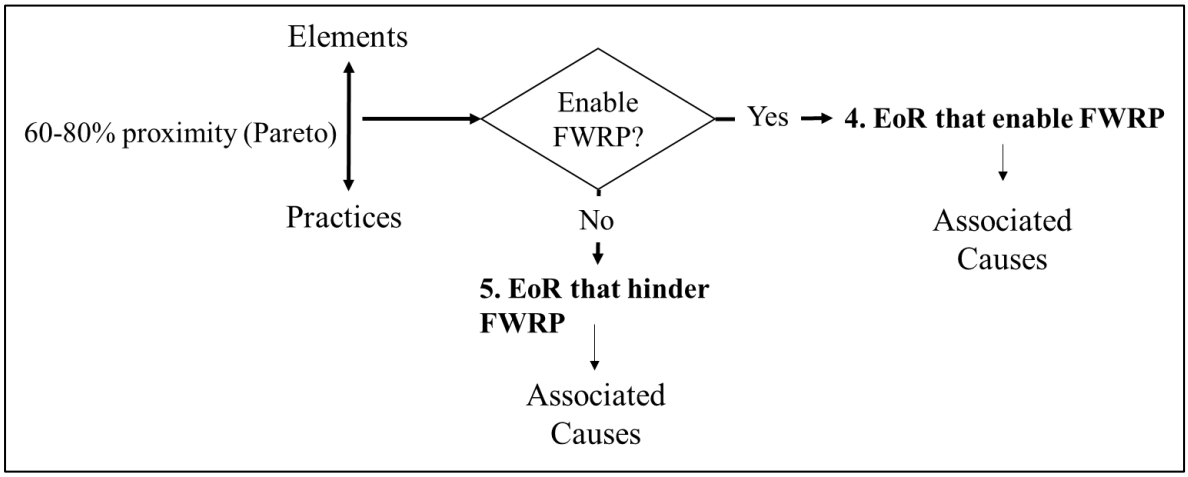
At the beginning of the coding process, an initial codebook was created through the literature review, and then complemented and changed according to data emerging from the interviews, observations, and secondary data (Gibbs, 2009). Important sentences were highlighted either during interviews, in transcripts or in critical reading to help in the coding process. QDA Miner software was used to facilitate the conduction of content analysis (Hutchison et al., 2010). The content analysis was based on the studies carried out by Chen et al. (2010), Pereira et al. (2020) and Costa et al. (2020).

The creation of encodings and their ramifications allow the location of commonalities to texts, enabling comparisons (Hutchison, Johnston and Breckon, 2010; Krippendorff, 2004). The relationships between the codes studied were identified by means of proximity, which represents the co-occurrence between EoR, FWRP and FWC (Qda Miner, 2017). The co-occurrence establishes a numerical correlation of proximity between terms, or codes, to map the relationships between concepts. This index represents the co-citation of the two pairs of terms. An example of this co-citation can be seen in Appendix E, in which a transcribed excerpt from the interviews has overlapping (Robredo and Cunha, 1998 and Chen et al., 2010). The co-occurrence used the segment overlap and the Jaccard coefficient, which gives equal weight

to cases where co-occurrence is identified (a) and cases where one item is found, but not the other (b and c). Thus, it is calculated from as a/(a + b + c) (Chen et al., 2010 and Qda Miner, 2017).

As many relationships between EoR, FWP and FWC were identified, we applied Pareto analysis (representing between 60 and 80% of the total proximity) to select the ones to be discussed. This strategy for analysis has been also used by Wiśniewska and Grudowski (2016), Moraes et al. (2020) and Costa (2021). Pareto analysis is a technique that is used for the selection of a limited number of factors that produce significant overall effect (Wiśniewska and Grudowski, 2016). We first applied this analysis to the relationship between EoR and FWRP, and then the same was done for FWRP and FWC. Finally, we discussed the relationship between EoR and FWRP that showed up in at least two cases (Appendix C and Appendix D), with their associated FWC. The Figure 2 presents the process of content analyses that has been undertaken.

