Industry-retail symbiosis: What we should know to reduce perishable processed food disposal for a wider circular economy

Abstract

This exploratory paper investigates how to reduce 25% of the potential perishable processed food disposal (PPFD) in the industrial-retail sector in a specific emerging economy The data were collected through 28 semi-structured interviews with suppliers and supermarket managers in an emerging economy. The findings contribute by revealing a paradox and a symbiosis that can advance the circular economy (CE). This paradox begins when suppliers reduce their own food disposal by offering benefits to supermarkets, which helps to sell items close to their expiration date. However, these benefits may induce supermarkets to place orders that exceed their sales capacity. When supermarkets do not sell these items before their expiration date, the products tend to be returned to the supplier, thus reducing the supermarket's waste but increasing the supplier's waste. These actions reveal a paradox: reducing PPFD in one link of the supply chain may exacerbate it in another. "Industry-Retail symbiosis" can improve the CE. Such symbiosis emerges when suppliers reduce their margins to offer additional benefits to supermarkets. These additional benefits improve supermarkets' sales to consumers with lower purchasing power or to smaller retailers that may use the items immediately, thus avoiding the return of items which are still suitable for human consumption and thereby improving the CE. Future studies could investigate: how to enhance Industry-Retail Symbiosis; what managerial information is required to use technologies to align products, stocks, prices, and stores; how suppliers can best manage the benefits offered to retailers or their partnerships with other suppliers (e.g., a shared sales center to improve symbiosis with retailers); and how retailers can best manage alternative sales channels and store managers' autonomy.

Keywords: Food waste; Paradox; Symbiosis; Supermarket; Industry-retail; Circular economy.

1. Introduction

From a retailer's perspective, customers cannot consume perishable processed food beyond its expiration date; products in such condition must be disposed of. However, perishable processed food disposal (PPFD) contributes to increased food waste (FW), which generates adverse economic, environmental, and social impacts. These impacts seem to be more evident in emerging economies, where managers tend to concentrate only on demands that are immediately relevant to customers (Nwoba et al., 2020). Such a focus may inhibit initiatives to address the FW problem. At the same time, the economic impacts of FW may occur across the whole supply chain (Papargyropoulou et al., 2014). These impacts include the cost of wasted food, the negative external consequences produced, and the opportunity cost of agricultural land (Beretta et al., 2017; Kumar et al., 2020; Messner et al., 2021). Environmental impacts include greenhouse gas emissions, soil degradation, depletion of water resources, and wastage of energy used to produce discarded food (Caritte et al., 2015), as well as soil contamination (Arub et al., 2020). However, the social and ethical impacts may be the most pressing category, since the discarded food could be used to feed millions of hungry people; for instance, those that have no access to the minimum amount of nutrients needed for their daily diet (Buchner et al., 2012; Mourad, 2016). The Food and Agriculture Organization of the United Nations (FAO) estimates that in 2019, 690 million people went hungry, and the post-COVID-19 scenario may be even more frightening, with an estimated 3 billion people deprived of a healthy diet (United Nations Environment Programme, 2021).

The existence of FW in all links of the food supply chain constitutes a barrier to mitigating this wastage (Porter et al., 2018; Stangherlin and de Barcellos, 2018). FW in the supply chain may be related to the food manufacturing and distribution process (Buchner et al., 2012; Matanda et al., 2016; Messner et al., 2021), to inefficiencies in external and internal operations (Filimonau and Gherbin, 2018; Teller et al., 2018), or to difficulties of predicting demand for perishable items (Kumar et al., 2020; Mena et al., 2011; Teller et al., 2018). FW may also be generated at the end of the food chain by consumers who select foods based on appearance or with a short lifespan (Göbel et al., 2015; Schanes et al., 2018; Tromp et al., 2016). Aiming to meet consumers' constantly changing expectations, retailers may increase the number of products offered (de Hooge et al., 2018; Devin and Richards, 2018; Mukonza and Swarts, 2020), establish high quality standards, or create aggressive marketing promotions (Filimonau and Gherbin, 2018; Teller et al., 2018). However, these actions may also increase FW.

The traditional options to deal with FW include using discarded food for energy generation (Huang Yuelu et al., 2021; Tseng et al., 2019), composting (Baul et al., 2021; Filimonau et al., 2020; Zeller et al., 2019), production of cement (Rehman et al., 2020), apple pomace (Scherhaufer et al., 2020), and animal feed (Boccia et al., 2019; Scherhaufer et al., 2020). However, these alternatives may not constitute the most environmentally sustainable ways to deal with waste (Slorach et al., 2020). In fact, preventing waste seems to be a better option (Marrucci et al., 2020; Wang et al., 2020). Such prevention can be increased by awareness campaigns designed to change consumers' habits or preferences (Abdelaal et al., 2019; Huang Yuelu et al., 2021; C. Liu et al., 2020).

The circular economy (CE) can also reduce waste generation. Accordingly, the EU included food waste as an area of focus in its circular economy (CE) action plan (Stewart and Niero, 2018). Improvements in the CE demand attention on value creation, value transfer, and value capture (Centobelli et al., 2020a; Morioka et al., 2018; Nußholz, 2018), as well as on knowledge of CE practices (Jiao et al., 2020; Moktadir et al., 2020).

CE can be leveraged in multichannel retail by selling items stored in retail premises (Frei et al., 2020). If a perishable processed food product close to its expiration date is sold and consumed before the deadline, no waste will be generated. Therefore, more research is needed to unveil how companies can sell products to customers more effectively and engage customers in a circular business model (Centobelli et al., 2020b; Mourad, 2016). Such an understanding should consider that organizations increasingly face contradictory goals, differing expectations, and convoluted missions while they search for actions and factors for ameliorating FW (Schad et al., 2019). More empirical research is also needed to develop a clearer picture of how to reduce FW in the supply chain (Filimonau and Gherbin, 2018; Teller et al., 2018; Young et al., 2018) and how to promote a dynamic connection between sustainable consumption and the circular economy (Joensuu et al., 2020; Shao, 2019). Aiming to fill these gaps, this study investigates the following research question:

> *RQ – How can the disposal of perishable processed food be reduced through its sale and consumption before the expiration date?*

This research question will be addressed through a multiple case study methodology. This study investigates six supermarkets operating in Brazil and six suppliers of perishable products. Executives who work in companies that utilize PPFD mitigation actions in the supply chain were interviewed. The findings contribute by highlighting a paradox in the food supply chain: reducing PPFD in one link of the chain may increase FW in another. The study also unveils the causes of such a paradox and how PPFD can be mitigated within the supply chain.

The structure of this article is organized as follows. Section 2 reviews the relevant literature and describes the theoretical underpinnings of the study in terms of two fundamental concepts: first, why FW occurs; second, how to cope with it. Section 3 immediately follows, covering the research methodology and including the research design, structure of data collection, and the framing, explanation and analysis of information related to actual practices and mechanisms. Section 4 presents the results, structured according to paradoxes in the perishables supply chain which generate FW, and ways to mitigate the problem through industry-retail symbiosis. This is followed by the analysis and discussion of the results in Section 5. Finally, the theoretical and management implications of the study are considered, along with its limitations and suggestions for future research in Section 6.

2. Literature review

2.1 Why is food disposed of?

For the purposes of this study, the sources of food disposal are classified into two broad categories – supermarkets and suppliers – with an emphasis on disposal in their business relationships and interactions. Although these also inevitably affect consumers' in-home waste, for the purposes of this paper, business supply-chain disposal rather than consumer disposal will be the focus. A review of the relevant literature with regard to the focus of this paper follows.

