Waste Not, Want Not: Understanding the impact of food characteristics on Circular Economy practices in the Italian Retail sector

Stella Viscardi*, Claudia Colicchia*

* *Department of Management, Economics and Industrial Engineering, Politecnico di Milano, Via Lambruschini, 4/b 20156 – Milano – Italy (stella.viscardi@polimi.it, claudia.colicchia@polimi.it)*

Abstract: The Food and Agriculture Organization estimates that each year, along the whole food supply chain, one-third of global food production is wasted and is consequently responsible for negative environmental, social, and economic impacts. Scholars, practitioners, and policymakers have identified circular economy as an effective approach to addressing food waste and its detrimental consequences. The application of circular economy principles to reduce and recover food waste has been broadly investigated in the scientific literature; however, studies have so far neglected the role of the characteristics of different products in food waste generation and management. Starting from a novel classification of food products in light of circular economy, this work aims to fill this gap by exploring how the food characteristics that most influence food waste along food supply chains affect the adoption of circular economy practices. First, the literature on circular economy and food waste is reviewed to define categories of food products. This initial inductive analysis reveals how the relevance of a characteristic varies along the supply chain, leading to the identification of different characteristics for each supply chain stage. To understand how these characteristics influence the implementation of circular economy, empirical data are collected using a case study methodology involving food retailers operating in the Italian territory. Retailers are at the last stage of the supply chain: beyond the validation of the developed classification, their perspective highlights how the identified characteristics intertwine going downstream the chain, creating peculiar conditions for food waste generation and management. The main contribution of this work is represented by the proposal of a novel perspective on circular economy for food waste prevention and management. This conceptualization, which poses food products at the core of the analysis and exposes their specificities, can ease the reduction and recovery of food waste along the supply chain.

Keywords: Food waste, Circular economy, Product characteristic, Retail

1. Introduction

Food waste constitutes one of the most relevant global waste flows: 1.3 billion tonnes of food are wasted yearly (FAO, 2019a). Wasted food is associated with grave socio-economic and environmental challenges, negatively impacting all three dimensions of sustainability (Gokarn and Kuthambalayan, 2017). Concerning economic and environmental impacts, wasting food entails wasting all those resources employed during production. For instance, wasted food accounts for nearly one-fourth of fertilizer and land use (Kummu *et al.*, 2012). From a social standpoint, food waste is strictly intertwined with food security. Wasted food is rising, as well as the share of the global population in food-deprived conditions, with 821 million people facing food insecurity (FAO, 2019b). Food wastage can affect any food product, from raw materials to finished products, with sources of waste found along the whole supply chain (Caldeira *et al.*, 2019). Hence, addressing this issue requires a broad and collective effort from companies, consumers, and policymakers.

Circular economy has been proposed as a possible approach to reducing food waste. The principles of circular economy aim to reconceptualize waste as a resource and eliminate waste from industrial systems (Ellen MacArthur Foundation, 2012). Several international policies have recognized circular economy as a promising novel economic paradigm. In the context of food waste, prime examples are the European Circular Economy Action Plan (European Commission, 2020a) and the European Farm to Fork Strategy (European Commission, 2020b). These policies set ambitious goals that can improve the sustainability of the food industry.

Embedding circularity in the food sector presents multiple challenges, as discussed in the literature (e.g., Gedam *et al.*, 2021; Mehmood *et al.*, 2021). Many of the barriers companies face relate to the complexity of translating circular economy principles into action (Gedam *et al.*, 2021). These difficulties are exacerbated by the inherent variability of food. Food industry outputs vary significantly regarding employed raw materials, processing techniques, or food matrix characteristics. Despite the growing scientific discourse on circular practices for food waste reduction, the scope of existing studies is often limited to one food product (Chauhan, 2020). This shortcoming indicates how literature has so far neglected the complexities arising from the intrinsic variability of food products (Ögel, Ecer and Özgöz, 2023; Viscardi, Colicchia and Creazza, 2022). Failing to consider the inherent characteristics of food products when discussing food waste can limit the comprehension of causes and reduction strategies (Viscardi, Colicchia and Creazza, 2022). This underexplored topic deserves a deeper investigation, as it can provide detailed guidance to food companies willing to engage in circular economy. Understanding how food product characteristics influence the generation and recovery of food waste can pinpoint effective circular strategies and promote food waste

reduction. The present study will address this gap by answering the research question: *"How do product characteristics influence food waste generation and its reduction through circular economy practices?".*

