FORUM

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DOES RESILIENCE IMPACT FOOD WASTE? MOVING THE DEBATE ON

Resiliência impacta a redução de desperdício de alimentos? Avançando o debate

¿La resiliencia afecta la reducción del desperdicio de alimentos? Avanzando en el debate

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ABSTRACT

The main purpose of this paper is to analyze the contributions of elements of resilience (EoRs) to food waste reduction practices (FWRP) and to deal with causes of food waste (FWC). Based on a systematic literature review, a content analysis process was carried out with 143 relevant papers. Three main EoRs were identified: knowledge management, collaboration and flexibility. Financial health and redundancy are factors which can increase food waste (FW). The ability to anticipate is the most important practice to develop. This paper is the first attempt to establish the role of EoRs in tackling food waste management, and to propose new avenues of research.

KEYWORDS | Food waste, resilience, retail, sustainability, elements of resilience.

RESUMO

O objetivo deste artigo é analisar as contribuições dos elementos da resiliência (ERs) para as práticas de redução de desperdício de alimentos (PRDAs) e para lidar com as causas de desperdício de alimentos (CDAs). A partir de uma revisão sistemática da literatura, realizou-se uma análise de conteúdo em 143 artigos. Entre os elementos que mais contribuem para as PRDAs, estão: gestão do conhecimento, colaboração e flexibilidade. Entretanto, saúde financeira e redundância podem aumentar o desperdício de alimentos (DA), e antecipação é a capacidade prioritária a ser desenvolvida. Este artigo é a primeira tentativa de estabelecer o papel dos ERs na redução do desperdício de alimentos, e uma agenda de pesquisa é proposta.

PALAVRAS-CHAVE */ Desperdício de alimentos, resiliência, varejo, sustentabilidade, elementos da resiliência.*

RESUMEN

El objetivo de este artículo es caracterizar y analizar cómo los elementos de resiliencia (ER) contribuyen a las prácticas de reducción (PRDA) y las causas de desperdicio de alimentos (CDA). Por medio de una revisión sistemática de la literatura, se realizó un análisis de contenido en 143 artículos. Entre los elementos que más contribuyen, están: gestión del conocimiento, colaboración y flexibilidad. Sin embargo, la salud financiera y la redundancia pueden aumentar el desperdicio de alimentos (DA) y la anticipación es la habilidad prioritaria a desarrollar. Este artículo es el primer intento de establecer el papel de los ER en la reducción del desperdicio de alimentos, y propone una agenda de investigación.

PALABRAS CLAVE */ Desperdicio de alimentos, resiliencia, minoristas, sustentabilidad, elementos de resiliência.*

INTRODUCTION

Tackling food waste (FW) has become a top priority on the agendas of various governments and economic sectors in their pursuit of achieving the UN's Sustainable Development Goals (SDGs). There is, however, no commonly agreed definition of food lost (FL) and food waste (FW). Both FL and FW refer to reductions in the quantity or quality of food in the food supply chain. FL generally refers to losses in the food supply chain from harvest up to - but not including - the retail level. FW, on the other hand, occurs in the final stages of the chain, such as during the distribution, sale, and/or consumption of the food. As this study analyzes distribution with a focus on retail, FW will be the term used herein (Food and Agricultural Organization of the United Nations - FAO, 2019). It is estimated that every month 25 kg of food are wasted per capita in both Europe and the United States, with figures of 18 kg in Latin America, and 10 kg in South and Southeast Asia (Gustavsson, Cederberg, Sonesson, Otterdijk, & Meybeck, 2011). Recognizing the significant levels of waste that are generated in food supply chains (Gustavsson et al., 2011) due to various factors, such as environmental instability, market dynamism and increasing globalization, new management approaches have been developed in order to optimize the use of organizational resources and maintain competitive advantage.

Resilience is one way in which supply chain performance can be managed and improved when facing different types of disruption (e.g., internal, external and environmental). In operations management, resilience is defined as the adaptive capacity of a supply chain to resist and deal with unexpected events (disruptions) while maintaining control over its structure and functions, and enabling it to recover and respond to such disruptions in order to restore the chain to its original (or better) state of operation (Christopher & Peck, 2004; Kamalahmadi & Parast, 2016; Ponomarov & Holcomb, 2009). Individuals and organizations can address disruptions or discontinuities better by utilizing the core elements of resilience (EoRs), i.e., the basic concepts that help develop the abilities required for anticipating, adapting and responding to, and recovering and learning from disruptions.

Resilience can be a means of ensuring that food production and distribution processes deal with the causes of waste, and respond to and recover from disruptions while achieving sustainable development goals (Food and Agricultural Organization of the United Nations - FAO, 2016). For instance, Mena, Adenso-Diaz and Yurt (2011) state that unexpected events, such as climate change and demand variability, are important causes of food waste. Visibility and flexibility are elements of resilience (EoRs) that can help minimize the impact of such events. On the other hand, the absence of EoRs, like trust, visibility and communication (Kamalahmadi & Parast, 2016) are highlighted by Canali et al. (2016) as causes of food waste.

Few existing studies (Macfadyen et al., 2016; Manning & Soon, 2016; Moraes, Costa, Silva, Delai, & Pereira, 2019) have focused on exploring whether resilience can reduce levels of food waste. The following are just some of the examples of previous areas of study within the field of resilience and FW. Moraes et al. (2019) explore the theoretical relationship between resilience and FW. They point out that studies on resilience and FW have generally been developed separately from each other, and that discussions on integrating these two topics are necessary in order to describe how resilience can influence FW, so that organizations can prepare to avoid waste and improve their operations. Gružauskas, Gimžauskienė and Navickas (2019) mention that adaptation – an aspect of resilience – improves the alignment of supply and demand and can reduce FW. These same authors

also highlight the need to maintain resilience in food systems in order to increase sustainability, while reducing FW. They address resilience as a means of preparing for upcoming market fluctuations and reducing the effects of such fluctuations on FW (Gružauskas et al., 2019).

Although a number of studies thoroughly explore the importance of EoRs (Ali, Mahfouz, & Arisha, 2017; Kamalahmadi & Parast, 2016; Scholten, Scott, & Fynes, 2014), and others deals with reductions in FW (Canali et al., 2016; Diaz-Ruiz, Costa-Font, López-i-Gelats, & Gil, 2019; Holweg, Teller, & Kotzab, 2016; Mena, Terry, Williams, & Ellram, 2014), discussions concerning the integration of these topics have not been found so far in extant literature. Hence, there is a need to explore how resilience contributes to the reduction in FW, so that organizations can implement practices to anticipate, prevent and reduce it.