Food disposal may be associated with factors related to supermarkets' marketing strategies (strategies that aim to enable profitability and market share) including product specifications. These specifications consist of aesthetic and product validity requirements (Aschemann-Witzel et al., 2017a; de Hooge et al., 2018; Devin and Richards, 2018), and product sensitivity (Gokarn and Kuthambalayan, 2019; Mena et al., 2011; Teller et al., 2018). These elements can increase FW generation (Filimonau and Gherbin, 2018; Teller et al., 2018), the number of operational errors (Teller et al., 2018), or problems associated with the variability of demand (Filimonau & Gherbin, 2018). Other problems may be related to the difficulty in predicting demand and replacement points (Arunraj and Ahrens, 2015; Mena et al., 2011; Teller et al., 2018). To

mitigate the impact of these problems, supermarkets use their purchasing power to impose specific contractual norms on suppliers. Past studies (Hingley et al., 2015a; Hingley, 2005; Matanda et al., 2016) have shown that large retailers certainly possess and utilize asymmetrical power relations in their favor against suppliers in negotiations and contracts(Mourad, 2016; Swaffield et al., 2018). These contracts specify acceptable aesthetic and quality requirements, as well as determining product prices (Eriksson et al., 2017; Ghosh & Eriksson, 2019; Matanda et al., 2016). Products that do not meet consumer expectations are discarded (Gollnhofer, 2017). By imposing such conditions on its suppliers, a supermarket manages to increase its protection against financial losses arising from FW.

Disposal may also stem from operational issues. These problems are related to difficulties in predicting demand or replenishment points, management failures, or infrastructure deficiencies (Kumar et al., 2020). Difficulties in forecasting demand may stem from climate variability, seasonality, uncertainty about new product launches, promotions, or sales on special days, for example, festival or religious dates (Mena et al., 2011). Taken together, these elements can lead to errors in stock replenishment orders, which contributes to increases in FW. Management failures may be associated with problems in forming external partnerships, lack of knowledge in information technology, or problems in production/harvest and transportation planning (Gokarn and Kuthambalayan, 2017). Suppliers also have deficiencies in terms of production and logistics operations, such as technical problems with temperature management of perishable items (Gokarn & Kuthambalayan, 2017; Kumar et al., 2020; Mena et al., 2011) or inefficiency in logistical order replacement processes (Holweg et al., 2016). Such inefficiencies drive FW through product perishability, inadequate control, storage and handling systems, food contamination, and portion size inflexibility (Canali et al., 2017). Ineffective training can also negatively affect suppliers' employees' compliance with guidelines. These inefficiencies can lead to the production of poor quality products, which then leads to rejection and disposal (Kumar et al., 2020; Mena et al., 2011). These causes of FW are summarized in Table 1

Table 1 - Why supermarkets and their suppliers dispose of food

Responsibility	Code	Cause	Sources
Supermarkets	Focus of offer	Abundance and diversification.	(Filimonau & Gherbin, 2018)
		Aesthetic or validity requirements.	(Aschemann-Witzel et al., 2017a; de Hooge et al., 2018; Devin and Richards, 2018)
	Resupply management	Incorrect order release due to problems in demand forecasting.	(Arunraj and Ahrens, 2015; Mena et al., 2011; Teller et al., 2018)
		Misapplication of supermarket's buying power.	(Eriksson et al., 2017; Ghosh and Eriksson, 2019; Mourad, 2016; Swaffield et al., 2018)
Suppliers	Market uncertainties	Incorrect demand forecast due to uncertainty about new product launches, promotion acceptance, or sales on special dates.	(Mena et al., 2011; Anish Kumar et al., 2020)
	Operations management	Problems in production and transportation planning.	(Gokarn and Kuthambalayan, 2017)
		Problems in temperature control.	(Gokarn & Kuthambalayan, 2017; Mena et al., 2011; Anish Kumar et al., 2020)
		Problems in the resupplying processes.	(Holweg et al., 2016)

2.2 How to reduce food disposal

PPFD reduction can have positive impacts on the food supply chain. In 2005, the British government formed a committee, including retailers and food industry representatives, to reduce waste. In the first four years of the project, 1.2 million tons of food and packaging were saved, worth approximately £1.8 billion (Buchner et al., 2012). The literature indicates that FW can be mitigated through improvements in purchasing process management. These improvements require accurate sales forecasts and stock replenishment. In addition to these improvements, FW problems can be addressed through improvements in operations management, and new distribution opportunities. These improvements and the tools or models involved are discussed below.

First, inaccuracy in sales forecasts and order replenishment across all links in the supply chain contributes significantly to FW. The literature suggests that the inclusion of collaborative sales forecasts between suppliers and supermarkets, and a full view of inventory and orders can improve planning as well as reducing FW (Kumar et al., 2020; Mena et al., 2011). Planning improvement requires more robust forecasting systems (Filimonau and Gherbin, 2018; Mena et al., 2011). Such demand forecasting models need to incorporate uncertainty and the influence of external variables, such as seasonality, holidays, price reductions, and weather (Arunraj and Ahrens, 2015). Resources such as data mining and sales-linked automatic replacement systems are also required (Mena et al., 2011). Another challenge is issuing stock replenishment orders in quantities that do not generate FW; a problem that can be mitigated by adopting systems that define the correct amount and scheduling of products to be replaced (Broekmeulen and van Donselaar, 2019).

Reductions in FW can also come from improvements in operational management. The main problem related to infrastructure is tied to shortcomings in cooling capacity for perishables. This problem could be mitigated through equipment overhauls to ensure the integrity of the cold chain (Mena et al., 2011), as well as investment in the cold chain and development of multiproduct compatible facilities (Kumar et al., 2020). The application of robotic technology and automation in food warehouses is another option. Such technologies can contribute to increased product handling efficiency (Wu and Huang, 2018). Excessive product handling contributes to damage or product imperfections. The literature also recommends standardizing containers and packaging to reduce quality inspections and handling (Gokarn and Kuthambalayan, 2019). Beyond that, technology can improve supply chain integration, communication, and relationships (Gokarn and Kuthambalayan, 2019; Kumar et al., 2020; Ndubisi, 2011), while support systems can improve the decisions taken (Fenu and Malloci, 2020).

Retailers play a pivotal role in the mitigation of operational problems. For instance, they can leverage their supply chain bargaining power and relationship management with suppliers to find alternatives to reduce FW (Aschemann-Witzel et al., 2015) or influence the reduction of customer food waste by using repeat messages through conventional communication channels (Young et al., 2018). Another option lies in reverse logistics activities that can significantly contribute to the management of green performance, and the minimization of food waste (Kazancoglu et al., 2020). Operational problems can also be addressed through training of store teams. The focus of such training should be on honing employees' skills and increasing their capacity to better select and treat perishable products (Mena et al., 2011).

The primary objective of investments by commercial or industrial organizations is to generate profits to satisfy shareholders' needs. Pricing is a component of marketing strategies that helps to increase corporate revenue and profit (LaPlaca, 1997). However, price management can have both positive and negative impacts on organizations. Thus, prices need to be reviewed and adjusted continually. This requires detailed environmental information, as well as marketing connectivity, which demands information sharing and proper storage for surplus products (Kumar et al., 2020). The literature indicates that price reductions may contribute to minimizing FW (Aschemann-Witzel et al., 2015; Filimonau and Gherbin, 2018; Teller et al., 2018), and some scholars regard discounting as an option (Buisman et al., 2019) or a panacea for FW. However, organizations need to be careful in applying these reductions to avoid affecting their brand image. One study found that accepting lower prices for sub-optimal products requires the right brand image and confidence in food safety (Aschemann-Witzel et al., 2017b). Further, price reductions or 'two for one' offers could increase the volume that consumers buy, and they may not be able to use the extra product in time before it perishes and is wasted.