Figure 2 - Qualitative content analysis

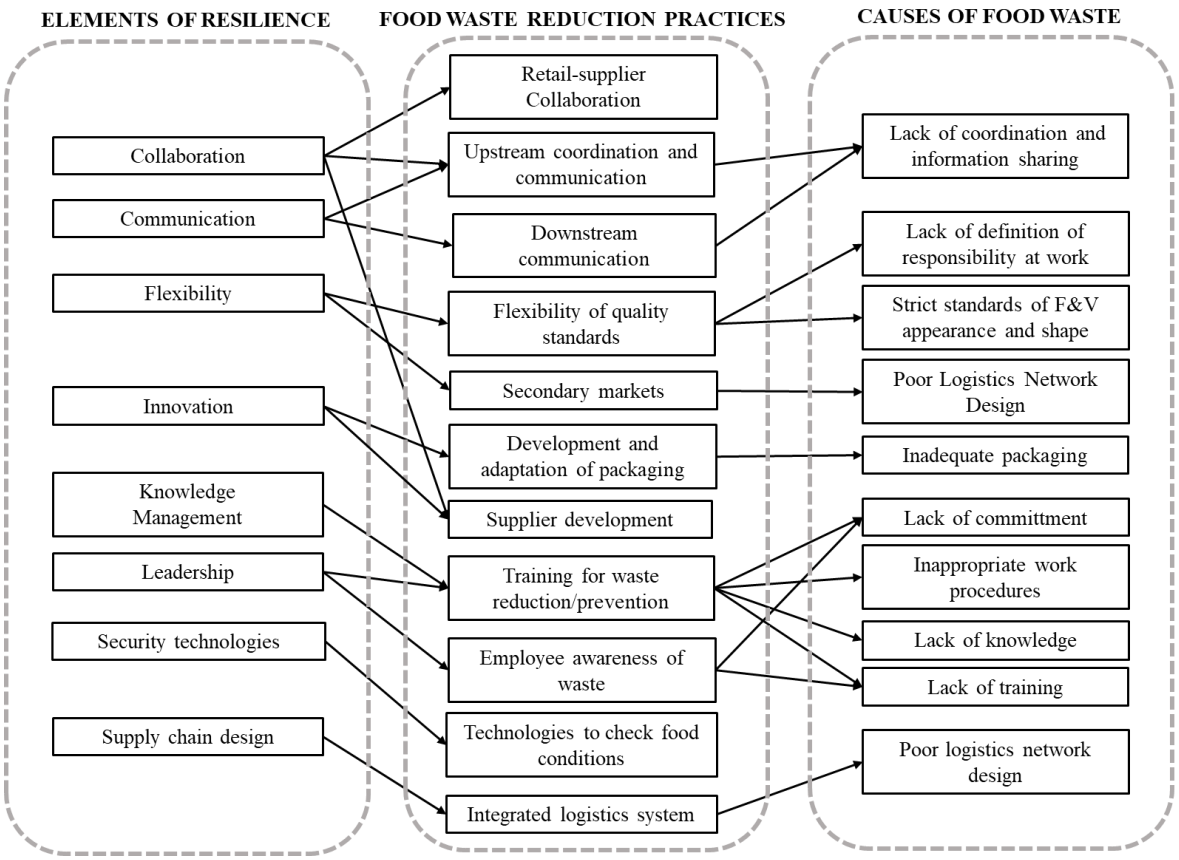


The results were analyzed in two ways: a) EoR that helped reduce FW (which were considered as enablers); b) EoR that increases FW (which were termed as barriers). To increase validity and reliability, the results (Figure 3 e 4) were validated with some interviewees during the COVID-19 pandemic and their comments helped in the discussion of sections 4 and 5.

4. EoR that enable FWRP

We identified EoR that helped in FW reduction through specific practices (FWRP), which address specific causes of food waste (FWC). These relationships (Figure 3) are discussed as follows (details in Appendix C).

Figure 3. EoR that enable FWRP



4.1 Collaboration

Collaboration was observed between retailers and suppliers, especially during disruptive events, such as the trucker strike that blocked many routes in Brazil (May 2018). We found that it helped the FWRP of retail-supplier collaboration, upstream coordination and communication, and supplier development. Alternate routes, changes in the negotiation of food quality during the off-season and retailers' financial support in providing fuel for the suppliers to make the deliveries on time gave support to collaboration efforts. For instance, it was noticed that retailers made their aesthetic standards flexible (by accepting products with lower appearance and indirectly reducing waste in the chain) only on disturbances. The importance of collaboration to reduce waste was also highlighted, especially during the COVID-19 pandemic. Interviewees mentioned that some actions were adopted, such as the reduction in the size of suppliers' shipping boxes to keep buying the same variety of products but in smaller quantities.

Collaboration also helps in the practice of supplier development, especially with long term suppliers, supporting ongoing supplier development projects. For this practice, retailers employ experts to monitor and assist product quality and to improve handling, harvesting, and storage practices. Finally, the collaboration also assists in upstream coordination and communication to align the demand and supply, and to provide information regarding the quality of the products and how they are fit for consumption. Lack of coordination can generate waste due to a lack of alignment of required quality standards or expected characteristics from the products.

> Retail is still far away from farmers. But, if a retailer combines this with his supplier, this guy can align with the production base. This needs education in terms of the ability to work with a systemic view and, to understand that there is an interdependence. Stopping with the attitude of wanting to take advantage of the other (...) there is a need to talk to the whole chain, especially in moments of critical disruptions, such as high volume of rain [Excerpt from an interview, Consultant G].

4.2 Communication

Retailers align their supply and demand through upstream coordination and communication. To do so, they use informal communication using WhatsApp to negotiate changes or orders and to send pictures of the received products as proof. During the COVID-19 pandemic, consumers have changed the frequency and the amout of purchases. As a result, retailers had to improve the level of communication with suppliers for capacity adjustments to implement quick changes in their operations and deliveries.

> We suffered a lot at the beginning with the small supermarket model. Today, I realized that there is stronger communication and we use messaging apps for different products such as F&V (...) [Excerpt from an interview, RetB_StorePManag].