There are typically lower rates of waste at the retail stage of the supply chain than at other stages, such as production and post-harvest (Stenmarck, Jensen, Quested, & Moates, 2016). Despite this, supermarkets are at the center of food systems and can exert significant influence on FW throughout a chain, making this area an important link to study (Gruber, Holweg, & Teller, 2015). Retailers are also able to understand consumers' decision-making processes better (Cunha, Spers, & Zylbersztajn, 2011), and influence their behavior by raising awareness of FW, for instance.

The objective of this article is to analyze the contributions of EoRs to food waste reduction practices (FWRPs) and deal with the causes of food waste (FWCs). The basis of this article is a systematic literature review (SLR) and it analyzes possible FW avoidance actions that can be implemented in retail chains. It contributes to the theoretical debate around FW by highlighting the role of resilience in helping retailers anticipate and respond to the causes of waste by avoiding and minimizing possible disruptions in their operations.

RESEARCH METHOD

An SLR was undertaken to understand the state of the current literature on EoRs and FW. In doing so, three macro-stages were used based on Tranfield, Denyer and Smart (2003). The first stage involved establishing the scope of the project in order to define the research problem, the research questions, and the review protocol. Four research questions were proposed:

Q1) What are the main elements required for building resilience in a supply chain?

Q2) What are the main causes of food waste in a supply chain?

Q3) What are the main practices for reducing and/or preventing food waste?

Q4) How do elements of resilience contribute towards reducing and/or preventing practices, and the causes of food waste?

Aiming to provide robust and reliable results, a review protocol (Exhibit 1) was developed that set out the details of all of the steps in the SLR., Several keywords (identified from the initial scope review) were listed for each research question covering the main points of interest. The keywords and codes used were extracted from the constructs of the research questions, and possible search strings were tested before defining the final versions. All of this information is available in Exhibit 2.

Exhibit 1. SLR Protocol

Stage	Details
Strategy for identifying studies	- Identify constructs (Exhibit 2); - Define keywords (Exhibit 2); - Develop search strings (Exhibit 2); - Search on Web of Science, Scopus, EBSCO Academic Premier, Scielo and Spell databases; - Search in 17-year period (2000 - 2017).
Selecting the studies	- 1st selection: titles, abstracts and keyword screening; - 2nd selection: introduction and conclusion; - 3rd selection: analysis of the quality of the journal, complete reading and evaluation of the quality of the article
Data extraction & monitoring process	- Read full paper; - Use QDA Miner (qualitative software) to code the content based on the results of the research questions.
Data synthesis	- Content analysis based on literature review by cross-referencing data from different concepts, discussion and authors; - Answer the review question based on what is known in the literature; - Highlight the relevant points and gaps in the literature.

Exhibit 2. Constructs, keywords and search strings

Construct/Research Question	Keywords Used	Search Strings
Supply Chain Resilience	Supply chain resilience; Resilient supply chain; Resilience; Supply resilience; Supply chain risk management; Risk management; Vulnerability; Supply chain vulnerability.	((("supply net*") OR ("value chain*") OR ("supply chain*")) w/3 (resilien* OR risk* OR vulnerabilit*))
FWC	Food supply chain; Food waste; Food loss; Food surplus; Food waste cause; Food waste source;	((("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*))
Practices for reducing and/ or preventing food waste	Food supply chain; Food waste; Food loss; Food surplus; Reduce food waste; Waste minimization; Waste prevention; Waste reduction; Waste management; Reduction practices; Waste management practices; Prevention 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))
Supply Chain Resilience and FW	All the words mentioned before	((("supply net*") OR ("value chain*") OR ("supply chain*")) w/3 (resilien* OR risk* OR vulnerabilit*)) AND ((food) w/5 (wast* OR surplus OR los*))

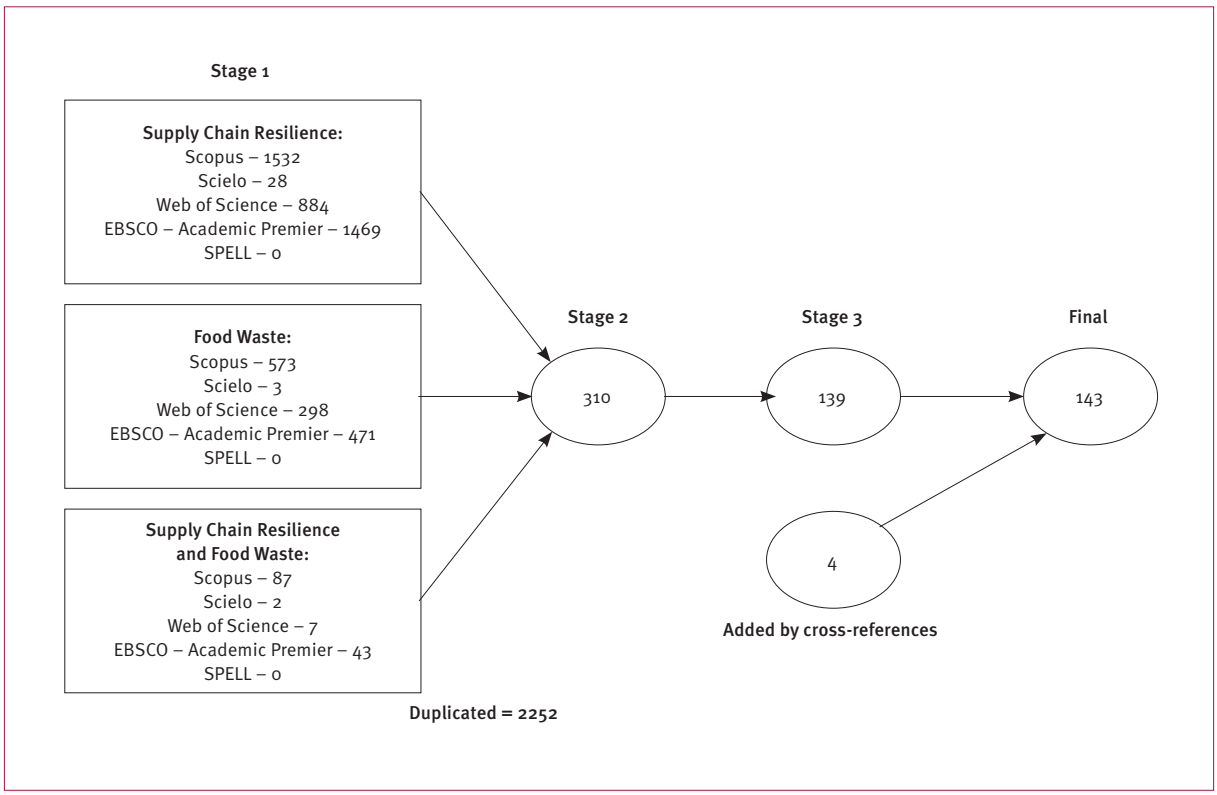
The search was conducted using five databases: Web of Science, Scopus, EBSCO, Scielo, and Spell, since combining sources provides better research results (Chadegani et al., 2013). The first two databases were chosen because they are regularly updated, and contain a wide breadth of coverage on most scientific subjects (Chadegani et al., 2013), besides offering powerful features for conducting searches and refining results (Boyle & Sherman, 2008). The EBSCO/Academic Premier database was considered because it is one of the most extensive databases in the field of management studies (Thomé, Scavarda, Fernandez, & Scavarda, 2012). Scielo and Spell were included as they provide specific information regarding emerging economies, such as Brazil, thereby enriching the results of the SLR. The study considered articles published between 2000 and 2017, recognizing that publications dealing with both resilience in supply chains and FW began to be published around 2000 at the earliest (Ali et al., 2017).