Enacting effective pricing and promotion strategies is vital. Management should consider the useful life of the product when defining or redefining the price offered. Consideration of these elements would allow lower prices to be charged for items nearing their expiration date to manage store waste. Offers utilizing these conditions will ensure that customers do not purchase only products with longer shelf life (Teller et al., 2018). Therefore, price definition or redefinition must also ensure that consumers are not induced to buy more than they can consume before the item expires or spoils, which can happen when too much (product) is offered for too little (price), otherwise this action is tantamount to simply shifting the FW from the store to the user, instead of eliminating FW from the chain.

Organizations can reduce FW by adopting alternative distribution channels, such as donation channels for charity, or food sharing entities (Mourad, 2016; Teller et al., 2018). In France and Italy for example, companies can receive tax breaks by donating food. Other benefits include savings on disposal costs as well as improved donor public image (Mourad, 2016). Despite these benefits, donation faces barriers in retail organizations. Managers see the need for financial investments to properly distribute their products, as well as seeking out more lucrative options (Swaffield et al., 2018). Active donation engagement is hampered by pressure to maximize sales revenue. There is concern about brand image in case donated food causes harm to the beneficiaries, which can happen when there is a delay in the donation process. It has been documented that delays in the donation process represent a serious obstacle to the donation of perishables (Filimonau and Gherbin, 2018). Also, some retailers are not enthused about donations based on anecdotal evidence that some consumers or social organizations (e.g. rehabilitation homes, orphanages,

etc.) may delay or even suspend their purchases in anticipation of donations, which they (retailers) view as a different form of cannibalization.

Another approach in tackling FW that has been gaining attention from researchers relates to possible business opportunities involving non-standard products, for example, in creating a market for less than visually perfect, or differently sized products. A developing business model aligned to this perspective is associated with sustainability, by focusing on connecting people, solving problems, combining competition and cooperation to form 'coopetition' among supply chain actors, as well as generating profits for stakeholders (Morioka et al., 2018). Another initiative in this vein is the offer of products through alternative retail methods (Aschemann-Witzel et al., 2017a), which has resulted in the gradual transformation of food retail business models, for example, in online or food service business. According to the literature, retailers can cooperate with other companies to leverage sales on electronic channels while reducing their costs (Wu and Huang, 2018). Finally, governments can encourage increased action on FW risks (Young et al., 2018). Table 2 presents a summary of the reviewed literature concerning possible causes of supply chain food waste and potential mitigating factors.

Table 2 - How to reduce food disposal

Code	How to reduce the disposal	Sources
Resupply management	By cooperating in sales forecasting or inventory management.	(Mena et al., 2011)
	By considering the impacts of seasonality; holidays; price reductions; and weather when placing orders.	(Arunraj and Ahrens, 2015)
	By improving accuracy in the definition of the moment and amount of product replenishment.	(Broekmeulen and van Donselaar, 2019)
Sales management	By reducing the price of items close to the expiration date.	(Aschemann-Witzel et al., 2015; Buisman et al., 2019; Filimonau and Gherbin, 2018; Teller et al., 2018)
	By improving brand image and confidence in food safety to induce customers to accept lower prices for sub-optimal products.	(Aschemann-Witzel et al., 2017b)
	By selling through electronic channels to reduce costs.	(Wu and Huang, 2018)
Operations management	By improving the use of technology in product handling, or communication and decision-making.	(Fenu and Malloci, 2020; Kumar et al., 2020; Mena et al., 2011; Wu and Huang, 2018)
	By standardizing containers and packaging.	(Gokarn and Kuthambalayan, 2019)
	By training in-store teams	(Mena et al., 2011)

3. METHODOLOGY

3.1 Research design

The perishable processed food chain is long, since it embraces farmers, industries, distributors, and retailers. Therefore, PPFD occurring in the supermarket-supplier link is harmful, since it wastes scarce natural resources that were used in the previous stages of the chain. Aiming to contribute towards reducing waste at this point of the chain, this study adopts a qualitative approach. The multiple case study methodology is compelling and robust because it allows for the analysis of individual cases and in-depth examination across cases (Kathleen M. Eisenhardt, 1989; Patton, 2002). A sample of supermarkets and suppliers was selected for the study, considering that large amounts of food are lost at this point in the supply chain (Beretta et al., 2017).

A systematic literature review was then conducted to identify relevant studies on the topic. Systematic reviews can increase methodological rigor and highlight future research opportunities (Arksey and O'Malley, 2005; Briner and Denyer, 2012). Our searches were focused on the causes and mitigators of FW in the perishable food supply chain. These searches were limited to peer-reviewed journals published in English. Web of Science and Scopus were used as the databases for this search. The keywords used to guide the searches included "food waste," "causes," "reason," "motives," "rationale," "mitigate", "reduce", "supermarkets," "suppliers," and "retail." The set of search criteria was developed using the snowball technique, checking articles found through the research databases.

Based on the results of the literature review described above, a coding approach was chosen for the qualitative text analysis step (Saldaña, 2015), based on grounded theory (Corbin and Strauss, 1990). This coding was performed using the ATLAS TI software. With the aim of supporting the qualitative data analysis in the following steps, the codes were organized around causes originating in supermarkets (supply focus and resupply management) and suppliers (demand uncertainty and operational management). The mitigators were coded as follows: resupply management, sales management, and operational management. Finally, we synthesized the collected evidence (Arksey and O'Malley, 2005) into two tables (details in Tables 1 and 2). The first table presents the causes of food waste in the perishables supply chain, while the second table presents its mitigators. The analysis of the papers selected also indicates emerging gaps in the scientific knowledge of this area.

Two different groups of questions were defined in order to interview the professionals from supermarkets and from suppliers. Both groups of questions were structured with reference to the literature review codification. The questions focus on identifying why PPFD occurs, as well as capturing how the managers interviewed deal with it. The group of questions to supermarkets focused on supply, resupply management, sales, and operations. The questions to suppliers aimed to shed light on operational management, market uncertainties, supply management, and sales processes. All the questions used are presented in Appendix A.

3.2 Data collection

The data used in this study can be viewed as case studies, as they involved in-depth data collection from multiple data sources (Yin, 2017). The activities associated with data collection began by defining the profile of the companies to be investigated. A purposive sampling technique was adopted in the selection of the participating companies to ensure that all selected companies have processes that emphasize PPFD reduction. Twelve companies were identified (six supermarkets and six suppliers). Qualifying organizations were invited to participate in the study. These companies operate in the Brazilian food supply chain with clear initiatives and actions identified to reduce PPFD. A profile of the characteristics of the companies investigated is presented in Table 3.

Table 3 - Profile of companies

Group	Company	Operation area	2019 Revenue (USD)	Details
Supermarkets	Supermarket A	Brazil	0.15 billion	27 stores
	Supermarket B	Brazil	0.15 billion	23 stores
	Supermarket C	South America	1.90 billion	68 stores
	Supermarket D	Brazil	0.29 billion	41 stores + 1 e-commerce
	Supermarket E	Global	7.00 billion	438 stores
	Supermarket F	Brazil	0.45 billion	47 stores
Suppliers	Supplier 1	Global	50.00 billion	Meat products
	Supplier 2	Global	25.00 billion	Sauces and ketchup
	Supplier 3	Global	30.00 billion	Cookies and chocolate
	Supplier 4	Global	92.60 billion	Condensed milk and heavy cream
	Supplier 5	Global	38.00 billion	Beverages
	Supplier 6	Global	68.00 billion	Beverages

Each company investigated indicated a group of professionals to participate in the study. These respondents hold leadership positions in the selected companies as well as decision-making power over PPFD mitigation actions in their companies. The participation of these professionals was purely voluntary, of which participants were duly informed. They were also informed that they could withdraw from the study at any point if they wished to. All the invitees agreed to participate in the study, and provided evidence of the importance and timeliness of the research problem and their interest in the subject matter. Accordingly, sixteen professionals from supermarkets and twelve professionals from supplier firms were interviewed. The profile of the interviewees from supermarkets is shown in Table 4, while the profile of the interviewees from suppliers is shown in Table 5.