Regarding downstream communication, retailers tried to influence the consumers' consumption habits to make them aware of the value of the food despite poor aesthetics. They did it by promoting marketing campaigns using locals' posters, internet or TV. The environment and work safety coordinator also mentioned that it was important to involve consumers in the effort to reduce FW so that they also feel responsible. For example, some specific consumer awareness campaigns were carried out by retailers to demonstrate the best use of food to reduce waste at home.

> We are trying to convince customers that a not-so-perfect product can be as good as that, and it is fine to consume and he will pay less for it [Excerpt from an interview, SupB1_Comerc_FEng].

Although upstream and downstream communication have shown importance for waste reduction, it still required investment as difficulties were found, such as lack of data sharing on demand, especially in large networks, as observed in Retailer B.

4.3 Flexibility

Flexibility has shown a close relationship with FWR through the use of secondary markets and the flexibility of quality standards. In the F&V sector, flexibility is normally applied due to climate issues. In these situations, retailers make changes in the food quality standards to prevent products from being rejected. It is observed that the main factor to invest in flexibility is when there is a risk of shortage, and not because of effort to reduce waste.

Regarding secondary markets, retailers make their logistics networks flexible to effectively deliver food to other channels and to change internal processes to easily reclassify products to send them for internal use in stores, donations or for composting. Experts also pointed out that flexibility is used by suppliers to redirect rejected products to other buyers, such as retailers with less rigid aesthetic standards or through donations channels.

4.4 Innovation

From the analysis of the cases, for the defined proximity level, the Innovation in this context relates to the FWRP development and adaptation of packaging. In the literature, the idea of innovation is related to the use of smart packages with sensors or other technological tools (Raak et al., 2017); which means that according to the reviewed literature, other forms of innovation that could be relevant. The empirical results showed a different form of this element, especially because of the high cost of adopting these types of innovative packages in the Brazilian context since neither retailers nor consumers are willing to pay for it. The identified innovations were related to the size or types of the packages, for instance, unit pack adaptations (depending on product size), made to fit packages (packaging with the shape of the fruit) and one-size-fits-all shipping box. This simple innovation has helped to prevent FW from excessive or wrong handling of fruits (such as grapes) in store.

Innovation sometimes requires the development of new suppliers. This occurs when the supplier generates or adapts a new process/product that can withstand the negative impacts of waste. Retailer A sought for more specialized suppliers in production technology, and transport

and package systems. However, retailers (or suppliers) were not found to engage in such innovative practices.

> He (supplier) knows that this responsibility to take a quality product is an investment (...) today the producer is investing more in technology, consequently in crops, because he wants to have less work, less problems. He does not want to have a return (...) [Excerpt from an interview, RetA_PurcManag].

4.5 Knowledge management

The results showed a close relationship between knowledge management and training for waste reduction or prevention. Contrary to the literature (Strotmann et al., 2017), knowledge on FW is transferred through training that normally occurs for the retailers' collaborators; but it does not reach suppliers and other supply chain members. Such lack of knowledge sharing can be a barrier to build resilience throughout the supply chain. The knowledge of the retailer can have a great impact on FW reduction considering the retailer has great influencing power upstream and downstream of the chain.

Differences in this practice were also noticed among the cases. Knowledge regarding handling, selection and displaying of F&V is normally transferred through formal training in Retailer B, whilst in Retailer A it is through informal training to maintain proximity and monitor the development of employees. In Retailer D, official training is provided by Abras National School of Supermarkets (ABRAS) and by the retailer's nutritionists. The presence of skilled employees is also found as a source of knowledge management. Nevertheless, interviewees highlighted the high turnover of employees as a problem for knowledge retention within the organization.

> Every time the economy gets hotter, you get a huge turnover, because people quit this kind of job to look for something better. The supermarket is not a place that pays well. So the turnover of people is big. We have a very ambitious generation wanting to grow fast, (...) There is no time for you to form, explain what a cold chain is, conservation, care with stock [Excerpt from an interview, Consultant G].

4.6 Leadership

Leadership relates to the practices of training for waste reduction and prevention and employee awareness of waste. The Retailer Store Manager A points out that leadership is needed to monitor employee activities and make them aware of waste reduction – this has helped to prevent waste in store's operations.

> (...) explain to him what his function is, what is his responsibility to make him aware. We seek to instruct, train, so they can understand the processes and can keep the product with quality and standard for the customer. The focus is more on awareness anyway [Excerpt from the interview, RetA_Manag].

In case D, the risk and prevention manager mentioned the creation of a committee on operational loss prevention, which aims to monitor the 20 items with the highest losses and to propose actions to reduce them.

4.7 Use of technology

Appropriate technologies can be used to check the condition of food across the supply chain. Technologies such as the QRCode label on the packaging, can support traceability by checking their conditions. Additionally, technology can help in tracking the transportation routes, and in case of road blockage and strikes, it can assist in the process of identifying alternative routes. Specifically, in retailer B, temperature sensors are used to check the conditions of the environment in which the food is stored, and thus, manipulate the foliage vaporization system to preserve shelf life.

