The current issue and full text archive of this journal is available on Emerald Insight at:
https://www.emerald.com/insight/1741-0398.htm

Enablers and barriers to circular supply chain management: a decision-support tool in soft wheat bread production

Marco Formentini
Department of Information Engineering and Computer Science (DISI), Universita degli Studi di Trento, Trento, Italy
Luca Secondi
Department for Innovation in Biological, Agro-Food and Forest Systems, Universita degli Studi della Tuscia, Viterbo, Italy
Luca Ruini
Supply Chain Department, Barilla G e R Fratelli, Parma, Italy
Matteo Guidi
Last Minute Market, Bologna, Italy, and
Ludovica Principato
Department of Business Studies, Facoltà di Economia, Università degli Studi Roma Tre, Roma, Italy

Received 5 February 2021
Revised 2 June 2021
Accepted 17 June 2021

Abstract

Purpose – There is a limited understanding of effective strategies for tackling food loss and waste (FLW) following a circular supply chain management approach. The aim of this study is to analyze the role of the FLW Reporting and Accounting Standard for identifying FLW occurrences throughout the agri-food supply chain and facilitate their measurement. Our objective is to describe how this FLW is then reused within a circular economy (CE) perspective, thus enabling companies to implement a circular supply chain approach for effective decision-making based on the concept of waste hierarchies, the 3R and 4R rules.

Design/methodology/approach – An in-depth analysis of Barilla's soft bread supply chain is provided in this study. By gathering both qualitative and quantitative data, this study investigates the implementation of the FLW standard by (1) identifying the main enablers and obstacles in measuring FLW throughout the entire production system; (2) providing a useful standardized tool for sustainable FLW measurement, minimization and reuse in other agricultural supply chains to enable circular economy approaches and (3) developing a decision-support strategy to use within the company for effective measurement, analysis and reuse according to a CE perspective.

Findings – The analyses carried out throughout Barilla's soft wheat bread supply chain provide an interesting example of a circular management system since almost nothing is lost or wasted while the value of resources is recovered through reuse thanks to a systematic and integrated measurement, representing a basis for effectively minimizing waste. The importance of developing an interconnected supply chain management emerged in order to obtain a comprehensive accounting framework for accurately quantifying and reporting the overall amount of wastage generated in the various phases of food production, paying particular attention to *ex ante* prevention initiatives and ex-post assessment actions.

Originality/value – An interdisciplinary approach integrating circular economy and supply chain management research streams was adopted in order to develop a decision-support tool that also includes the identification of the main facilitators and obstacles to the implementation of a comprehensive standardized accounting process that would enable companies to reduce-reuse-recycle losses and waste throughout the entire production process. Besides the studies available in the literature, the original of this study is that it focuses on organizational implications related to FLW measurement.

Keywords Sustainable management, Circular economy, Decision-support model, Strategy implementation, Bread product, Food loss and waste

Paper type Research paper

Journal of Enterprise Information Management

1741-0398
DOI 10.1108/JEIM-02-2021-0069

1. Introduction

Food Loss and Waste (FLW) issue represents one of the most relevant environmental, social and economic challenges, as recently highlighted by institutions and researchers (FAO, 2013; Halloran *et al.*, 2014; Grizzetti *et al.*, 2013; Corrado *et al.*, 2019; Principato *et al.*, 2020, 2021; Vargas-Lopez *et al.*, 2021; AL-Dalaeen *et al.*, 2021) and emphasized within the Sustainable Development Goals (SDGs) framework promoted by the United Nations (UN) [1]. Currently, nearly one billion people are heavily affected by hunger or malnutrition and it is intolerable that over one-third of the world's food is left on fields or ends up in landfills (Gustavsson *et al.*, 2011). FLW have a strong impact on the environment, since every food product releases CO_2 throughout its lifecycle and also generates a water footprint that profoundly influences climate change. Besides the ethical and environmental implications, FLW have also reduced the "value" of food from a social perspective. Following the industrialization of agri-food processes, food prices have dropped considerably thus offering the false hope that it would be possible to feed everyone on the planet. Conversely, it has caused people to alter their perception of the true value of food, which would compromised all of the efforts made at supply chain level to cultivate, harvest, produce and distribute food.

As a result, recent studies underline that FLW management is an extremely serious issue for our planet (Murray and Koehring, 2018; Garcia-Garcia *et al.*, 2017; Winkler and Aschemann, 2017), and according to a study conducted in Europe (Xu *et al.*, 2018) global FLW are predicted to increase to 126 million tons per year by 2020 unless additional prevention initiatives and policies are put into force. Unfortunately, this prediction is not in line with the ambitious goal established by the UN in their SDG n. 12.3 which by 2030 aims to halve global food waste at retail and consumer levels (per capita) and reduce food losses along production and supply chains including post-harvest losses (United Nations General Assembly, 2015).

Due to the urgency of the FLW issue, the aim of this study is to understand why FLW occur and how they are generated throughout the supply chain. In order to achieve these objectives, a structured approach based on the implementation of the FLW Accounting and Reporting standard was adopted. The current knowledge on FLW management is expanded by integrating a supply chain perspective with circular economy concepts which has previously overlooked in the literature. It is essential to have a good understanding of FLW management, the concepts of waste hierarchies, the 3R (Bassi and Dias, 2019) and 4R rules (Barreiro-Gen and Lozano, 2020) wastage on which the framework of the Circular Economy (CE) paradigm is based (Secondi, 2021), in order to minimize wastage throughout the entire supply chain.