Table 4 - Profile of respondents from supermarkets

Company	Role of interviewee	Code	Experience	Age	Interview duration
Supermarket A	Regional Manager	RMSA	35 years	65	73min
	Store Manager	SMA1	23 years	42	45 min
Supermarket B	Regional Manager	RMSB	30 years	52	70 min
	Store Manager	SMB1	18 years	41	60 min
Supermarket C	Regional Manager	RMSC	10 years	33	78 min
	Store Manager	SMC1	20 years	47	78 min
	Store Manager	SMC2	17 years	39	67 min
Supermarket D	Regional Manager	RMSD	10 years	48	85 min
	Store Manager	SMD1	22 years	47	45 min
	Store Manage	SMD2	19 years	56	75 min
	Store Manager	SMD3	21 years	42	59 min
Supermarket E	Regional Manager	RMSE	30 years	56	70 min
	Store Manager	SME1	17 years	47	51 min
	Store Manager	SME2	19 years	53	47 min
Supermarket F	Regional Manager	RMSF	10 years	32	88 min
	Store Manager	SMF1	19 years	42	59 min

Table 5 - Profile of respondents from suppliers

Company	Role of interviewee	Code	Experience	Age	Interview duration
Supplier 1	Key Account Manager	KAM1	20 years	45	73min
	Key Account Supervisor	KAS1	8 years	34	45 min
Supplier 2	Key Account Manager	KAM2	15 years	37	59 min
	Key Account Supervisor	KAS2	7 years	36	51 min
Supplier 3	Key Account Manager	KAM3	8 years	31	83 min
	Key Account Supervisor	KAS3	12 years	40	46 min
Supplier 4	Key Account Manager	KAM4	18 years	41	66 min
	Key Account Supervisor	KAS4	7 years	33	54 min
Supplier 5	Key Account Manager	KAM5	10 years	35	57 min
	Key Account Supervisor	KAS5	11 years	45	44 min
Supplier 6	Key Account Manager	KAM6	15 years	44	61 min
	Key Account Supervisor	KAS6	8 years	36	56 min

Data were collected through multiple methods, including interviews, observations, field visits, and document analysis. This allowed us to triangulate the data sources to ensure the reliability of the data collected from different sources (Eisenhardt and Graebner, 2007; Yin, 2017). All interviews were concluded in March 2020. The full-scale interviews were preceded by a pilot study in supermarkets C and E and suppliers 2 and 4. Such pilot studies aim to test and validate the research instruments. The participants in the pilot studies were also investigated in full later. Data collection involved semi-structured interviews with participants, in addition to document analysis. The meetings were scheduled by email, and interviews were held via Skype or telephone. The authors conducted the interviews and took notes of all information reported, since recording was not authorized. These notes were later transferred to Microsoft Word for text editing. Interviews were considered completed when two conditions were met: all research protocols had been applied, and no new evidence was emerging from the interviewee (Corbin and Strauss, 2007). After each session, we asked the participant to provide documents related to the topics discussed. These documents are mainly public and management reports from the investigated companies. Results from publicly available electronic documents identified on the Internet were also considered, thus allowing for some triangulation between interviews and documents. The secondary documents collected are presented in Appendix A.

3.3 Trustworthiness, credibility, and reliability

To allow for future replication, experts in other relevant fields have reviewed the research methodology used here (K. M. Eisenhardt, 1989). A strict set of criteria was used to ensure reliability and credibility. These criteria included adjustment, understanding, generality, control (Corbin and Strauss, 2007), transferability, reliability, verifiability, and integrity.

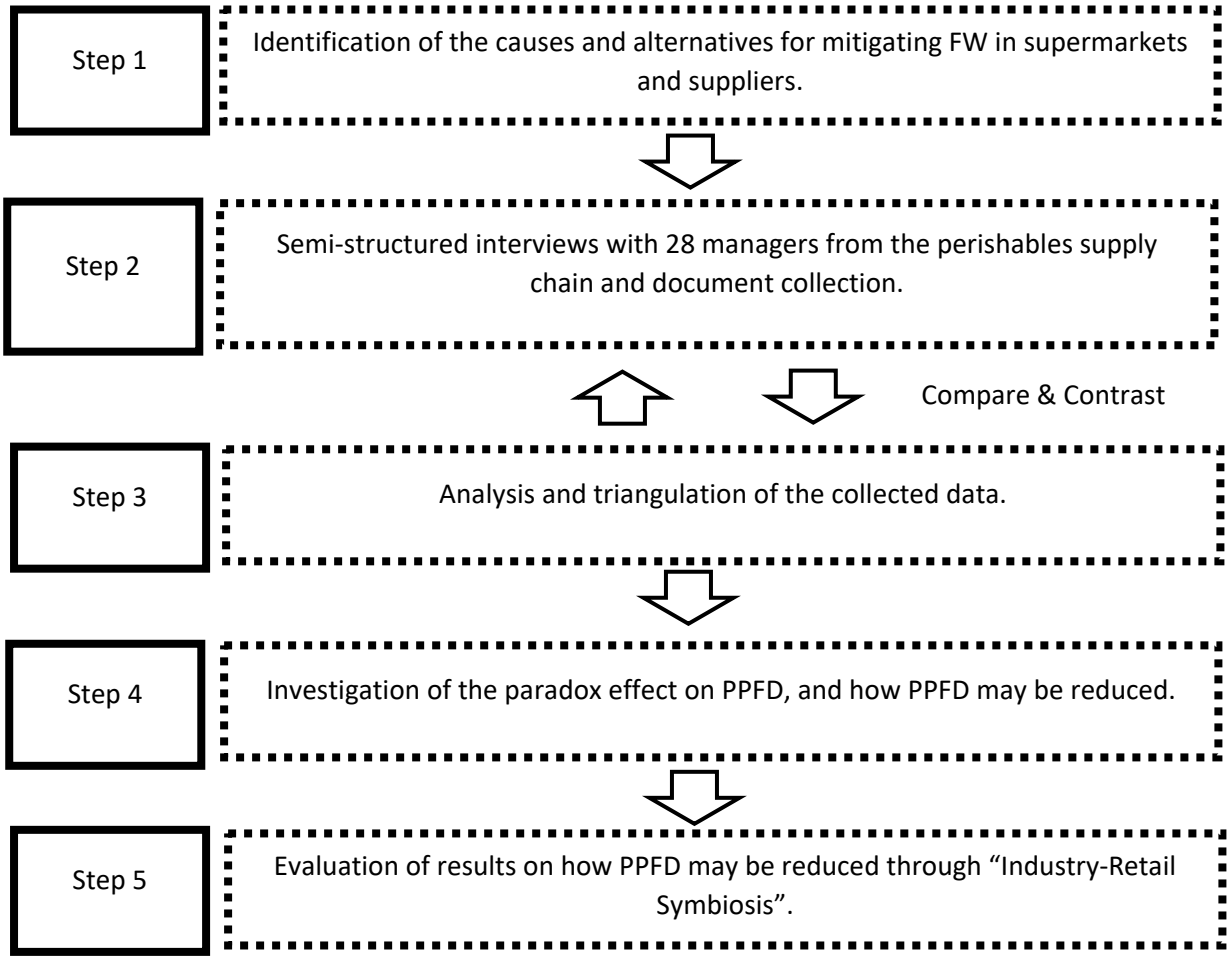
The research involved five essential steps. In the first stage, each practice was identified in the literature regarding the causes and alternatives to mitigating food waste in supermarkets and suppliers. At this stage, the questions used in the study were developed.