4.8 Supply chain design

Supply chain design is related to the practice of developing an integrated logistics system. Because F&V has a short shelf life, the time between harvest and distribution should be as short as possible or there is a need to have an appropriate mode of transport which is a challenge in Brazil, because of long distances between consumers and producers in many cases and, both weather conditions and productivity varies across the country.

> So I have production in the south, here in São Paulo (southeast), then I have production in the center west, for example. That's why everything is controlled by this here [...] So we can migrate according to the producing region to have year-round supply [Excerpt from the interview, RetA_PurcManag].

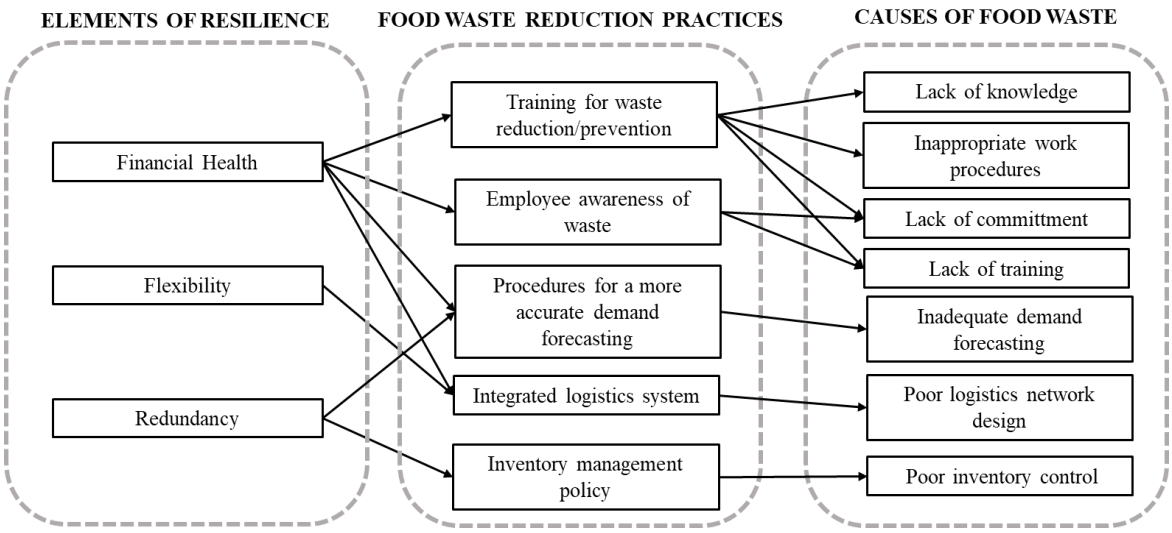
As a result, many products are transported over long distances and transportation time consumes F&V shelf life. Hence, it is important to reduce transportation times using integrated logistics systems (Balaji and Arshinder, 2016; Liljestrand, 2017). However, the current structure of the Brazilian food chain does not allow this agility. According to the suppliers, investments in the integrated logistics system and supply chain design were drastically reduced after the 2016 crisis in Brazil. Before it, companies used to have more human resource to plan

and think of actions in the Logistics area, while after 2016, many of these people were fired, which negatively impacted the integrated logistics system. Right after this crisis, the country's economy retracted 3.6%, and there was a drop in commodity prices, the imbalance of public accounts and the consequent loss of the country's credibility, aggravated by the impeachment of the President of the Republic (Trevizan, 2017).. Thus, because of reduced investments in the integrated logistics system, the waste generated by poor logistics network design (inadequate trucks and difficulties for delivery store to store) increased. Supply chain design contributes to creating distribution centers at optimal locations and by improving transportation conditions.

5. EoR that hinder FWRP

In contrast to the previous section, we found EoR that can hinder FWRP. Figure 4 illustrates these elements and the related FWRP and FWC (details in Appendix D).

Figure 4 - EoR that might increase FW.



5.1 Flexibility

Although flexibility helps in the process of reducing FW, it was also noticed that having a flexible source of suppliers can increase FW upstream in the chain. In this case, when retailers change suppliers to get a better product in terms of aesthetic characteristics this might result in FW at the replaced supplier side.

The integrated logistics system seeks to map products and producing regions. Thus, in times of seasonality or when the region has a phytosanitary issue, retailers decide to switch suppliers

in order to reduce waste on their side, but not across the chain. Thus, this flexibility will lead to complexities in the logistics system, as new producing regions often have a greater distance and greater logistical complexity (as Brazil is a large country with different motorways in medium infrastructure conditions). As the discussion is focused on the F&V (perishable foods), long distances might compromise quality conditions and hence resulting in FW.

5.2 Financial Health

Short-term thinking to improve sales or reduce costs also results in over ordering thereby contributing to waste. The first identified issue was the mixture of types of fruits in the same transportation load to reduce the logistic cost. Nevertheless, fruits like banana, tomato and garlic release ethylene gas, which accelerate the ripening of other perishables and consequently, increase the level of FW, especially after a long-distance transportation (poor logistics network design).