The starting point of this work is the proposal of a novel classification of food products in light of circular economy, derived from a literature analysis (section 2). The considered literature investigates industrial contexts, not considering food waste at the consumer level, as food waste generated by consumers strongly depends on their behavior (Stancu, Haugaard and Lähteenmäki, 2016). While the literature analysis constitutes the starting point for this research, the current manuscript focuses on empirically investigating how the nature of food products influences food waste generation and management. The exploratory empirical analysis is performed to corroborate the classification derived from the literature and derive further insights on the topic. Among the several industrial activities studied in the literature review, the scope of the empirical analysis is restricted to the retail stage of the supply chain. Considering the exploratory nature of this work, it is appropriate to limit the scope of the analysis to expand it in further studies. Data regarding food waste causes and circular economy practices are gathered using a case study methodology, as detailed in sections 3 and 4. The influence of product characteristics is discussed in section 5, enabling the drawing of conclusions and identifying future research directions.

2. Theoretical background

2.1 Literature analysis

To begin understanding how food product characteristics may influence food waste, the research initially focused on analyzing papers discussing food waste generation and its recovery through circular economy practices. These aspects have been explored along the whole food supply chain, adopting an overarching perspective of the food sector. This approach provides a thorough assessment of how the intrinsic characteristics of food products influence food waste.

Figure 1: Proposed classification of food products in light of circular economy principles

The analyzed paper sample was built following the steps for a systematic literature review recommended by Denyer and Tranfield (2009). Articles were located through a search of the Scopus database, conducted by defining a coherent set of keywords and inclusion criteria. The selected keywords are related to the main areas of this research: food waste, circular economy, supply chains, and food product characteristics. The screening of titles and abstracts, followed by full-text reading, led to a final sample of 281 papers. The selected articles have been analyzed inductively to isolate the characteristics of food products that influence food waste. The inductive analysis was based on mapping food waste causes and circular economy practices in relation to the discussed food products along the whole supply chain, derived from a thorough assessment of all papers in the sample. The inductive analysis led to identifying factors that influence food waste generation and management: the results have been reported through the proposal of a classification of food products in light of circular economy.

2.2 Classification proposal

The classification of food products derived from the review of literature is presented in Figure 1. The inductive analysis confirmed the relevance of food product characteristics in determining causes and recovery of food waste (Viscardi, Colicchia and Creazza, 2022; Chabada *et al.*, 2014). However, the considered supply chain stage is key to defining such characteristics. As depicted in the proposed classification, a different categorization of food products is proposed depending on the supply chain stage. The operations carried out at each step of the supply chain influence the causes of food waste and the available circular economy practices. This consideration entails that certain food characteristics can be extremely relevant or entirely negligible depending on the positioning along the chain. This evidence is part of the developed classification and constitutes a significant contribution.