The second stage was carrying out the review. Three filters were used at this stage to select relevant papers (Exhibit 1), which were collected and read in full by two junior researchers. The general evaluation criteria used are detailed in Exhibit 3. Based on the keywords chosen, the initial search yielded 5,397 articles, of which 2,252 were duplicates. After applying the inclusion and exclusion criteria (Tranfield et al., 2003), 143 articles were ultimately selected, with four new articles being added by manual cross-referencing, as they were not identified using the established keyword strings. The general results of the search and filter process used are shown in Figure 1.

Exhibit 3. **General assessment criteria**

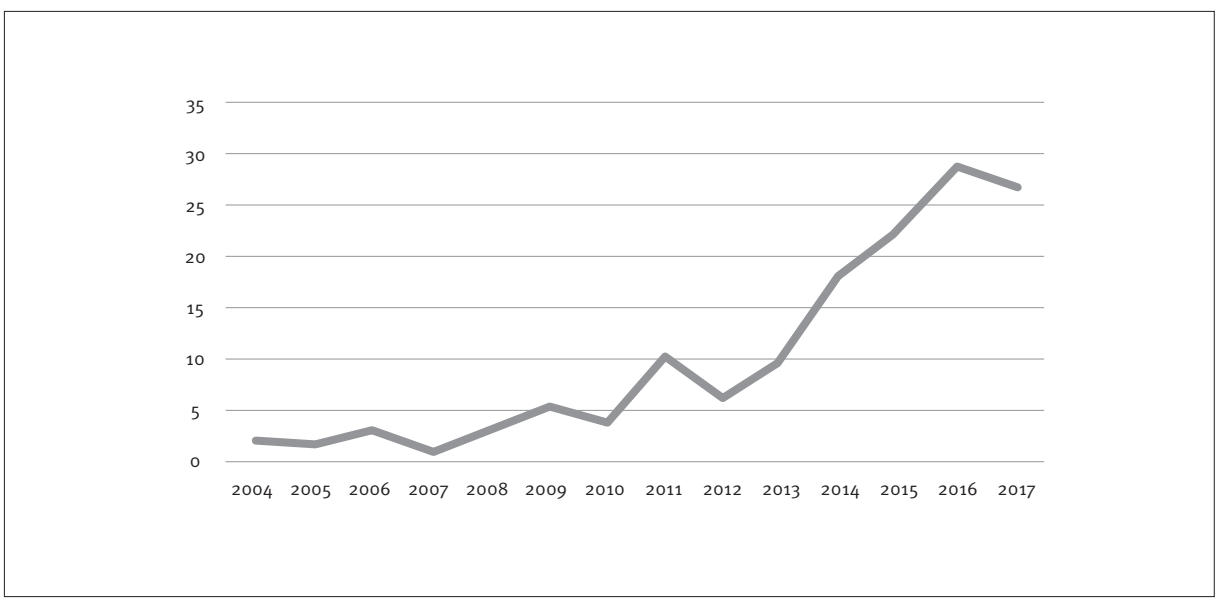
	Criteria	Inclusion Criteria	Exclusion Criteria
1	Focus	Dealing with resilience and/or FW in SCM, Operations Management and Sustainability..	Refers to resilience and/or management (reduction) of FW focusing on another area rather than supply chain and operations management.
	Resilience	Directly addresses resilience and/or includes elements for building up resilience.	Does not refer directly to resilience and/or management (reduction) of FW in the supply chain, does not consist of enablers for creating supply chain resilience.
	Food waste	Directly addresses the causes of FW in the supply chain and/or practices for reduction and prevention.	Does not directly address the causes of FW in the supply chain and/or practices for reduction and prevention.
2	Access	Has access to the paper, is written in English or Portuguese.	Does not have access to the paper, it is not written in English or Portuguese.
	Quality	Peer-reviewed scientific journals.	Scientific journals not peer-reviewed, business journals, current journals, conferences, books and websites.
	Theoretical framework	Concepts of resilience and/or FW in a context of operations management and/or supply chain management, sustainability as the focus of work.	Concepts referring to material science or the environment, physiology, psychology and human behavior, strength and urban studies.
	Unit of analysis	Supply chain resilience and/or waste focused on distributing products from the retail supplier, internally from retail and the final distribution by the retailer.	Deals with resilience and/or FW in communities, materials, environment or unrelated individuals to organizations.

Figure 1. **Results of the SLR filters**



An important aspect to highlight is the evolution of these topics over the years. Figure 2 depicts the historical distribution of the articles that were identified.

Figure 2. **The historical distribution of the articles identified**



The third stage included reporting and dissemination. The content analysis method was chosen to synthesize and communicate the results (Krippendorff, 2013). The full papers were input into QDA Miner (Qualitative Data Analysis software) for processing as part of content analysis. This software was used to divide up the articles at the sentence and text levels, according to the codifications created. The creation of codifications with branch levels enabled common patterns in the articles to be identified, and initial comparisons to be made. A scoping review was carried out to codify the articles considered in this research and, with the aid of senior researchers, a number of initial codifications were identified and used to create a codebook.

Codes were added, withdrawn or combined during the detailed reading of the articles. As this research began with a small group of previously defined categories and underwent changes during the coding process, both concept-driven coding, which starts from a group of previously defined codes and seeks to extract them from texts, and data-driven coding, where the research begins without any pre-defined codes, but allows them to 'emerge' from the literature, were used (Gibbs, 2009).