Another issue that contributes to increasing FW is promotion during the sales period. Pressure to increase sales influences managers to buy larger batches of products, to take advantage of a discount and promote products at discounted prices. However, it might result in unsold products or motivate consumers to buy more than they need. Additionally, suppliers' performance can be affected due to the existence of the bullwhip effect in case they order large batches (Duong et al., 2018), as this might increase the level of waste throughout the supply chain (Durán Peña et al., 2021). Both actions result in FW for any member of the supply chain. We know that retailers will only invest in FW reduction if they see a risk to their reputation or impact on financial value (ReFED, 2018). This shows that in the cases analyzed, the financial health element increases the waste because it does not represent an impact (reputation and financial) for retailers. Expert D also highlights this behavior.

> Because it's a problem, and until the problem does not hit you, you don't solve it. So, while someone is paying this bill, which is us, the consumers, retailers do not solve it (…) the consumer at some point will have to have a role, we will have to press, 'I want to know where this tomato is going at the end of the day'. Anyway, I think that we, the consumers, are going to have to make a revolution at some point, to be able to pressure the guys to sit at the table [Excerpt from an interview, Consultant D].

Consequently, to this, retailers become financial weak to keep investing in training for waste reduction/prevention, as highlighted in the following quote:

> Due to the economic crisis, we cannot qualify an employee to have this awareness level [Excerpt from the interview, RetA_PurcManag]

5.3 Redundancy

In order to guarantee product availability to customers and to avoid disruption, the retailers choose to have F&V redundancy. This decision can increase waste since it compromises the inventory management policy and the procedures for a more accurate demand forecasting. Retailers have a key priority that is to keep high availability of products (F&V) even though this decision might lead to FW generation.

> This company doesn't care about the stock value. There can't be a shortage of products, even the president himself says that if he buys a lot he doesn't care, but if there's a shortage we'll have problems. So when you work with a high number of products, there will hardly be a case of a problem affecting this disruption [Excerpt from the interview, RetA_LogManag].

Another issue related to redundancy is that retailers had a maximum level (percentage of total bought) of waste accepted and if they do not exceed this number, they do not take action. Also, the economic loss is shared with suppliers in their agreements. Thus, retailers do not feel they are losing a lot of money with waste. Moreover, retailers in Brazil are facing very little pressure to take more proactive/social and environmental behaviors from consumers and society, as they are not aware of the FW level. Redundancy can also hinder certain practices at one stage of the supply chain, thus leading to wastage in the others. For instance, retailers usually acquire higher amounts of products during sales seasons to avoid a shortage of products. This would not be a problem if there was equipment that prolongs the shelf life of food. Thus, companies could focus their efforts on creating redundancy of equipment, for example, refrigeration, which would reduce waste in a time of disruption.

6. Discussion

Our results show that collaboration, communication, innovation, knowledge management, leadership and supply chain design can reduce food waste, whilst the emphasis on financial health and redundancy can increase it.Therefore, findings corroborate with those of Bajželj et al. (2020) which concluded that some EoR (e.g. flexibility) can reduce or increase FW, depending on what FWRP they are associated with. In this sense, retailers can consider developing joint planning (with suppliers) and define how to “sell right, not sell more” (Mollenkopt et al., 2011). Further attention should be paid by retailers to ensure that they reduce FW while maintaining their financial health. At the same time, having strong financial health should not encourage retailers to waste more food; they must understand the negative

implications of ordering in large lots, which will also lead to the bullwhip effect, high inventory and lost sales (Duong et al., 2018). The following paragraphs detail the managerial implications, social implications, limitations and further research.

6.1 Managerial implications

This study contributes to analyzing the relationship between EoR, FWRP and FWC for F&V in the retail-supplier dyad. Our findings suggest that the dyad needs to improve actions on the EoR that can assist them both in mitigating risks arising from different types of disruptions, and in developing FWRP that will act on the FWC. Specifically, retailers need to invest in communication with their suppliers to improve demand forecasting and to develop awareness among consumers (Liljestrand, 2017; Muriana, 2017; Aschemann-Witzel et al., 2016). This would result in less food handling and the best use of food at home to reduce waste. Leadership development in store operations is essential for generating knowledge and commitment; for example, creating waste prevention committees in which suppliers and retailers discuss a wide range of common issues and solutions. Additionally, combining the elements of flexibility, collaboration and innovation with security technology are effective ways to increase SCRes as well as implement various types of FWRP.

EoR related to waste reductions also contributes to organizations responding quickly to disruptions. Taking the context of COVID-19 pandemic, interviewees from retail affirmed that initially, they struggled to understand the real demand and this ended up increasing the level of waste. After this first impact, they realized how collaboration and communication with their suppliers helped them to develop initial responses to reduce waste of F&V. On the consumer side, they stated that because of the drop in the number of consumers in stores to handle and pick up F&V, the level of waste has also decreased. However, demand in domestic consumption has suddenly increased through innovative ways of buying goods (such as telesales or apps), which, in this case, the supermarket staff was trained to handle F&V for delivery. As a result, the level of waste in one of the retail chains dropped from 6% to 4.5%. Babbitt et al. (2021) and Sharp et al. (2021) also observed the reduction of FW during the lockdown, and they attributed that to consumers' behavior in adopting practices of food preservation, better using the leftovers, and meal planning before shopping.