Concerning harvesting, most differences have been found between products of animal and plant origin. Moving to manufacturing, significant differences arise between minimally processed and processed food. Distribution activities are influenced mainly by temperature, leading to distinguishing between products requiring controlled or ambient temperature. At the retail stage, products with short shelf life and long shelf life show significant differences. This stage, which is the main focus of the current study, encompasses both wholesalers and retailers (FAO, 2019a). Concerning these actors, the most common causes of food waste are found for short shelf life products, concerning natural degradation and aesthetic defects (Trento *et al.*, 2021). The natural decay of these products can be enhanced by inadequate storage conditions and packaging (Ögel, Ecer and Özgöz, 2023) or careless handling (Liu *et al.*, 2022). It is then difficult to sell imperfect products as consumers expect food to be aesthetically flawless (Esparza *et al.*, 2020). Accordingly, many circular economy practices are employed for their prevention and recovery. These focus on improving infrastructures, packaging, and consumer education (Eičaitė *et al.*, 2022). Digital technologies can also be used to reduce waste, for example, through shelf life monitoring or with intelligent packaging (de Moraes *et al.,* 2020). Long
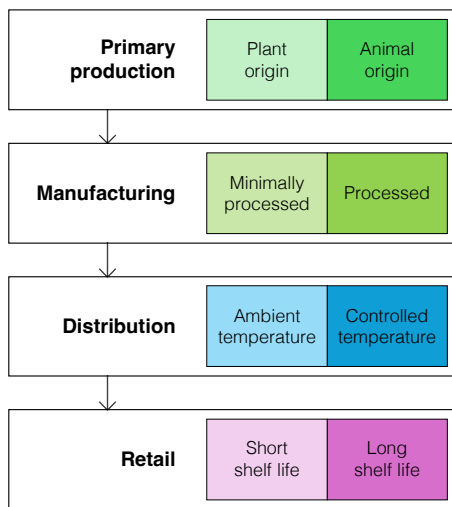
shelf life products are less concerned in terms of food waste. Fewer waste causes are found in the literature, related to product expiration and damage (Riesenegger and Hübner, 2022). These products are primarily recovered through donations to charitable organizations (Lowrey, Richards and Hamilton, 2023).

3. Methodology

The main focus of this work is the empirical analysis of the influence of food product characteristics on food waste, starting from the discussed preliminary literature findings. The case study methodology is appropriate for collecting primary data on this novel topic and corroborating literature findings. Case studies are suited for early-stage research as they allow the examination of complex phenomena in their real-life context (Eisenhardt, 1989; Yin, 2018). Multiple case studies appear especially appropriate for this work, which aims to compare products with varying characteristics (Eisenhardt, 1989).

3.1 Case selection

Case selection is the first critical step of the case study methodology, for which it is necessary to define the unit of analysis and the scope of the investigation (Yin, 2018). The classification of products presented in Figure 1 has a broad scope, encompassing the whole food supply chain. Considering the exploratory nature of this work, it is appropriate to restrict the scope of the analysis. Within the context of this research, limiting the scope of the investigation entails selecting one stage of the supply and, hence, one product attribute to be analyzed in detail. The unit of analysis is hence limited to the retail stage, which includes retailers and wholesalers (FAO, 2019a). Defining the boundaries of the research enables a proper selection of cases. As suggested by Eisenhardt (1989), theoretical sampling is appropriate for case selection. Theoretical sampling entails a purposive selection of cases to build a sample that can provide compelling insights into the phenomenon (Eisenhardt, 1989). Following this logic, cases were selected among food retailers and wholesalers operating in Italian territory. The choice of limiting the geographical scope of the analysis can be reconducted to the exploratory purpose of this work. Italy has been selected as a suitable area since it is a leading country in the retail sector in Europe (EUROSTAT, 2023). Moreover, when selecting cases, particular attention was devoted to ensuring including a variety of food products,

characterized by both long and short shelf life. This aspect is crucial to gather empirical data on food waste generated by products with different characteristics. Hence, the cases of interest included firms only commercializing mainly one food type (either with a short or long shelf life) and companies selling both. Non-specialized retailers can provide a broader overview of food waste causes and circular economy practices. On the other hand, specialized retailers offer deeper insights into a specific type of product. Altogether, comparing cases allows differences to emerge, which can be reconducted to specific product characteristics. The case sampling led to the inclusion of six cases, with a balanced distribution of short and long shelf life products. This number was considered sufficient to provide enough depth in the observation and highlight patterns (Yin, 2018). The description of each case is presented below and summarized in Table 1, where the numbers have been rounded to maintain anonymity.

Company A
This company is a large hypermarket chain with more than twenty-five points of sale in northern Italy. The points of sale offer a wide variety of fresh and shelf-stable food products and other non-food products. Some of the fresh items are prepared and cooked within the store. The supply chain manager and the ESG manager participated in the interview.