The second stage consisted of data collection. This was carried out through semi-structured interviews with 28 managers from the supply chain of perishable products. In addition to their testimonies, other documents were collected, such as management reports and publicly available electronic documents identified on the Internet. Analysis of the findings and the generalization of the results included presenting the interviewees' findings and access to executives who work in companies of a similar type, respectively. The validation of the participants' responses and transferability with integrated control refers to selecting executives who work for companies that have developed PPFD mitigation actions in the supply chain. Reliability was covered with a focus on the benefits of these actions in reducing PPFD. Confirmation refers to the individual analysis of each case. This analysis was carried out in up to three days, covering all the evidence regarding the investigated companies' actions.

In the third stage, after analyzing each case individually, a cross-case analysis was performed using the ATLAS TI software. The objective of this analysis is to identify similarities and differences between respondents and the reasons for such similarities/differences. In both analyses, the findings were coded to compare and contrast them with the elements extracted from the literature. This method was based on grounded theory (Corbin and Strauss, 2007; Denzin, 2017). The revised documents were necessary for the respondents. Aspects of integrity include anonymity and ethical standards.

In the next step, we identified the Paradox effect on PPFD generation, which can be reduced through "industry-retail symbiosis." In the last step, based on the results, we discuss and contribute to the scientific field on how food waste can be reduced through "industry-retail symbiosis." Figure 1 depicts the methodological steps that were carried out in the research.

Figure 1 – Methodological steps



4. Findings

Losses from PPFD seem to be related to a paradoxical relationship in the perishable processed food supply chain. In this relationship, suppliers and retailers try to transfer items which are close to their expiration date to another link in the supply chain. This approach reduces PPFD at one link of the chain but increases it at another. Despite its negative implications, this "transferring approach" seems to lower PPFD in suppliers and retailers and reduces their financial losses, which is good for both parties. This conclusion suggests that industry-retail symbiosis results from this dynamic. Figure 2 shows these paradoxes and symbioses.

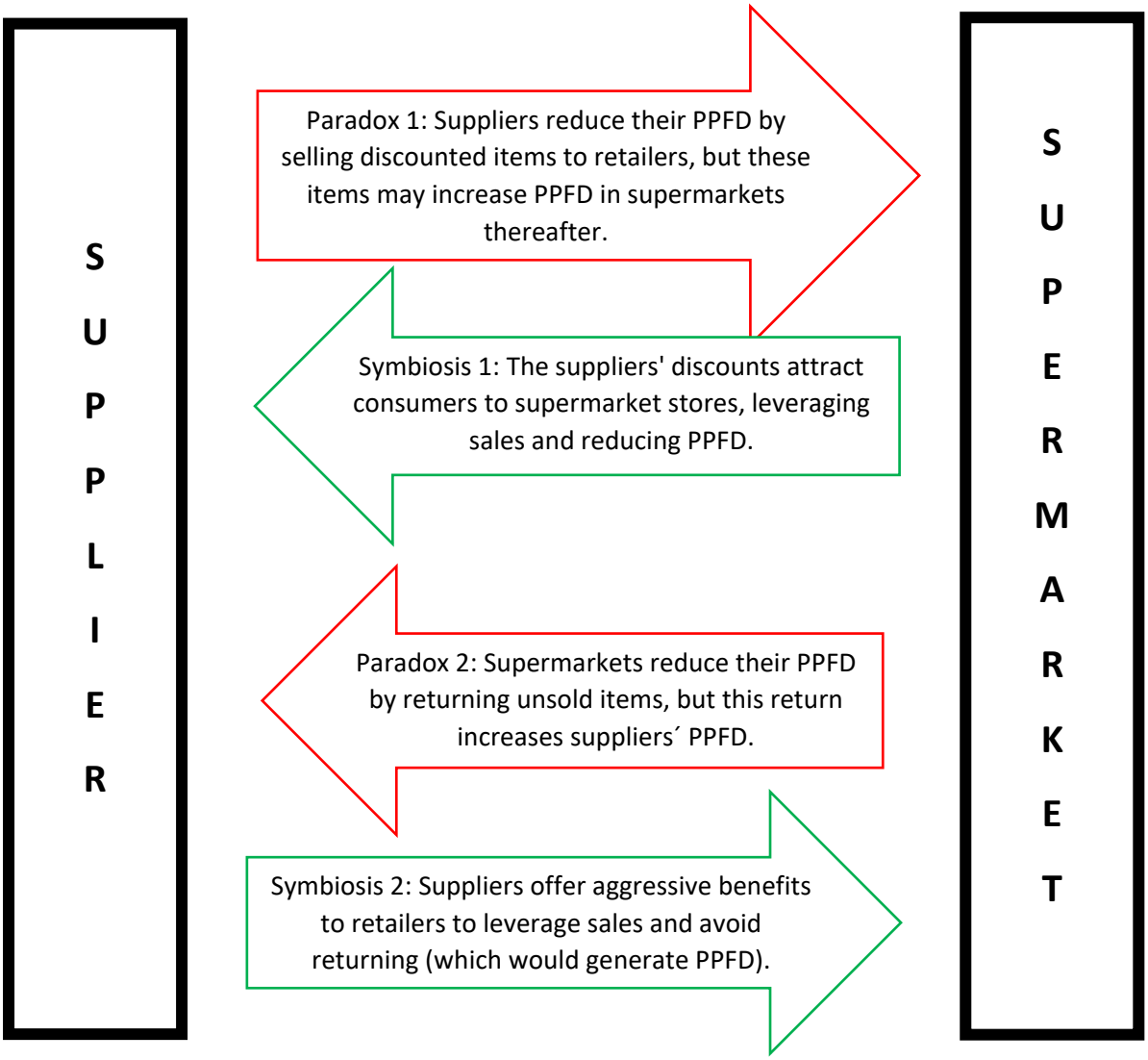


FIGURE 2 Simultaneous paradoxes and symbioses in the perishable processed food supply chain.

4.1 Paradox 1

Products approach their expiration date in the supplier's warehouses due to the difficulty of synchronizing the quantities produced with retail sales (even for bestselling products). Items in such a condition must be sold rapidly by the supplier to avoid PPFD.

The first paradox arises when suppliers reduce their rate of PPFD by selling items close to the expiration date to a retailer at a discount. Once in the supermarket, the items must be sold rapidly. Otherwise, these products may end up causing PPFD in supermarkets. As ascertained, the suppliers in this case are attempting to reduce their PPFD by transferring the problem to the retailers. Aggressive sales targets may induce the supplier's sales team to sell quantities beyond the retailers' sales capacity. Below are examples of pertinent interviewee quotations that illustrate these points:

> *'Poor synchronization (no matter the product) generates a time bomb.' (KAM1).*
>
> *'Items not sold will turn into PPFD in the industry warehouse. So, you must sell them.' (KAM2).*

Supermarkets could refuse to receive this time-bomb. However, the chance to generate some financial gains induces supermarkets to help suppliers to reduce their PPFD. This engagement begins the first form of symbiosis among the companies (details below).

4.2 Symbiosis 1

To leverage their sales of items close to their expiration date, suppliers offer supermarkets attractive benefits. These benefits allow supermarkets to offer lower prices to consumers, thus attracting consumers to the store. The higher the number of consumers who visit a store, the higher the chance of increasing sales of perishable and non-perishable products in these stores. So, the combined reduction of PPFD in the supplier's warehouse and increase in the supermarket's sales constitute the first symbiosis.

The benefits offered by the supplier induce supermarkets to engage in the supplier's PPFD reduction. Initially, supermarkets lower items' prices when they are close to their expiration date but are still fit for human consumption. Our observations indicate that discounts in some supermarkets start at 10% and may reach 40%. However, not all stores follow this discount policy, especially those mainly servicing higher-income customers who are not price-sensitive. Therefore, the retailer must send these items to its stores that cater to lower-income customers. According to one store manager, customers that visit such stores look for cheaper items, and these are mostly items that are closer to the expiration date. These

customers buy these items for two main reasons: (1) by saving money through reduced prices, they can buy other things; and (2) customers with lower income usually can afford to buy only small amounts, which can be consumed on the same day or before the expiration date.