However, managers should be aware that some EoRs, when associated with certain FWRP, increase food waste. Findings have shown that product redundancy can increase waste, compromising inventory management policies and procedures for a more accurate demand

forecast. Unfortunately, retailers will only invest in FWRP if they see a risk to their reputation or impact on financial value (ReFED, 2018). Therefore, the pressure to reduce cost (in a way to maintain financial health) can increase FW. For example, mixing different types of fruits in the same transportation load to reduce the logistic cost can increase FW. In addition, pressure to increase sales influences managers to buy larger batches of products and then take advantage of a discount. The negative impact of redundancy and financial health on FW is highlighted by Costa et al. (2021). This research further advances the current knowledge on the topic by empirically analyzing the negative effects of these EoRs on the FWRP. Finally, when the flexibility of suppliers is adopted, it can generate FW upstream in the chain, as retailers change suppliers to get a better product in terms of aesthetic characteristics.

6.2 Social implications

The Sustainable Development Goals (SDG) highlight the need in reducing FW and increasing resilience when referring to zero hunger (SDG 2) and responsible consumption and production (SDG 12) (Amicarelli and Bux, 2020). It is directly related to the call for maintaining sustainable production systems and implementing resilient agricultural practices. Similarly, these SDGs mention the necessity to halve FW per capita worldwide and for that, food waste must be reduced throughout the supply chain. This research contributes towards these aims as they point out paths to reducing FW through the use of EoR (considering the dyad retailer-supplier). Although our study is focused on the F&V sector, other food chains can take advantage of the current findings and then develop their own FWRP.

As previously mentioned by Amicarelli and Bux (2020), it is impossible to ensure that every human being has access to sufficient, safe and nutritious food without fairer, healthier and more sustainable food distribution. This matter represents an ethical issue as about 800 million people are suffering from hunger (Fao, 2019). Therefore, reducing FW can be a fruitful path to ensure better performance in the process of food distribution throughout the chain. This is also highlighted by Costa et al. (2021), who conclude that resilience allows actions to mostly anticipate losses.

Damiani et al. (2021) and Amicarelli et al. (2021b) add that after preventing FW in the production stage, surplus food donation can be an effective way to limit the burden of these impacts. Thus, when anticipation is not possible, donation and composting strategies are the final effective solutions, which have social implications. From the perspective of the circular

economy, this strategy allows the creation of new business opportunities and guarantees a sustainable model of waste management, taking advantage of the resources used in food production. This can be done directly for consumption through donation to NGOs or to foodbanks (Mandal et al., 2021), or as a by-product, through composting, which will promote circularity.

However, to implement FWRP initiatives to deliver those objectives, non-governmental organizations and retailer associations can play a crucial role in raising awareness and communication about reducing waste across the chain. Furthermore, trying to build commitment with other supply chain actors (e.g. consumers) might contribute to learning and changing cultural habits that hinder food waste reduction. Finally, retailers should play an important role, fostering communication, promoting FWRP knowledge exchange and training initiatives all over the supply chain.

6.3 Limitations and further research

This study has some limitations. First, it focused only on the retail-supplier dyad, which is an important one due to its influence and impact on the final consumer, but it does not cover other parts of the supply chain, such as other retail formats like street fair, grocery stores, virtual stores and platforms. Furthermore, four retail chains were analyzed in two regions of an emerging economy. Hence, there is a need for case studies from other regions as well as for different types of perishable food. Future studies could advance these by extending the identification of EoR in FW (reduction practices and causes) and their analysis to producers and consumers, besides analyzing the different formats of retails. Another research stream is to explore the distribution to secondary markets, relating them to industrial symbiosis and circular economy. Analysis from the perspective of industrial symbiosis and circular economy has the potential to reduce FW and add value to items that would be discarded.

Additionally, studies on FW drivers and their interrelationships with EoR should also open-up the research avenues. Future research could analyze the impact of online food sales as advances in online marketing can impact FW as distinct channels for receiving and distributing are required, reducing customer exposure to F&V. Gruchmann et al. (2019), for example, evaluated sustainability-related practices in online distribution channels in Germany and Austria. Our study demonstrates both positive and negative impacts of some EoR on FWR; however, there is still a need for studying by considering a system view and by applying

methods like system dynamics modeling (Kuo et al., 2021; Mangla et al., 2021). The result of these might help deepen the understanding of the impact of adopting resilience in enhancing practices on FWR through economic, environmental and social sustainability in food supply chains.

7. Conclusions

This research investigated if and how Elements of Resilience (EoR) can contribute to food waste (FW) reduction in the Fruits and Vegetables (F&V) retailer-supplier dyad by following food waste reduction practices (FWRP) that address the causes of food waste (FWC). Our results show that collaboration, communication, innovation, knowledge management, leadership and supply chain design can reduce food waste, whilst the emphasis on financial health and redundancy can increase it. Overall, our findings suggest that the dyad needs to improve actions on the EoR that can assist them both in mitigating risks arising from different types of disruptions, and in developing FWRP that will act on the FWC. EoR related to waste reductions also contributes to organizations responding quickly to disruptions. However, managers should be aware that some EoRs, when associated with certain FWRP, increase food waste.