Company B
Company B is a consortium that manages a large wholesaler market of fresh fruit and vegetables in central Italy. The market area includes several wholesaler stands, processing facilities, and refrigerated storage areas. The quality manager for Company B was interviewed.

Company C
The company is among the market leaders in the wholesale of fruit and vegetables in Italy. The product range is very broad and includes more than fifty types of fruit and vegetables. The items are sold whole or cut and packed in a ready-to-eat format. The marketing manager was the interviewee for Company C.

Company D
Company D sells fishery products through its wholesale channel and seven points of sale in northern Italy, one of which is a cash-and-carry. The commercialized products include a wide variety of seafood species, sold fresh or frozen. The quality and HSE managers were involved in the study.

Company E
The company commercializes frozen fishery products through its more than a hundred points of sale scattered across Italy. The seafood products are sold loose and include whole animals (fish, mollusks, crustaceans) and ready-to-cook meals, such as pasta condiments. The quality manager was the respondent for this company.

Company F
This company, located in central Italy, specializes in meat and meat products, some of which are manufactured by the company. These products are mainly sold through a wholesale channel to the HoReCa sector. The company also owns a point of sale. The director of Company F took part in the interview.

Table 1: Details of the six companies involved in the study

	Employees	Turnover [k€, 2022]	Products
A	5700	1800000	All
B	35	9500	Fruit and vegetables (fresh)
C	280	350000	Fruit and vegetables (fresh)
D	85	41000	Fish (fresh, frozen)
E	380	79000	Fish (frozen)
F	10	5500	Meat (fresh)

3.2 Data collection and analysis

The data was triangulated from three main sources: semi-structured interviews, internal reports, and websites. Interviews represent the main source of information, as they provide rich descriptions of the topic under study (Kvale, 1994). The interviews followed a semi-structured approach, allowing flexibility in the responses to gather in-depth insights (Yin, 2018). The questionnaire was developed based on findings from the literature and was aimed at investigating the causes of food waste and circular economy practices implemented by the company. Website and reports consultation was used to adjust interview questions in preparation for each interview.

Data analysis was conducted using interviews and material gathered through websites. The interviews were recorded and transcribed to facilitate the case analysis. These materials were coded by adopting open coding techniques. The coding process aimed at coding labels describing each case, focusing on the causes of food waste and the related circular economy practices. Have been considered causes of food waste all those events that may lead to the removal of food from the supply chain. Concerning circular economy practices, have been included in the analysis all those actions aimed at preventing or recovering food waste aligned with the practices suggested in the food waste hierarchy (Teigiserova *et al.*, 2020). The initial descriptive codes were compared to develop aggregated codes describing similar causes or circular economy practices. This process led to creating a sound data structure used to analyze each case and for their comparison (Yin, 2018).

4. Results

4.1 Company A

Company A reported a wide variety of causes of food waste. The natural decay of products, overstocking, and cold chain problems arising during truck unloading operations are mainly related to short shelf life products. The inaccurate forecasting of demand and the expiration of products on the shelves are instead reported for items with a long shelf life. A peculiar cause of waste found in this case relates to the high service level offered by Company A. This cause is especially relevant for bread and other fresh products, such as cheese. As explained during the interview: "*Customers choose us because they know they can always find full shelves. It would not work if we only displayed the number of items we plan to sell today.*" This issue is exacerbated in the case of bread, which is baked fresh every morning at the point of sale and cannot be replenished during the day, leading to significant wastage.