> *'Some stores sell cheap items, usually the ones that are close to their expiration date.' (KAM3).*

> *'Lower-income customers do not care for closer expiration dates since they will eat the item today.' (SMD3).*

One supermarket chain adopts business intelligence (BI) and sales forecasting systems to select and assign the chain stores to deliver orders. This supermarket has dozens of units selling hundreds of perishable items. Dozens of suppliers of different sizes provide these items. Business intelligence (BI) and sales forecasting systems helped this retailer identify that the same amount of a product can sell well in some units but not in others. Thus, managers claim a better alignment between sales capacity and the amount or type of products offered in each store, even when the vendor manages its stock in the supermarket's warehouses. The findings also indicate the importance of the store's manager and cross-functional teams. These teams must analyze the information provided by the systems. This heterogeneous team must include experienced professionals in inventory management, purchasing, engineering, and statistics. Such professionals should also cooperate with suppliers that use Vendor Managed Inventory (VMI). Despite the importance of such alignment tools, not all investigated supermarkets used them:

> *'Purchasing staff should know which product sells in each store.' (KAM3).*

> *'Reducing PPFD requires an alignment of products and stores.' (RMSF).*

4.3 Paradox 2

Symbiosis 1 may lead to paradox 2. The attractive benefits offered by suppliers in symbiosis 1 induce supermarkets to purchase quantities that exceed their stores' sales capacity. Supermarkets also do this due to problems in demand estimation. Therefore, the second paradox occurs when supermarkets do not sell all items that were bought. To avoid PPFD, supermarkets may ask to return items that will reach their expiration date shortly. This period becomes shorter when compared with the remaining shelf life shown in paradox 1. Suppliers must accept all returns due to supermarkets' contractual clauses, no matter their remaining shelf life. The return of an item in such a stage will increase the suppliers' PPFD immediately.

> *'When supermarkets do not sell all the items, they avoid their PPFD by asking for the return of the items.' (KAM4)*

Paradox 2 is also based on the "transferring game" attested in paradox 1. However, paradox 2 is more severe, since the items have a shorter remaining shelf life (in most cases, just a few days). Furthermore, the items involved in paradox 2 are stored in the supermarket's warehouse, which reduces the supplier's redirection options. In most cases, the supplier has a short time to redirect these items to another retailer, bearing in mind their remaining shelf life. When redirecting a product, the costs incurred by the supplier may be prohibitive, considering the price that another retailer would accept to pay for an item that is close to its expiration date. Knowing these facts, retailers try to generate financial gain by exploiting the supplier's weaknesses.

The opportunistic purchases by supermarkets in paradox two do not constitute a problem unless the stores manage to sell all items acquired before the products' expiration dates. To increase sales of the items not sold and stored in retail, suppliers are incentivized to initiate a new supermarket symbiosis (details below).

4.4 Symbiosis 2

Suppliers can avoid the returns resulting from paradox 2 by offering additional and aggressive new benefits to the retailer. Internal messages from suppliers indicate that their prices can be reduced by up to 70%, in order to avoid PPFD. The benefits given depend on the expiration date, remaining inventory, and the supermarket's purchasing power.

Despite the negative possibilities, both groups of managers indicated that taking such a risk may pay off. According to the supermarket managers, their stores have made money by selling items in large amounts in the past. In such situations, supermarkets have also helped to mitigate the PPFD in their suppliers' warehouses. For the supplier managers, this problem is not a worst-case scenario. According to them, the remaining quantities are usually lower those that the supermarket originally bought, as the supermarket would have sold part of the initial order. In such a context, this solution is cheaper and more convenient for the supplier, compared to the resolution of the PPFD problem inside the suppliers' own warehouses.

> *'Suppliers' benefits offered for the items close to the expiration date turn into lower prices in retail. Lower prices leverage sales in supermarkets (which helps to reduce PPFD). For a retailer, the problems arising from the unsold items can be solved later.' (RMSC)*

'Supermarkets may not sell all items, but they will sell part of the inventory. By doing so, they solve part of the suppliers' problem.' (KAS5).

'It's better to provide a benefit than to face a retaliation.' (KAM3).

So, symbiosis 2 occurs when suppliers offer additional benefits for supermarkets to increase sales of items that have a short shelf life and are already in the retailer's warehouse. These discounts avoid the need for reverse logistics and attract supermarket customers.

'I must generate sales for the supermarket. Lower prices help me to do it.' (RMSE).

'I must generate sales that reduce waste in the manufacturing plant.' (KAM6).

Suppliers' additional and aggressive discounts also allow supermarkets to redirect products close to their expiration dates to other establishments. These establishments may include the supermarket's more minor associates which serve lower-income customers, as well as small establishments that use products in a few days. Sales to these small establishments require new channels. Internal messages indicate that a supermarket sells 17% of the items it purchases through channels other than its stores (known as alternative channels). Alternative channels include distributors, sales representatives, and the Internet. As ascertained, all alternative channels listed can be used by supermarkets, and they seem to help to reduce PPFD in the supermarket:

'Selling to other establishments or our small associates reduces the PPFD in retail.' (RMSA).

'This kind of redirection of products by the supermarket also helps us to reduce our PPFD ' (KAM3).

Table 6 shows the sales resulting from each alternative channel in 2019.

Table 6 Sales closed by each alternative channel of Supermarket E.

Channel	Share
Wholesale	50%
Sales representatives	33%
Internet	17%

Table 7 shows product volumes near the expiration date that were sold through the alternative channels of Supermarket E in 2019.

TABLE 7 Products sold through the alternative channels of Supermarket E.

Product	Share
Soft drinks	31%
Dairy products	29%
Beer	24%
Processed meats	21%
Other items	17%

4.5 Remaining problems

Although these reductions in PPFD can be generated through Industry-retail symbiosis, some losses are still observed in the chain. Documents indicate that FW has caused severe losses in the supermarkets investigated (around 4% of revenue generated, or $0.6 billion in 2019). Other documents point out that the 500 biggest Brazilian supermarkets' revenue amounts to $66.7 billion per year. Considering that FW may represent 4% of these retailers' revenues, the financial losses associated with this sort of waste may be up to $2.7 billion per year in Brazil.

Internal messages indicate that PPFD generates financial losses of up to 4% of suppliers' sales, including compensation and disposal of products. Documents indicate that the Brazilian food and beverage industry's revenues are $175.0 billion per year. If PPFD represents 4% of these companies' revenues, the financial impact of such losses may reach $7.0 billion per year.

Such numbers indicate that new alternatives must be orchestrated in order to reduce PPFD and financial losses in the chain.

5. Discussion

This study examines what managers in the perishable processed products supply chain in an emerging economy can do to reduce about 1/4 of the possible PPFD while at the same time positively impacting sustainable development. The findings unveil a paradox and its mitigators, as discussed below.

5.1 The paradox

Supermarkets and their suppliers each try to reduce their PPFD by transferring the problem to the other party. Analysis of this "transferring approach" suggests the existence of a paradox - reducing PPFD in one link of the chain may increase PPFD in another. This paradox may constitute another challenge that may hinder improved performance of perishable food supply chains in emerging markets (Kumar et al., 2020) or the mitigation of climate change (Günzel-jensen and Rask, 2021; Reisch et al., 2021). The findings indicate a power game that may increase PPFD along the whole supply chain. This conclusion contributes by suggesting that this "power game" related to the paradox produces tensions between partners (Ndubisi, 2011; Russo Spena and Di Paola, 2020), thus limiting the creation of sustainable solutions to extensive environmental challenges (Günzel-jensen and Rask, 2021; Sajjad et al., 2020).