This research is aligned to the Sustainable Development Goals (SDG) in a way it aims to maintain sustainable production systems based on resilient practices. It also contributes towards these aims by pointing out paths to reducing FW through the use of EoR. As our study is focused on the F&V sector, other food chains can take advantage of the current findings and then develop their own FWRP. When referring to FW, it is important to consider anticipation strategy, which proactivetly seeks to identify and monitor disruptions that can cause waste. For example, unit pack adaptations, made to fit packages and one-size-fits-all shipping box prevent FW from excessive or wrong handling of fruits. When anticipation is not possible, donation to NGOs and food banks and composting, by promoting circularity, can be effective strategies

Furthermore, consumers have changed the frequency and quantity of their purchases during the pandemic due to restrictions rules. In this sense, retail chains had to increase the level of communication with suppliers, so as to make quick adjustments in the orders, and consequently maintain supply and reduce any type of waste. For instance, in a low demand scenario, the size of suppliers' shipping boxes was reduced to keep buying the same variety of products but in smaller quantities.

To sum up, it was possible to recognize which EoR contributes to food waste reduction and how such EoRs work. To the best of our knowledge, this is the first empirical study that explores the relationship between EoR and food waste, making a modest contribution by operationalizing this relationship and paving the way to better understanding how these phenomena are related.

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APPENDIX A

Table V: EoR, adapted of Kamalahmadi and Parast (2016), Ali et al. (2017), Stone and Rahimifard (2018), Sá et al. (2019) and Costa et al. (2020)

Elements	**Description**
Agility	It considers the speed in decision making and so that necessary adaptations for the recovery of disruptions are taken.
Collaboration	Ability to work effectively with another entity to obtain mutual benefit in situations related to disruptions. Includes social capital.
Communication	Information exchange to reduce asymmetry between the manufacturer and its suppliers (downstream members and upstream supply chain).
Financial strength	Capacity to absorb possible fluctuations in the company's cash flow based on its financial strength, being able to provide economic incentives and maintain additional suppliers.
Flexibility	Capacity to change (flexibilize) a process, product/supplier or customer/logistic network.
Innovation	Creation process/adopting products, improvement or technology. Helps to recover disruptions when it is innovated to avoid using a certain raw material or process, or when a new product is generated that can resist the negative impacts of a disruption.
Knowledge management	It includes the review of the company's leadership policies and factors related to the knowledge accumulated by managers to take more actions that are effective in disruption events, especially when like those that previously occurred.
Leadership	Commitment and support of the company's top managers with the creation and maintenance of the chain's resilience
Redundancy	Redundancy is the overlap of operations, processes, products, suppliers or systems, based on an extra pre-existing capacity, which is brought about from a disruption. This extra capacity can be used during times of disruption.
Risk management	Composed by monitoring, knowledge and prevention of risks to disruptions. Includes contingency plan.
Security Technologies	Advance defense mechanisms such as automatic identification, cameras, global positioning system (GPS), methods involving X-ray, digital security and information.
Sensing	It includes interpreting events, continuity planning, mapping supply chain vulnerabilities, defining alert strategies, risk prevention and containment, risk control / transfer / sharing.
Supply Chain design	Organization of the chain, including factors such as distance from suppliers, company location and transportation infrastructure.
Trust	Trust that exists among members of the supply chain. It refers to the expectation that the partner will not act opportunistically, fulfilling what has been agreed and contributing to the chain.
Visibility	Company visibility of the demand, risks and other important information to manage and control its supply chain. Based on this visibility, it is possible to anticipate risks, respond in a more coordinated way and recover faster.

APPENDIX B

Table VI: FWC and FWRP that are not in Table IV

Not related FWC: Climate/weather changes [16;18]; Consumer aspects [6;18]; Excessive stakeholder pressure [5;8]; Food polemics [10;11]; Lack of collaboration[2;4;5;19]; Lack of definition of responsibility at work [16;17] ; Lack of integrated IT systems for food tracking [2]; Lack of waste measurement [5;8]; Non-compliance with food safety and quality standards [2] ; Phytosanitary aspects [16]; Problems with labelling[19]; Problems with storage structure [4;16;18;21]; Restrictive laws [11]; Supply and/or demand seasonality [16;17;19]; Unpredictability of competition [4;19]; Lack of stock rotation[4;19]; Excess production [19]
Not related FWRP: Flexibility of quality standards [10;11]; Flexibility of laws without compromising consumer health [11;19]; Maintenance, checking and adjustment of equipment [16;18]; Own brands[16]; Reduction-focused integrated operational systems [21]; Retail pricing and promotion policies[4;19]; Supplier management [19]; Use of technologies for measuring waste [4;19]
Authors
1-Amicarelli et al. (2021a) 2-Balaji e Arshinder (2016) 3-Bilska et al. (2016) 4-Costa et al. (2021) 5-Derqui et al. (2016) 6-Diaz-Ruiz et al. (2018) 7-Garrone et al. (2014) 8-Ghosh et al. (2016) 9-Giuseppe et al. (2014) 10-Göbel et al. (2015) 11-Gruber et al. (2016) 12-Holweg et al. (2016) 13-Jedermann et al. (2014) 14-Kaipia et al. (2013) 15-Liljestrand (2017) 16-Mena et al. (2011) 17-Mena et al. (2014) 18-Moraes et al. (2019) 19-Moraes et al. (2020) 20-Strotmann et al. (2017) 21-Thyberg and Tonjes (2016) 22-Tromp et al. (2016)