To ensure the accuracy and reliability/validity of the coding process, two researchers read and coded all the articles and reviewed each other's encodings (Krippendorff, 2013). To guarantee that all relevant excerpts from the articles were coded, and to answer possible doubts about certain codified sections, three senior researchers reviewed the results. Proximity plots were used to identify the relationships between the constructs studied. This type of graph presents the proximity of encodings across the texts studied, or co-occurrences among the constructs, thus enabling an understanding and illustration of the elements that are most frequently associated with the main FWCs and the practices of reduction and/or prevention (QDA Miner, 2017).

The coefficient of co-occurrence was calculated based on Jaccard's coefficient, which attributes equal weight to cases where co-occurrence is identified and cases where one item is found but not the other (Chen, Ibekwe-SanJuan, & Hou, 2010). By codifying the articles and identifying the sections that referred to elements of resilience, causes of waste and prevention practices, the relationships between these three main constructs could be analyzed.

To facilitate this analysis, the intersections between the elements of resilience and the causes and practices of reducing and preventing FW were classified using Ishikawa groups. Table 1 shows the proximity values generated from the content analysis with the aid of QDA Miner software. The numbers highlighted in Table 1 represent the relationships that are within 80% in terms of proximity values, and that are the focus of the discussion in this article. The numbers in bold indicate the use of the Pareto principle to select elements that represent 80% of the total proximity between the elements (Defeo & Juran, 2010), the causes and practices of each Ishikawa (1986) group of causes; these elements are discussed throughout this article.

Proximity reports were generated in pairs in order to conduct this analysis – first between EoRs and FWCs, and then between EoRs and FWRPs. The EoRs with the greatest influence on both FWCs and FWRPs are detailed in the following section.

Table 1. **Intersections between the elements of resilience and the Ishikawa groups (causes and practices)**

		machine_ cause	machine_ practice	method_cause	method_ practice	people_cause	people_ practice
Element	Supply chain structure	0,206	0,006	0,783	0,237	0,066	
	Flexibility	0,133	0,016	0,545	0,251		
	Leadership	0,111		**0,619**	**0,301**	0,310	
	Collaboration	0,100		**0,598**	**0,455**	0,057	
	Knowledge management	0,059		**0,522**	**0,310**	**0,338**	**0,043**
	Visibility	0,151	0,014	0,403	0,242	0,109	
	Sensing	**0,133**	**0,063**	0,295	0,337		
	Trust	0,063		0,519			
	Communication	0,061		0,433	0,229		
	Innovation	0,181		0,273	0,247	0,066	
	Security Technologies	**0,248**	**0,087**	0,326	0,210	0,115	
	Agility	0,111	0,042	0,388	0,331	0,109	
	Risk management	0,127		0,361			
EB	Redundancy	0,112		0,512	**0,356**	0,205	
	Financial Strength	0,057		**0,481**	**0,362**	**0,121**	**0,111**
Total		1,853	0,228	7,058	3,868	1,496	0,154

		material_ causa	material_ practice	measurement_ cause	measurement_ practice	environment_ cause	environment_ practice
Element	Supply chain structure	0,094	0,020	0,117		0,079	
	Flexibility	0,149	0,025	**0,190**	**0,031**	0,130	
	Leadership	0,049		0,102		0,072	
	Collaboration	0,066	0,025	0,157	0,025	0,111	
	Knowledge management	0,028		0,071		0,071	
	Visibility	**0,142**	**0,027**	0,227	0,027	0,120	
	Sensing	0,015		**0,237**	**0,038**	0,167	
	Trust	0,016		0,054			
	Communication	**0,081**	**0,051**	0,092	0,029	0,084	
	Innovation	**0,171**	**0,061**	0,095	0,034	0,120	
	Security Technologies	0,071	0,026	0,056	0,026	0,071	
	Agility	0,236		0,101	0,028		
	Risk management	0,050		0,072		0,162	
EB	Redundancy	0,046		0,173		0,068	
	Financial Strength	0,025		0,074		0,218	
Total		1,239	0,235	1,818	0,238	1,473	

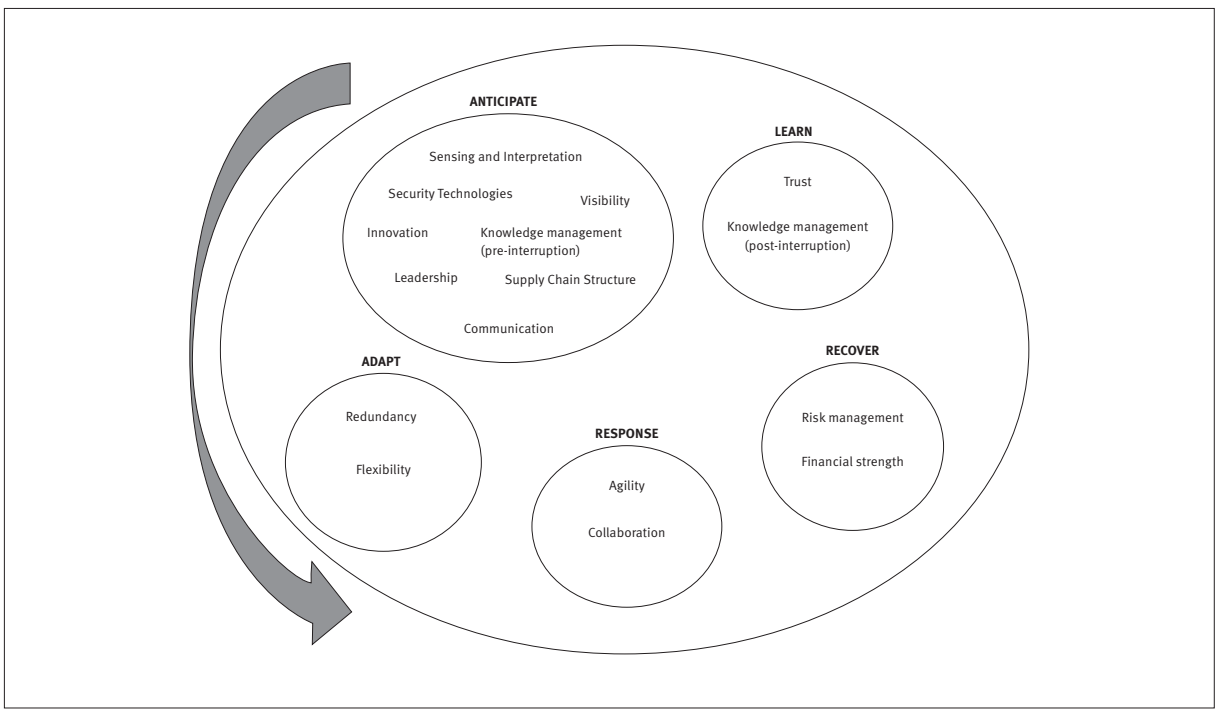
RESULTS AND DISCUSSIONS

This section presents the results of the SLR, which are organized in order to answer the four research questions proposed above.