This study also contributes by suggesting that the "transferring game" related to the above paradox constitutes a new barrier to the circular economy (Patala et al., 2020; Pitk et al., 2021; Shao, 2019). Nonetheless, adopting this transferring approach may help both parties reduce their PPFD, which has benefits for the environment, for companies, and for supermarkets' lower-income customers. Such a reduction demands cooperation among suppliers and retailers. We term such cooperation "Industry-Retail Symbiosis (IRS)." Details about how this symbiosis can generate sales and profits and still minimize PPFD from items that are still fit for human consumption are presented below.

5.2 The symbiosis

Retailers play a pivotal role in leveraging sales of items that are near to the end of their shelf life. This finding contributes by revealing retailers' importance to implementing circular business models (Centobelli et al., 2020b; Frei et al., 2020; Pitk et al., 2021) or to promoting efficient use of resources (Oliveira Neto et al., 2018). This study also contributes by showing a new type of symbiosis: the symbiosis between industry and retail – IRS (de Moraes et al., 2020; Mallawaarachchi et al., 2020).

Devoting attention to IRS can reduce PPFD, a problem that affects several food industries and retailers. Since the problem is common to several suppliers, these manufacturers could come together to improve their symbiosis with retailers (Ghinoi et al., 2020). Indeed, this cooperation seems to constitute a new focus of industrial symbiosis (Neves et al., 2020; Vahidzadeh et al., 2021). The combination of industrial symbiosis with Industry-Retail Symbiosis can reduce negative impacts on the environment (Lawal et al., 2021; Schlüter et al., 2020; Yazan et al., 2020), leverage sustainable manufacturing in the food industry (Malek and Desai, 2020), and enable the achievement of Sustainable Development Goals (SDGs) (B. F. Giannetti et al., 2020; Biagio F. Giannetti et al., 2020). Cooperation among these actors can also create value in a CE business model (Centobelli et al., 2020b). Improvements in the said cooperation demand attention to the eco-systemic business model and the actions that can be orchestrated by the focal firm. (Zucchella and Previtali, 2019).

5.3 Symbiosis and retailers

Retailers face some challenges in improving the symbioses mentioned above. Findings indicate that a reduction in PPFD requires attention to the management of offers. As ascertained, management of perishable items should be delegated to each supermarket store, especially stores that cater to lower-income customers (Ubirajara et al., 2021). Increasing the salience and appropriateness of store managers' autonomy may improve decision-making regarding sustainability and organizational goals (Buzzao and Rizzi, 2020; Filimonau and Gherbin, 2018; Spada et al., 2018). However, the degree of autonomy should align with organizational objectives (Hartmann and Rutherford, 2015), corporate performance, and other relevant metrics (Friend et al., 2019) and might be a barrier for retail organizations that have heavily centralized management of stores which takes autonomy away from store managers (for example, in the UK and Europe).

Digital tracking technologies and information management could play a key role in selecting the destination for products, thus helping to improve supply chain resilience in the post-COVID-19 scenario (Fonseca and Azevedo, 2020). Besides, IoT and blockchain can improve visibility and tracking in the perishable food supply chain (Kumar et al., 2020; Messner et al., 2021; Morone et al., 2019), while AI could be used to solve complex problems (Syam and Sharma, 2018). These conclusions also suggest that the redirection process needs to consider up-to-date information on each store's stocks, as well as historical sales in each period of the year. The combination of this information with AI, ML, IoT, and Big Data may increase the sale of products with shorter shelf life, thus contributing to FW reduction (Teller et al., 2018; Wang and Li, 2012). Digital technologies can still facilitate internal resource planning (Satyro et al., 2021)

or external resource sharing (Palmié et al., 2021), as well as enhancing collaborative digital ecosystems (Del et al., 2021).

This study suggests the need to review supermarkets' strategies (Satyro et al., 2017). Supermarkets should consider PPFD reduction when defining their sales targets. To do this, the definition of sales targets should combine sales forecasting with products' historical disposal (in the supermarket's different stores). This conclusion adds to earlier literature results that indicate the need to incorporate product/store analysis into sales forecast models (Arunraj and Ahrens, 2015; Gokarn and Kuthambalayan, 2019). Once again, technologies can help with this definition. This is the case with machine learning, artificial intelligence, and big data (Kumar et al., 2019; Syam & Sharma, 2018), as well as IoT (Kamble et al., 2019).

5.4 Symbiosis and suppliers

Symbiosis and CE could both be improved if suppliers revise their sales targets. This revision should incorporate the manufacturer's financial losses, mainly those generated by the additional discounts offered to leverage sales of items that exceeded supermarkets' sales capacity. Such an analysis could be based on Big Data and blockchain (Chen et al., 2020; Köhler and Pizzol, 2020; P. Liu et al., 2020) and artificial intelligence (Camaréna, 2020). This study suggests that suppliers' definition of sales targets should also consider which supermarket stores can rapidly sell food nearing the end of its shelf life and the remaining stock in these stores. This information would make it possible to align the number of perishables available through retail stores and their momentary demand (Kumar et al., 2020; Parashar et al., 2020), as well as helping suppliers to better define the destination of their products (Perey et al., 2018) or to deal fairly and ethically with suppliers (Modak et al., 2020). Considering that retailers look for affordable prices, suppliers should also re-evaluate their pricing policy. The costs of a solution that improves both suppliers' and retailers' definition of targets could be shared among partners, since this solution would improve joint greening efforts in an agri-food supply chain (Cao et al., 2020; Dokić et al., 2020).

To improve the definition of sales targets, suppliers could attempt to capture supermarket teams' knowledge. As ascertained, these teams know the local purchasing habits of the consumers that visit each store. Understanding these habits can help suppliers assist other retailers in their sales and discount management, thereby potentially contributing to the joint reduction of PPFD. It is estimated that such support can enhance retailers' sustainability by allowing for better purchasing practices (Spada et al., 2018; Toon et al., 2016), and sustainable strategies (Hampl and Loock, 2013). This study also contributes by indicating that a better understanding of these habits would help suppliers mitigate the retailer's power in

the transferring game. This research finding adds to other strategies for overcoming power asymmetries in B2B relationships (Hingley, Angell & Lindgreen, 2015; Matanda et al., 2016; Toon et al., 2016).

5.5 Symbiosis in the relationship

Other improvements in symbiosis demand higher cooperation or new joint actions between retailers and suppliers. A coordination plan could increase the system's adaptability to disruption (Nami and Farshadfar, 2020). This study contributes by pointing out the options to reduce conflicts and product returns (Alizadeh-basban and Allah, 2020; Frei et al., 2020).

Such options focus on the sale of items before their expiration date. Dialogues among all stakeholders throughout the value chain seem to be necessary to improve sales and symbioses (Pitk et al., 2021). Such dialogues should focus on how to leverage sales and reduce PPFD in both groups of companies. First, suppliers and supermarkets should analyze where they can sell items close to their expiration date (Filimonau and Gherbin, 2018; Perey et al., 2018; Teller et al., 2018). For instance, products with shorter shelf life seem to be more highly in demand with lower-income customers. Therefore, suppliers and supermarkets should redirect such items to the stores that serve these customers. This redirection may improve the food chain's circular economy processes (Borrello et al., 2020). This conclusion contributes by suggesting the need to improve our understanding of the diverse interests that may leverage the CE (Bittar, 2018; Niskanen et al., 2020; Zhang et al., 2019), as well as that paying attention to such interests may help to feed poorer consumers (Borchardt et al., 2020; Kumar et al., 2020; Pizzi et al., 2020).