APPENDIX C

Table VII: Enablers identified in the cases

EoR	FWRP	A	B	C	D
Collaboration	*Retail-supplier collaboration*	■	■	■	■
	Coordination and communication with members of the chain	■	■		■
	Supplier development		■	■	■
Communication	*Coordination and communication with members of the chain*	■	■	■	■
	Communication with consumers			■	■
Flexibility	*Flexibility of quality standards*	■	■		
	Secondary markets		■	■	
Innovation	*Development and adaptation of packaging*		■		■
	Supplier development	■			■
Knowledge Management	*Training for waste reduction/prevention*	■	■		■
Leadership	*Employee awareness of waste*	■			■
	Training for waste reduction/prevention	■		■	
Security technologies	*Technologies to check food conditions*		■	■	■
Supply chain design	*Integrated logistics system*	■	■	■	■

****Cells in bold indicate the cases in which relationships were found*

APPENDIX D

Table VIII: Barriers identified in the cases.

EoR	FWRP	A	B	C	D
Financial Health	*Procedures for a more accurate demand forecasting*	■	■		
	Employee awareness of waste	■	■		■
	Training for waste reduction/prevention		■		■
	Integrated logistics system		■		■
Flexibility	*Integrated logistics system*	■	■		
Redundancy	*Upstream coordination and communication*	■			
	Inventory management policy	■	■	■	
	Procedures for a more accurate demand forecasting	■	■		
****Cells in bold indicate the cases in which relationships were found*					

APPENDIX E

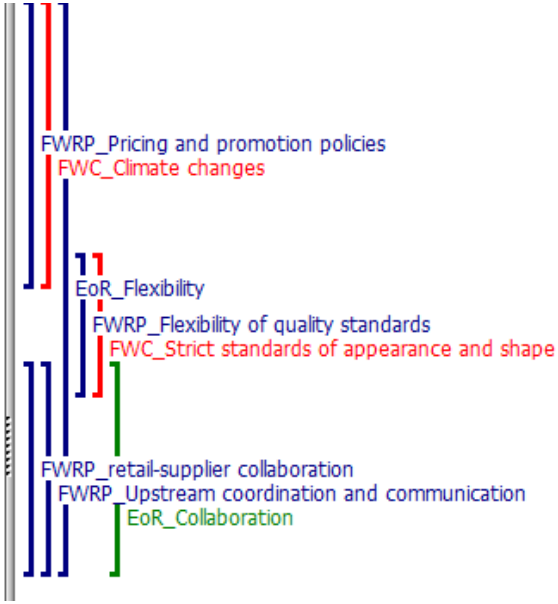
However, the credibility that we have is superior or at most equal, because I have flexibility in some processes within the company. Let's imagine that an onion arrived, it rained and it didn't get in here, the guy "I'm going to spend it on freight, I'm going to lose product that goes to the trash, I have nowhere to dispose of it". So, I have this flexibility to help him, to give him a solution "this onion you were wanting me to pay R$ 2, I'll pay R$ 0.50, I'll sell it for R$ 0.99 and I'll solve your problem. You won't have a problem with loss, with freight, coming back with this product", that's an example. The big ones retailers, on the other hand, have a business so tight that it doesn't allow, you'll get there "this onion here...?, sometimes the guy arrives there with a bag, went to inspect "it's not approved", the guy returns with the onion truck. This is the big difference. They also have a longer payment period which is 45 days. I can pay cash depending on my supplier's needs. Do you want to make an investment? I want. I'm going to make an investment here and in 60 days I'm picking up it for you. Fine then, send this load you have, I'll pay in cash, you go there when you need to and make the investment." This partnership that the small and medium retail stands out in relation to the large.	

Table IX: Excerpt from the interview analysis, RetA_PurcManag

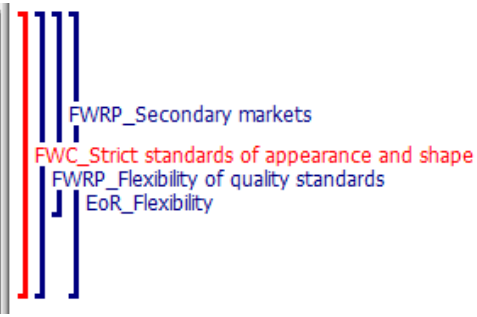
As we work with different public, from the top to those that have a small market, that way we can take it out, left the package that is more or less to put in a store that does not demand so much for quality, which is what we call a small market, right? What comes out of special stores goes here too and in some cases can be used for the (name of wholesale) because it comes out uncalibrated. The problem is the lack of calibration, for example, (case B) today is the most annoying customer on the face of the earth.	

Table IX: Excerpt from the interview analysis, SupB1_Comerc_FEng.