Elements of resilience (EoRs)

Disruptions in the flow of goods, services and/or information are sudden and unexpected events that can cause a supply chain to fail in its mission to deliver products and/or services to its customers according to specified locations, quantities, time and defined costs (Ponomarov & Holcomb, 2009). EoRs might be organized in terms of abilities, such as the anticipation of, adaptation and response to, and recovery and lessons learned from disruptions. Figure 3 was based on the abilities and elements of resilience that were identified and classified by Ali et al. (2017), combined with other elements that were found in the extant literature.

Figure 3. **Elements of resilience**

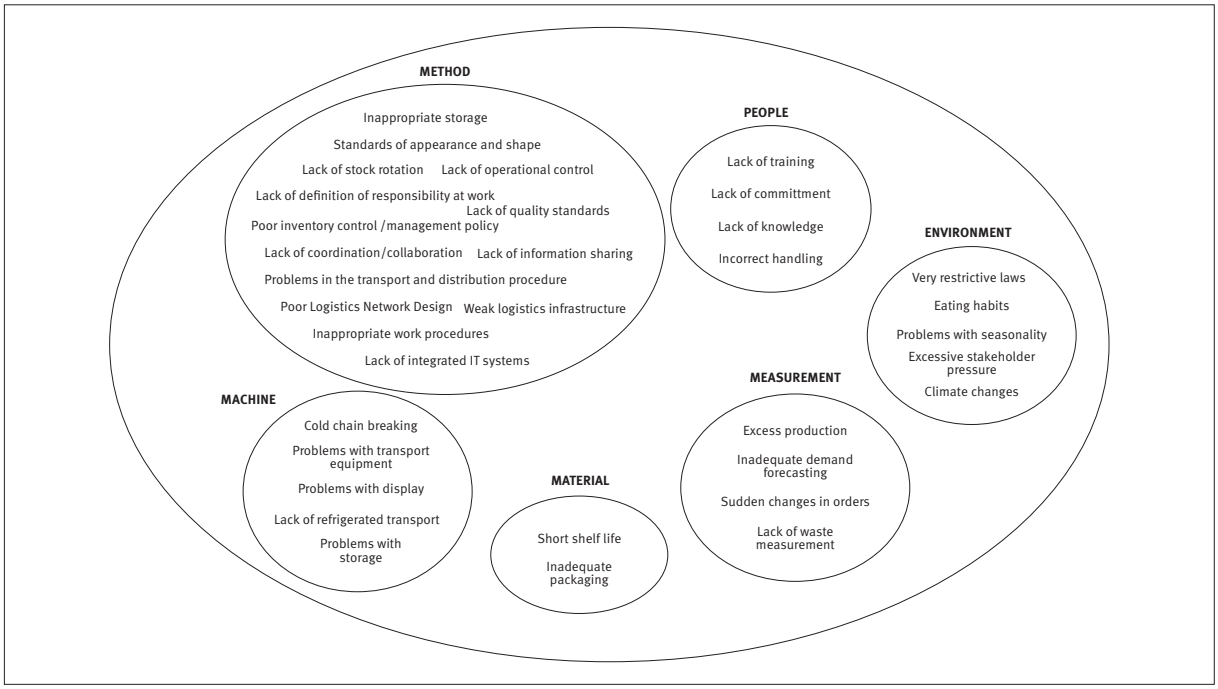


Source: Adapted from Ali et al. (2017).

Food Waste Causes (FWCs) and Food Waste Reduction Practices (FWRPs)

Figures 4 and 5 were developed based on the FWCs and FWRPs identified in the articles of the Systematic Literature Review, following the codebook presented in the methodology section, which were later classified into Ishikawa groups to facilitate analysis, following the method used in the Systematic Literature Review performed by Moraes, Costa, Pereira, Silva and Delai (2020). The main FWCs identified are shown in Figure 4. To better identify and group these causes, the model developed by Bilska, Wrzosek, Kołożyn-Krajewska and Krajewski (2016) was followed. Using this method, it is possible to discover, organize and summarize a group's knowledge about the possible causes that contribute to FW.

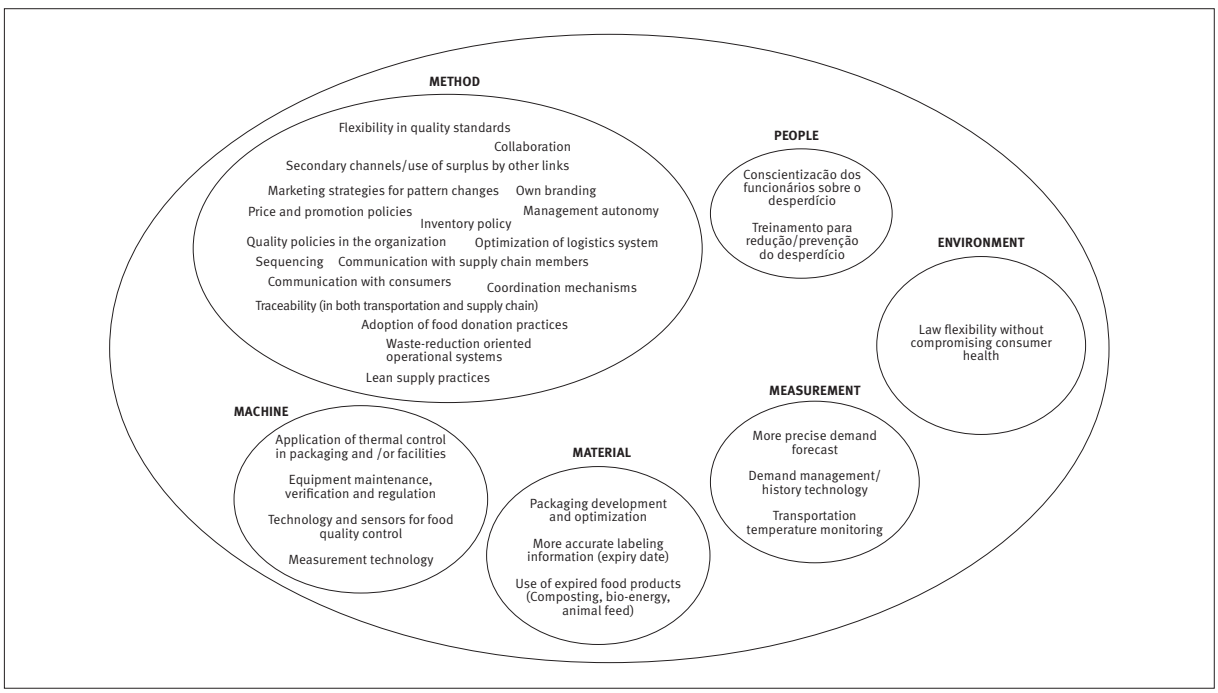
Figure 4. **FMC**



Source: Adapted from Moraes et al. (2020) and Bilska et al. (2016).