Suppliers can reciprocate retailers' support through reduced prices (Vesalainen et al., 2020), thus helping to promote cooperation in the chain (França et al., 2017; Yazan et al., 2020) or among retailers of different sizes (Morioka et al., 2018). Similarly, Hingley, Lindgreen and Grant (2015) identify retailer-supplier opportunities for improved relationships through intermediary collaboration in supply chains, using shared assets. As such, 'coopetition' can also help top managers to allay tension and conflict (Manzhynski and Figge, 2020; Pereira et al., 2019). Sales to other establishments or small competitors require that the supermarket has alternative sales channels (Brege and Kindström, 2020). This study contributes by indicating that using these channels is justified due to the great diversity of items near the end of validity and the sizeable geographical dispersal of stores that serve lower-income groups (Holt and Littlewood, 2017).

6. Conclusion

6.1 Contributions to theory and practice

This study's findings indicate that FW's financial impact on the top 500 Brazilian supermarkets is estimated at $2.7 billion per year, and $7 billion per year for suppliers. Previous studies have reported that many managers prefer to discard food than to deal with FW through sustainability-oriented approaches or routes (Scholz et al., 2015). Also, supermarket managers seek contractual protections that oblige the supplier to take back or even compensate the retailers for unsold items nearing their expiration date (Eriksson et al., 2017). This study presents a set of valuable suggestions for suppliers and supermarket managers interested in reducing PPFD.

Notably, we offer new insight into the adverse effects of paradoxical perishable supply chain relationships that ultimately impact FW. We contribute to the theory by indicating that actions in one link of the chain can impact PPFD in another link. We also contribute by indicating that there is a "transferring game" embedded in this paradox. This "game" may constitute a new barrier to CE.

However, this game may also reduce PPFD in both links. Despite its negative implications, both groups of managers indicate that taking a risk may pay off in terms of PPFD reduction. Furthermore, our research contributes to the theory by suggesting a symbiosis between industry and retail. This new type of symbiosis establishes strategies to cope with the paradoxes identified by leveraging sales and reducing PPFD and financial losses. Such benefits suggest that this symbiosis seems to be the best alternative to managing PPFD, as well as extending the circularity of the PPFD chain.

Given the pressing need for actions to develop the CE, our research also introduces valuable information on how the industry-retailer symbiosis can positively impact CE extension. The actions identified were divided into suppliers, supermarkets, and suppliers and supermarkets. A summary of these actions is presented in Table 8.

Table 8 – How to improve Industry-Retail Symbiosis and CE

Responsible Party	Action
Suppliers	To offer attractive benefits to supermarkets in order to generate sales, thus avoiding waste in the supplier's warehouses and supermarkets' returns. Not to sell items beyond the supermarket's sales capacity. To improve symbiosis and CE by reviewing sales targets. It is recommended to incorporate the manufacturer's financial losses, and to focus on all items that can generate additional discounts offered to leverage sales
Supermarkets	To use the benefits provided by the supplier to leverage sales in stores that serve lower-income customers or to generate sales to small establishments that will use the items promptly. Such actions may make the extension of circular economy principles within the food supply chain possible. To use business intelligence (BI) and sales forecasting systems to define which products will be redirected to each supermarket store, as well as to define the best moment for this redirection. To establish a proactive sales channel to avoid PPFD.
Suppliers and supermarkets	Dedicating attention to IRS can reduce PPFD, a problem affecting many food industries and retailers. The fostering of Industrial-Retail Symbiosis can reduce negative impacts on the environment as well as creating value in a CE business model. To improve the dynamic price and stock management to leverage sales.

Despite the identified actions, the amount of PPFD remaining will still be significant. Therefore, we also indicate the need for better understanding on how to improve Industry-Retail Symbiosis. To fill this gap, we suggest that future studies investigate the questions presented in Table 9.

Table 9 – Suggestions for future research into Industry-Retail Symbiosis and CE

Code	What we should know
Suppliers	What should suppliers know to evaluate partnerships with other suppliers (e.g., a shared sales center to improve symbiosis with retailers)? What managerial information should suppliers know to use digital technologies to enhance the production, handling, storage, and transportation of perishable items? Which benefits better contribute to leveraging Industry-Retail symbiosis?
Supermarkets	What managerial information should supermarkets know to use digital technologies to define what products should be redirected, which stores, and when? What should supermarkets know to define the limits of store managers' authority when mitigating PPFD? What managerial information should supermarkets know in order to use digital technologies in dynamic pricing? What should supermarkets know to establish a proactive sales channel?
Suppliers and supermarkets	What else should suppliers and supermarkets know to reduce PPFD based on closer cooperation? How could supermarkets and suppliers jointly leverage symbiosis and the circular economy?
Other suppliers and other retailers	What other types of symbiosis could a supplier establish to reduce PPFD in the food chain? Beyond the food industry, what other types of Industry-Retail Symbiosis could help leverage the CE beyond the food industry (e.g., in the electronic or fashion industries)? How can these symbioses be improved?

6.2 Research Limitations

Like any other study, this research has some limitations, which may serve as opportunities for future research. First, this is a qualitative study with results drawn from a limited number of supermarkets and suppliers in an emerging economy. As such, the findings cannot be generalized outside the present study's context until more studies are conducted to verify these initial findings.

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Appendix A

Table 10 - Questions proposed to supermarket professionals.

Code	Question
Focus of offer	How do customers' preferences affect FW (positively or negatively)?
Resupply management	How could supermarkets improve the orders of perishable items sent to its suppliers? How could supermarkets and suppliers cooperate to reduce PPFD? How do you evaluate the barriers to this cooperation? How would it be possible to mitigate such barriers?
Sales management	How do prices affect PPFD (positively or negatively)? How could supermarkets improve price management in stores? How do you evaluate the suppliers' pricing policies that aim to reduce FW?
Operations management	How would it be possible to improve supermarkets' operations to reduce PPFD? How could technology help to reduce PPFD?

Table 11 - Questions proposed to supply professionals.

Code	Question
Operations management	How would it be possible to improve suppliers' operations to reduce PPFD? How could technology help to reduce PPFD?
Market uncertainties	How would it be possible to improve your sales forecasting?
Resupply management	How could suppliers help to improve the orders sent by supermarkets? How could suppliers and supermarkets cooperate to reduce PPFD? How do you evaluate the barriers to this cooperation? How would it be possible to mitigate such barriers?
Sales management	How do prices affect PPFD (positively or negatively)? How could price management be improved in the buyer-supplier relationship? How do you evaluate suppliers' pricing policies that aim to reduce PPFD?

Table 12 - Secondary Data (documents collected).

Group	Company	Documents
Supermarkets	Supermarket A	Balance Sheet, Supplier Contracts, Internet Sources, FW Confidential Internal Reports (Qualities)
	Supermarket B	Balance Sheet, Supplier Contracts, FW Confidential Internal Reports (Qualities)
	Supermarket C	Balance Sheet, Supplier Contracts, Internet Sources, Reports on Sales to Small competitors, FW Confidential Internal Reports (Qualities)
	Supermarket D	Balance Sheet, Supplier Contracts, Internet Sources, E-commerce Sales Reports, FW Confidential Internal Reports (Qualities)
	Supermarket E	Balance Sheet, Supplier Contracts, Internet Sources, Reports on Sales to Small competitors, FW Confidential Internal Reports (Qualities)
	Supermarket F	Balance Sheet, Supplier Contracts, Internet Sources, Reports on Sales to Small competitors, FW Confidential Internal Reports (Qualities)
Suppliers	Supplier 1	Internet Sources, FW Targets Reports (Qualities and Quantities)
	Supplier 2	Manager's performance Reports, FW Targets Reports (Qualities and Quantities)
	Supplier 3	Internet Sources, FW Targets Reports (Qualities and Quantities)
	Supplier 4	Report on Customers and Contributions to FW, Area Targets and Performance (Report)
	Supplier 5	Manager's performance Reports, FW Targets Reports (Qualities and Quantities)
	Supplier 6	Competitors Performance (Report), Confidential Internal Sources, Company's Targets