Company A uses a variety of circular economy strategies to prevent and recover food waste. The practices are employed both for short and long shelf life products, with no significant differences. One of the most relevant practices is using food waste in other products, where items that are damaged or close to expiration are employed as ingredients. This is enabled by the structure of points of sale, which embed laboratories to prepare fresh food products. As recognized by the company, this is a strength: "*One of our strong points is having some fresh food prepared within the supermarket, enabling flexibility and autonomy in the recovery.*" This flexibility partially counterbalances one of the main difficulties faced by the company, which lies in the variety of produced waste. The heterogeneity of waste flows is perceived as a complication of circular economy. Another aspect the firm considers when discussing circular economy relates to its costs. Many of the wasted products are fresh fruit and vegetables with very low economic value. This can hamper their recovery, which may be difficult even in the form of donations: "*There's the need for refrigerated transport, and considering their low value, they don't cover the transport cost. Also, most charities do not have adequate transportation equipment.*" When possible, these products are employed as ingredients; otherwise, they are directed to composting.

4.2 Company B

The products handled by Company B all fall under the category of "short shelf life." The reported causes are homogeneous for all fruits and vegetables but can become more prominent throughout the year due to produce seasonality. As explained: "*Some summer products, such as tomatoes and watermelons, ripe very quickly, and can quickly become waste if not sold in time.*" A portion of the waste is generated due to temperature problems during transportation and storage, especially during summer. This can damage the products, which become hard to sell due to their imperfect appearance. The strict aesthetic requirements of customers have a significant impact on waste generation. Company B employs many strategies to prevent food waste generation, as shown in Table 3. The company only sells fruit and vegetables and has a deep knowledge of these products. This enables the optimization of operations and storage to minimize waste. For example, during storage, "*We avoid putting in the same cold room products that during ripening release substances* (such as ethylene) *that could accelerate the ripening of other produce. We also have ethylene sensors.*" Beyond this aspect, the preferred recovery strategy is diverting products with low residual shelf life or visual defects to the "*market of opportunities.*" The products destined for this area are then sold at a discounted price or donated. Company B encourages donations by providing the certifications required for the donation for free. This area was created to recover value from products that have a very short shelf life and risk becoming waste in a short period of time. This destination is encouraged as it has a low cost for the company and can be justified when considering the low economic value of the products. When this option is unavailable, fruit and vegetables are destined for composting: "*It is a cost; the management of the area where waste is stored is an expense for us.*"

4.3 Company C

Company C reported a few causes of food waste, as reported in Table 2. The main discussed cause is client returns, which primarily derive from supermarkets. These players have stringent requirements on product aesthetics and do not accept products with minor imperfections. This cause is also linked to product damage, as the ripening process continues during distribution. When returned, the produce may be too ripe to be marketed again. Products can also be damaged during transportation and potentially become waste at inbound.

The causes of food waste and its generation are limited thanks to the precise planning and forecasting performed by the company. This enables minimizing overproduction and the holding of excessive stocks. Concerning the strict

aesthetic requirement imposed by supermarkets, the company has a precise strategy to mitigate this potential source of waste. The fruit and vegetables are divided into categories I, II, and III, depending on their appearance and characteristics. Category I products are destined for supermarkets, category II products have some visual defects and are sold to discounts, and category III products are not suitable to be consumed as a whole and are sold to manufacturing companies to be employed as ingredients (most are sold for the production of fruit juice). The availability of multiple channels to market the products enables minimizing waste: "*Many companies only sell high quality products, leading to the generation of enormous quantities of waste, which is not a sustainable way of working. We disagree with this approach, so we have different channels to sell our products.*" This flexibility entails that very few products cannot be sold and are donated to local charities. These usually coincide with fourth-range products, such as ready-to-eat salads, that have an extremely short shelf life. Donating products is the least preferred strategy, as the company tries exploiting the other available channels before donations.

4.4 Company D

The products commercialized by Company D include fresh and frozen fish, characterized by drastically different shelf life. Most food waste causes are found for fresh products with a very short shelf life. The inaccurate forecasting of demand can represent a source of waste: "*The order must be placed a week in advance, and there can be inaccuracies in forecasting market requests. The problem is we handle products with a short shelf life, that after three or four days can start*

having problems." This waste source also exists for frozen products, but the relevance is much smaller. Imprecise orders can lead to excessive stock and thus to product aging and natural degradation, compromising marketability. This is exacerbated by the strict aesthetic requirements imposed by some clients, which often lead to product returns. The products may be returned after a few days, losing a part of their short shelf life and thus potentially becoming waste.