The main FWRPs identified are shown in Figure 5.

Figure 5. **FWRP**



Source: Adapted from previous SLR Moraes et al. (2020)

How do elements of resilience contribute towards minimizing food waste in the supply chain?

This section characterizes and analyzes how EoRs contribute to FWRPs and, consequently, to reducing FWCs. In doing so, EoRs are organized in terms of abilities (anticipation, adaptation, response, recovery and lessons) (Ali et al., 2017). Exhibit 4 shows the relationships generated by these proximities and presents only the relationships found between EoRs, FWRPs, and FWCs.

Exhibit 4. **Intersections between EoR, FWRP and FWC**

	EoR	FWRP	Clas.	FWC	Clas.
ANTICIPATE	COMMUNICATION	Packaging development and optimization	MAT	Inadequate packaging	MAT
				Short shelf life	MAT
		More accurate labeling information (expiry date)	MAT	Inadequate packaging	MAT
				Short shelf life	MAT
	INNOVATION	Packaging development and optimization	MAT	Inadequate packaging	MAT
				Short shelf life	MAT
	KNOWLEDGE MANAGEMENT	Communication with supply chain members	MET	Lack of information sharing	MET
		Communication with consumers	MET		
		Training for waste reduction/prevention	PEO	Lack of training	PEO
				Lack of knowledge	PEO
		Employee awareness of waste	PEO	Lack of training	PEO
				Lack of knowledge	PEO
	LEADERSHIP	Management autonomy	MET	Lack of coordination/ collaboration	MET
				Appearance and shape standards	MET
				Inappropriate work procedures	MET
				Lack of operational control	MET
		Quality policies in the organization	MET	Lack of coordination/ collaboration	MET
				Appearance and shape standards	MET
				Inappropriate work procedures	MET
				Lack of operational control	MET
	SECURITY TECHNOLOGIES	Technology and sensors for food quality control	MAC	Cold chain breaking	MAC
	SENSING	Technology and sensors for food quality control		Cold chain breaking	MAC
		More precise demand forecast	MEAS	Inadequate demand forecasting	MEAS
	VISIBILITY	Packing development and optimization	MAT	Inadequate Packing	MAT

Continue

Exhibit 4. **Intersections between EoR, FWRP and FWC**

Concludes

	EoR	FWRP	Clas.	FWC	Clas.
ADAPT	FLEXIBILITY	Secondary channels/use of surplus by other links	MET	Poor Logistics Network Design	MET
				Poor inventory control / management policy	MET
				Lack of stock rotation	MET
		Inventory policy	MET	Poor Logistics Network Design	MET
				Poor inventory control / management policy	MET
				Lack of stock rotation	MET
		More precise demand forecast	MEAS	Excess production	MEAS
				Inadequate demand forecasting	MEAS
				Sudden changes in orders	MEAS
	REDUNDANCY (BARRIER)	Inventory policy	MET	Poor inventory control / management policy	MET
RESPOND	COLLABORATION	Collaboration	MET	Lack of information sharing	MET
				Lack of coordination/ collaboration	MET
		Adoption of food donation practices	MET	Lack of information sharing	MET
				Lack of coordination/ collaboration	MET
		Communication with supply chain members	MET	Lack of information sharing	MET
				Lack of coordination/ collaboration	MET
RECOVER	FINANCIAL STRENGTH (BARRIER)	Inventory policy	MET	Problems in the transport and distribution procedure	MET
		Optimization of logistics system		Inappropriate work procedures	MET
		Training for waste reduction/prevention	PEO	Lack of training	PEO
				Lack of knowledge	PEO
				Lack of commitment	PEO
	Ishikawa Classification	MET – METHOD	MEAS – MEASURE		
		MAC – MACHINE	ENV - ENVIROMENMENT		
		MAT - MATERIAL	PEO – PEOPLE		

Anticipate

According to Ali et al. (2017), this ability encompasses elements that are proactive in identifying ruptures and changes in the environment. As a consequence, these interruptions do not affect supply chain operations, thus avoiding FW. Seven elements of the ability to anticipate were found that relate to FWRPs and FWCs, as follows.

Communication

Communication refers to the exchange of information required to reduce asymmetries between manufacturers and suppliers (Wieland & Wallenburg, 2013). Since FW is produced at all links in the supply chain, FWRPs should include communication between these links (Aiello, Enea, & Muriana, 2015; Derqui, Fayos, & Fernandez, 2016). For example, more accurate shelf-life information on labels can reduce information asymmetries among suppliers, retailers, and consumers. Clear date labels and storage instructions are also essential for the correct storage of food until its consumption (Aschemann-Witzel, Hooge, & Normann, 2016). Communication between links in a food supply chain can improve the development of packaging. As a result, more efficient distribution packaging can reduce shipping and handling damage, which increase waste. An example of efficient packaging is prepacked vegetables and fruit, which reduces handling and improves turnover in stores (Verghese, Lewis, Lockrey, & Williams, 2015).

Innovation

Innovation is related to the creation/adoption of new products, processes or packaging, and improvements in technologies, which generate adaptability (Golgeci & Ponomarov, 2013; Kamalahmadi & Parast, 2016). Innovation enables the optimization of food packaging for better quality monitoring, appropriate ventilation and temperature control, and increased shelf life for fresh produce (Shafiee-Jood & Cai, 2016). Further innovations include efficient distribution packaging to reduce transportation and handling damage, more appropriate serving sizes and clearer labels indicating contents and shelf life, to avoid consumer waste (Verghese et al., 2015).

Security technology

This EoR refers to early defensive mechanisms, such as global positioning systems and digital/information security (Rajesh & Ravi, 2015). The primary application of sensing systems is for monitoring the attributes of food products (Raak, Symmank, Zahn, Aschemann-Witzel, & Rohm, 2017). The use of these sensors reduces FW caused by fluctuating temperatures during transportation and storage. Jedermann, Nicometo, Uysal and Lang (2014) mention that a data logger with a built-in sensor is crucial for monitoring and adjusting deviations in produce temperature along the chain.

Leadership

Leadership, or the commitment to and support of the company's top managers in the creation and maintenance of chain resilience (Christopher & Peck, 2004; Kamalahmadi & Parast, 2016; Scholten et al., 2014), can influence FWCs and FWRPs, insofar as they can have a direct impact on management's autonomy and commitment to develop and implement a quality policy. By carrying out regular management reviews and guaranteeing adequate resources (Bilska et al., 2016; Göbel, Langen, Blumenthal, Teitscheid, & Ritter, 2015; Gruber et al., 2015), the supply chain can reduce the causes of FW, such as inappropriate work procedures, a lack of operational control/information sharing/coordination/collaboration, and changes in the appearance and shape of food.

Sensing

Sensing (detecting problems) involves interpreting events, planning for the continuity of operations and mapping out the vulnerabilities of the supply chain (Ali et al., 2017). This element is influential in implementing food waste reduction practices, such as using technologies and sensors to evaluate the condition of the food, allowing for problems to be interpreted (equipment/process), and response and control strategies to be defined (Ali et al., 2017; Derqui et al., 2016).

This aspect also influences the measurement, interpretation, and analysis of sales and production forecasts, as well as monitoring and perceiving changes in demand (Raak et al., 2017). It assists in analyzing the information collected about supply, demand, and quantities wasted, and in decision-making based on the information obtained from this monitoring (Hodges, Buzby, & Bennett, 2011).

Visibility

This aspect enables companies to identify risks, demands and other crucial information for supply chain management and control (Kamalahmadi & Parast, 2016; Pettit, Fiksel, & Croxton, 2013). Bilska et al. (2016) argue that visibility helps in planning the use of resources, equipment and processes. A clear understanding of the supply chain and consumers allows those areas to be identified that require more appropriate information in terms of labels and product presentation on the shelves (Mena et al., 2014; Verghese et al., 2015).

Knowledge management

This aspect includes reviewing the company's leadership policies and factors related to managers' accumulated knowledge, the goal being to take effective action in case of disruptive events (Sahu & Mahapatra, 2017; Scholten et al., 2014). Scholten et al. (2014) found that previous experience, lessons learned and training can all assist in recovering from disruptions. According to both Scholten and Schilder (2015) and Kamalahmadi and Parast (2016), the ability to manage knowledge derives from training, access to information, or experience gained from previous disruptions. It reflects the need for organizations to share information with other links in their supply chains, as knowledge often tends to be limited to only a few individuals, thereby increasing the frequency of causes related to the lack of information sharing (Canali et al., 2016).

Waste reduction and prevention campaigns have either been inspired by previous initiatives or recognized by subsequent ones (Thyberg & Tonjes, 2016). According to Aschemann-Witzel et al. (2016), this reinforces the importance of promoting and facilitating the dissemination of knowledge about existing initiatives throughout the chain. Employees' knowledge of safe handling helps reduce FW (Bilska et al., 2016). The extent to which managers and employees are aware of safe food handling and know how to communicate issues make it possible to exchange ideas about preventing and reducing FW (Gruber et al., 2015).

Bilska et al. (2016) posit that training should be conducted regularly in order to update knowledge, implement behavioral changes and enhance employee commitment to the task of preventing FW. The knowledge accumulated by managers and those in higher positions can positively influence waste reduction and can be passed on to employees and to other agents in the chain for decision-making (Gardas, Raut, & Narkhede, 2017).

Adapt

This ability encompasses the concurrent capabilities required to continually manage and adjust critical supply chain resources during disruptions, by adapting to change quickly and readily (Ali et al., 2017). Two elements belonging to the ability-to-adapt category were found to be related to FWRP and FWC.

Flexibility

Flexibility, or the ability to alter a process, product/supplier or customer/logistic network, may impact the journey of products to secondary markets, which can be ensured by having flexible logistics networks, and by firms' internal processes for reclassifying products as capable of being destined for other markets (Garrone, Melacini, & Perego, 2014). In other words, flexibility enables surplus products or products that have lower quality standards to be reclassified or repurposed, which in turn reduces waste. Holweg et al. (2016) state that flexibility allows products to be repurposed for other areas, thus contributing to reducing waste generated by errors or unexpected changes in demand.

Redundancy as a barrier

The literature reviewed supports the idea that this element can negatively influence reduction practices; it does not contribute towards reducing waste, and may even increase it. According to Gruber et al. (2015), this is because managers request a higher quantity of products to guarantee a temporary 'safety stock'. Mena et al. (2014) posit that there is a tendency to keep excess stocks because managers prefer to lose surplus products, rather than lack products that are needed. They also suggest that changes in this behavior could help reduce waste.

Redundancy can hinder certain practices at one stage in the supply chain, thus leading to FW in others. For instance, this can occur when the inventory level at a retail store is reduced and permanent availability from suppliers' inventories is required, thus transferring the risk of deterioration to an earlier stage of the chain (Göbel et al., 2015).

Respond

This ability encompasses the concurrent elements needed to react to supply chain events quickly and efficiently to lessen the impact of disruptions. It refers to a company's immediate response to sudden and significant shifts in the environment in the form of uncertain demand, maintaining control and offering a first response to disruptions (Ali et al., 2017). Collaboration in this area was found to be related to FWRP and FWC.

Collaboration

Since waste can be produced at all stages of the chain, *collaboration* – individuals or entities working effectively together and obtaining mutual benefit in disruption situations (Johnson, Elliott, & Drake, 2013; Pettit et al., 2013) – is necessary. Collaboration influences both the primary topics, as the actions of one link in a chain can contribute either positively or negatively to the other links (Aiello et al., 2015). A lack of collaboration can generate a context whereby each company involved will try to optimize its processes, leading to the accumulation of waste in the pre-and post-chain stages (Göbel et al., 2015). Therefore, there is a need to collaborate with logistics partners and suppliers (Derqui et al., 2016; Gruber et al., 2015).

Moreover, federal, state and local government agencies need to collaborate with both the private sector (retail, community groups, NGOs and the waste industry, for instance) and the public sector to make joint efforts to tackle FW and accept shared responsibility (Hodges et al., 2011).

Recover

This ability refers to reactive elements that are essential in the aftershock of a disruption in order to assess the plans that can be activated in this phase (e.g., adjustments in product market share and organizational efficiency, supply chain reconfiguration, scenario analysis) (Ali et al., 2017). In this area, financial health was found to be related to FWRP and FWC, although it acted as a barrier.

Financial health as a barrier

This element entails the firm's ability to absorb possible fluctuations in its cash flow, provide economic incentives and maintain additional suppliers (Pettit et al., 2013). Financial health can be considered to be a barrier, because economic efficiency prevails in decision-making and may restrict various investments that are needed for implementing reduction practices. This may encourage the use of cheaper logistics systems or means of transport, and lead to failures in inventory, forcing food product to travel longer distances, require more frequent manipulation, and so increase the risk of causes related to the method group (Mena et al., 2011).