The company has developed several strategies to prevent discarding food products, as displayed in Table 3. The company shows great flexibility in managing its fresh products, aimed at reducing wastage. The customers are clustered into different categories based on their requirements. As explained during the interview: "*We diversify our clients because if we only had Michelin-starred restaurants, we would only be able to sell extra-perfect products. We sell compliant but not-perfect products to clients that have lower expectations, sometimes at a discounted price. With this clusterization, we can sell all our products.*" The fresh products that cannot be sold to alternative customers and are

Table 2: Causes of food waste found across cases, with details on the type of product (S = short shelf life, L = long shelf life)

Cause	A	B	C	D	E	F
Aesthetic defects		S		S, L		
Cold chain problems	S	S			L	S
Customer returns			S	S		
Damaged products	S, L	S	S		L	S
Excessive stock	S			S		S
High service level	S					
Inaccurate demand forecasting	L			S, L		S
Natural decay	S			S		S
Product expiration	L	S			L	
Selection and processing scraps	S	S	S	S, L	L	S

Table 3: Circular economy practices found across cases, with details on the type of product (S = short shelf life, L = long shelf life)

Circular practice	A	B	C	D	E	F
Forecasting and order improvements		S	S			S
Monitoring of environmental parameters	S, L	S		S, L	L	S
Operations and infrastructure improvement	S	S	S	S, L		S
Price discounts	S, L	S		S, L		S
Selling to alternative customers		S	S	S		S
Storage improvement and monitoring	S, L	S	S	S, L	L	S
Donation for human consumption	S, L	S	S		L	S
Reuse for other products	S, L		S	S		S
Pet food production	S, L			S, L	L	S
Composting	S, L	S				
Energy production	S, L					

approaching the end of their shelf life can be frozen (as whole, or cut and then frozen), later sold as frozen products. This flexibility leads to the minimization of waste and the possibility of recovering all products through market channels. This is guided by the value and the short shelf life of products: "*The high cost of the product and its perishability lead us to try recovering it. Sometimes, I cannot sell at full price, but at least I can recover something.*" Beyond these aspects, the company also monitors temperatures, keeps infrastructures updated, and optimizes operations and storage to minimize waste.

4.5 Company E

The frozen fishery products commercialized by Company E are characterized by a long shelf life. If stored at the correct temperature, these products are very stable and do not incur many possible causes of food waste. The products may become waste mainly due to temperature problems during transportation and storage or prolonged storage, strongly limiting their useful shelf life. At the point of sale, products may be discarded if ruined or contaminated by customers.

Company E has adopted strategies to punctually address these potential sources of food waste, as shown in Table 3. Temperature monitoring is crucial for frozen products, and the company is really strict on this aspect. The containers transporting the fish from the supplier have a continuous monitoring of temperature. This ensures the cold chain has been maintained throughout the journey, which can last months. Once stored, the company tries to ensure a good product rotation to avoid aging. In the few cases of products approaching the end of their shelf life, they are donated to local charities. The donation is simplified thanks to the long shelf life of the products, which can further be extended to streamline its management: "*Before donation, we perform tests and analyses on the product to evaluate its true residual shelf life. This way, we can donate with a shelf life of two to three months.*" Maintaining low stocks and donations enables the company to avoid disposal costs and avoid wasting good products: "*We do not want to waste. Beyond the fact that we would have to pay, we would also be throwing away good food.*"

4.6 Company F

As reported in Table 2, Company F faces many possible sources of food waste in its operations, which focus on fresh meat. Meat is a fragile product that is easily damaged if not handled correctly and is subject to degradation over time. This is especially relevant during storage since prolonged storage could lead to significant waste. Over time, the meat loses liquids and changes color, forcing the elimination of the external part of the products. Moreover, the vacuum packaging could loosen, potentially shortening the shelf life of the meat. Excessive stocks accumulated due to inaccurate forecasting or imposed minimum order quantities can exacerbate this problem.

Company F is very attentive to avoiding waste due to the high value of meat: "*We must not throw away meat. We always have to find a way to recover it. From an entrepreneurial point of view, waste is an economic loss. Then there is also the human perspective, and wasting must be avoided.*" To reach this goal, the company tries to improve its operations, storage, infrastructures, and forecasting to minimize waste, along with precise monitoring of temperatures during storage

and transportation. Regarding the excess stock, the company usually transforms the meat into other, more processed products, such as steaks or hamburgers. This enables selling these products more easily and avoiding waste. Other viable alternatives are applying price discounts, diverting some of these products to the point of sale, and donating to local charities. The efforts to reduce waste expand beyond the company's boundaries towards customers and other meat wholesalers. A part of Company F customers is constituted by restaurants that only open during the summer months. At the end of the season, if the client has many leftover products, Company F collects them after assessing their compliance. A similar attitude is found towards other meat wholesalers in the area: "*We try establishing relationships, where we try selling our excess products to them, and they do the same. Also, if we know that a certain wholesaler is commercializing a certain product, we can buy it directly from them. This creates an added cost, but we can avoid minimum order quantities and only buy what we need, minimizing waste.*"

5. Discussion and conclusion

The findings presented in this paper provide an overview of food waste causes and reduction practices employed by retailers operating in Italy. The application of the food product classification derived from literature, presented in Figure 1, enables studying how the characteristics of food products influence food waste.

As emerging from the literature, the main characteristic driving food waste generation at the retail stage of the supply chain is the duration of product shelf life. Short shelf life products appear to be more susceptible to waste generation, confirming the literature findings. This is clear in Table 2, where the causes of waste mostly refer to short shelf life food. Especially Company B, C, and D discussed how the short shelf life of products strongly complicates product management, entailing a higher risk of food waste generation. Ensuring the cold chain enables avoiding waste, which may be generated when the cold chain is interrupted. For products characterized by a long shelf life, fewer causes are found, in line with the literature.

When analyzing circular economy practices, the positioning of retailers along the supply chain highlights how the identified food characteristics intertwine going downstream the chain. This especially emerges in relation to the value of waste, which is frequently mentioned during the interviews. Fruit and vegetables are described as low-value products (A, B), whereas fish and meat have a higher value (D, E, F). This derives from the origin of the products (animal or plant origin, see Figure 1) and corroborates the literature findings. The economic value of these products plays a significant role in preventing and recovering food waste. Low-value products are perceived as more complex because the recovery costs exceed their value. More effort is instead put into preventing high-value products from becoming waste. Another characteristic identified in the classification that emerges as relevant in the interviews is the temperature required during distribution activities. The need for controlled temperature storage and transportation has also been shown to influence logistics activities related to food waste recovery. The necessity of using controlled temperature vehicles in the recovery of food waste can make circular

economy practices more complex, especially when food is recovered through donations.

Beyond the influence of product characteristics, the interviews provide further insights into the adoption of circular economy. The availability of multiple recovery strategies, and hence the flexibility in redirecting waste towards the most appropriate destinations, appears as a facilitator for circular economy. The ability to tailor recovery to the specificities of the product, for instance, through internal reprocessing, emerges as pivotal in establishing successful circular practices. Moreover, the studied cases show a positive attitude towards food waste. All companies report being aware of the importance of food waste minimization, even if driven by economic purposes.

The main theoretical contribution of this work is represented by the proposal of a novel perspective on circular economy for food waste prevention and management. The analysis of food retailers has enabled a partial validation of the proposed literature-based classification. The analyzed cases clearly depict how the characteristics of food products influence both the generation and recovery of food waste. This conceptualization, which poses food products at the core of the analysis and exposes their specificities, can have significant practical implications by easing the reduction and recovery of food waste along the supply chain.

Despite the novel contributions, this work is not exempt from limitations. The main shortcoming of this study relates to the limited number of cases, which, combined with the restricted scope, could limit the generalizability of the findings. This exploratory study represents the first step in the understanding of the topic. Further research should strive to consider more supply stages and a broader variety of food products.

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