This is an important factor behind the lack of investment in training, and monetary and non-monetary benefits, such as bonuses for employees. Gruber et al. (2015) found that, according to retailers, it is cheaper to throw food away than to invest in staff training for addressing FW issues.

RESEARCH AGENDA

This study identified several relationships between resilience and the reduction in FW. The following are some of the key findings and suggested research directions for future development of the field. First of all, considering the number of related causes (see Exhibit 4), the conclusion is that four EoRs (leadership, knowledge management, collaboration and flexibility) are broadly related to FWRP and FWC. The first two elements have a greater influence on the method and people cause/practice groups, while collaboration plays an important role in the method group (particularly in coordination and communication), while flexibility contributes to the method and measurement groups.

Second, the majority of the EoRs that help reduce FW relate to the ability to anticipate it, since a higher number of relationships was identified in this phase. This result differs from the perception that FW is generally an unavoidable consequence of uncontrollable events, as cited by Muriana (2017). Thus, considering the ability to anticipate it, it is possible that companies can respond in advance to the occurrence of waste, and only in secondary cases consider food recovery, donation (Aiello et al., 2015; Bilska et al., 2016; Garrone et al., 2014) or industrial uses (Girotto, Alibardi, & Cossu, 2015).

Third, with regard to the Ishikawa classification of FWCs and FWRPs, it was observed that most of the causes and practices identified were classified in the method group. This predominance indicates the large influence that the internal working methods of retail companies – such as procedures and policies related to quality, logistics,

product display procedures, management and the measurement of waste – have on the generation of FW, as identified by Moraes et al. (2020). The second most widely relevant group is linked to people, which highlights the need to expand internal engagement in organizations, mainly by developing practices such as training for waste reduction/prevention, and employee awareness of waste. These actions should also be extended to encompass all tiers in the supply chains, which enables a systemic approach to the food chain to be developed and incentivized.

We found that the elements of resilience can influence FWCs and FWRPs both positively and negatively. Most of the elements of resilience that help reduce FWCs are classified in the ability to anticipate, as defined by Ali et al. (2017). We corroborate the work on FW of Holweg et al. (2016), who pointed out that as food has a short shelf life, it loses its value if it is not sold, processed or donated in a timely manner. When disruptions happen, therefore, waste will occur if there is no quick and effective response to them. In order to avoid waste, the impact of breakages in the chain must be minimized, or avoided before they occur, so the ability to anticipate FW should be emphasized in food supply chains.

Finally, the following are suggestions for advancing the research agenda with regard to how EoRs can influence FWRPs and/or FWCs. We developed these suggestions taking into account the results previously mentioned and the general finding that EoRs and FW have so far been studied in a disconnected and incipient fashion. Highlighting major topics that have not been discussed in the existing literature, the following are suggested avenues for future research:

- Leadership, knowledge management, collaboration and flexibility may assist focal companies design the structure of supply chains in an attempt to reduce FW. According to Scavarda, Ceryno, Pires and Klingebiel (2015), members of a supply chain may compromise the building of resilience in the chain as a whole, so it is important to align the resilience abilities of all members of the chain.
- Leadership, knowledge management, collaboration and flexibility are the main EoRs for dealing with the FWRPs and FWCs resulting from various sources. Future studies could analyze which digital and virtual technologies might help retailers improve coordination and information sharing within and across a supply chain, and how.

In-depth studies addressing the EoRs mentioned (see Exhibit 4) could be carried out to identify best practices in order to develop guidelines for retailers on how to apply them for reducing FWCs. These practices include: communication with members of the chain, training for waste reduction/prevention and employee awareness of waste, management autonomy, company quality, secondary channels/usage practices by other links, and more accurate demand forecasts.

It is worth studying critical success factors in depth in order to develop EoRs aimed at the method and people groups of causes.

It is also important to investigate whether or not companies have adopted EoRs as a means of achieving sustainable FW development goals, in particular zero hunger and responsible consumption and production.

Studying these matters using theoretical approaches is another possible research avenue. The Resource Dependency Theory could be useful for observing the influence of external resources on retailers, and whether there is a dependency relationship between the various organizations that go to make up the chain (Pfeffer & Salancik, 2003). Another opportunity could be the use of the Resourced Based View to understand the internal conditions

of a firm; being able, for example, to develop resilience abilities by observing and analyzing how resources are acquired, combined and applied, and result in competitive advantage (Barney, 1991).

Expanding the focus of analysis beyond retail to observe the food supply chain as a whole, including production, processing, distribution and consumption aspects. This can be useful for analyzing whether EoRs and FW act differently in different supply chain links. In this case, culture is an important variable to be considered.

FINAL COMMENTS

The key theoretical contribution of this article is that it identifies the synergy that exists between resilience and the reduction in food waste. In this sense, this research sought to unify the resilience literature (specifically its elements) as an approach for explaining the problem of food waste in supply chains (specifically in the retail link). It was pointed out that not all EoRs can help reduce food waste, as is the case with redundancy and financial health. Most of the elements that help reduce food waste are related to the ability to anticipate it. This finding differs from the view that food waste is generally considered to be an unavoidable consequence of uncontrollable factors. Managerially, it helps retail managers better identify which practices are appropriate for mitigating the causes of FW and developing certain EoRs.

As with all research, this study has certain limitations. First, the unit of analysis used covers only a part of the supply chain and its specific problems related to food waste. Despite being part of a larger research study, this article does not include empirical data, the present results being limited to a theoretical focus. Second, it cannot be inferred that there is no relationship between EoRs, FWRPs and FWCs for elements that are not discussed in this article.

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AUTHORS' CONTRIBUTIONS

Flávio Henrique de Oliveira Costa, Camila Colombo Moraes, Andrea Lago da Silva, Carla Roberta Pereira and Ivete Delai worked on the conceptualization and theoretical-methodological approach. The theoretical review was conducted by Flávio Henrique de Oliveira Costa and Camila Colombo Moraes. Data collection was coordinated by Andrea Lago da Silva, Carla Roberta Pereira and Ivete Delai and collected by Camila Colombo Moraes. Data analysis was coordinated by Andrea Lago da Silva, Carla Roberta Pereira, Ivete Delai and Ana Beatriz Lopes de Sousa Jabbour, and was conducted by Flávio Henrique de Oliveira Costa and Camila Colombo Moraes. All authors worked together in the writing and final revision of the manuscript.