The importance of the CE approach as enabler to achieve sustainable production and consumption systems has been underestimated (Kirchherr *et al.*, 2017), until recently when both researchers and practitioners recognized its great potential (Schulze, 2016; Sehnem *et al.*, 2019; Ünal *et al.*, 2019; Jaeger and Upadhyay, 2020; Walker *et al.*, 2020; Beckmann *et al.*, 2020) in the light of our transition towards CE models as established in the 2015 Circular Economy Action Plan (CEAP) (European Commission, 2015) and in the new CEAP established by the European Commission (European Commission, 2020). A more effective SDG contribution (Corrado *et al.*, 2019; Tseng *et al.*, 2020) which is essential for improving FLW management (Teigiserova *et al.*, 2020; Ciccullo *et al.*, 2021), emerged for those supply chains adopting collaborative relationships with the aim of supporting circular models (Dora, 2019).

Our research is based on an in-depth case study of Barilla's bread supply chain. Barilla is a leading company in sustainability (Formentini and Taticchi, 2016) as it adopts a structured strategy focused on the triple bottom line concept with an extended supply chain perspective. Some important supply chain sustainability initiatives designed and developed by Barilla are reported in literature, such as durum wheat supply chain contracts (Formentini *et al.*, 2016; Tang *et al.*, 2016).

Using both quantitative and qualitative data collected and provided by Barilla [2], bread loss, waste and their respective causes were analyzed throughout the entire product lifecycle. From a quantitative perspective, recording the FLW quantity generated throughout the entire supply chain and the practical implementation in the company of the 3R rule were carried out using the FLW Accounting and Reporting Standard, launched internationally in 2013 and provides a credible, practical, transparent and consistent basis for accounting and reporting on FLW (Hanson *et al.*, 2016). From a qualitative perspective, in-depth interviews involving Barilla and its partners' employees enabled us to test, evaluate and determine if and to what extent the principle underlying the FLW Accounting and Reporting Standard is shared within the organization with the aim of identifying the related main enablers.

This dual approach to data collection and analysis has enabled us to implement a decision-support tool combining CE principles with a focused supply chain management strategy therefore contributing to the new research stream on Circular Supply Chain Management (Farooque *et al.*, 2019; Lahane *et al.*, 2020).

This paper is structured as follows. Section 2 describes the theoretical framework that motivated our research, recalling the importance of the FLW issue, its causes throughout the supply chain and the need to integrate production chain management with the principles of the circular economy. In Section 3, the research design of this study is presented which illustrates the FLW Accounting and Reporting Standard which was used to implement the Barilla bread supply chain case study. Section 3 quantifies the amount of FLW generated at each stage of the bread supply chain and reveals the main underlying causes and way of reusing wasted food. The FLW inventory results are discussed in Section 5 by merging quantitative results with the qualitative findings obtained from in-depth interviews. In the same section, our proposed joint strategy of analysis is presented which provides suggestions for future research topics in the field. Some concluding remarks are drawn in Section 6 and the limitations of our research are presented.

2. Literature review

2.1 Food loss and waste: a significant challenge

In line with the Food and Agriculture Organization (FAO) definition (Gustavsson *et al.*, 2011), food loss is represented by the losses that occur during the upstream food supply chain stages (i.e., from cultivation up to industrial processes for transformation) while food waste is represented by the food wasted downstream at the retail and consumption stages. Food losses occurring at the initial supply chain stages are generally managed by agri-food companies and farmers. For this reason, their involvement in identifying, evaluating and reducing food loss is essential for achieving the SDG n. 12.3. However, there is a strong need of coordination among the various actors of the food supply chain as well as appropriate tools for supporting decision-making and implementing strategies that embrace a supply chain perspective integrated with CE pillars.

The progress report published by Champions 12.3 (2018) underlines that even if over 25% of the world's 50 largest food companies started measuring the FLW generated during their production processes in 2017, only 20% of these firms actually developed and implemented FLW reduction programs (Principato *et al.*, 2019). In this perspective, the CE can enable food companies as well as the stakeholders, to achieve other SDGs, in addition to n.12.3, for instance those concerning climate action or life on land. The European Commission highlighted the importance of FLW prevention by including it as a key component of the CE package (European Commission, 2015) and confirming the importance of food waste reduction in the recent edition of CEAP (European Commission, 2020).

These strategies offer new opportunities for research aimed at identifying and understanding food losses in the upstream food supply chain tiers.

2.2 Causes of FLW along the supply chain

The available scientific literature confirms that food is wasted throughout the entire food supply chain, from upstream agricultural production processes to the final household consumption phase. In low-income countries, food is generally lost during the production-to-processing stages of the food supply chain (Gustavsson *et al.*, 2011). Food loss occurring at harvesting phase are primarily caused by climatic and environmental factors (Parfitt *et al.*, 2010). Moreover, in emerging and some developed countries, the urgent need for food or income may result in premature harvesting during which food can be lost (Gustavsson *et al.*, 2011). Post-harvest losses are attributable to the available technology in a country, poor storage facilities, lack of the necessary infrastructures (Rolle, 2006; Stuart, 2009) and compliance with standards and regulations (Parfitt *et al.*, 2010).

Food is also lost during processing due to spoilage along the production line, technical limits and lack of processing facilities, above all in developing countries. Furthermore, food loss is also caused by re-trimming carried out during the processing phase to ensure that the final product is of the right shape and size. (Stuart, 2009; SEPA, 2008).

At retail level, inadequate market systems in developing countries (Kader, 2004), high "external quality standards" for fresh produce required by supermarkets (Stuart, 2009; Cicatiello *et al.*, 2019; Secondi *et al.*, 2019b) and the number of products that remain unsold because they reach their "sell-by" date before being sold (SEPA, 2008) generate a large amount of food waste.

At consumer level, the over purchases of food, consumers' bad habits and behavior lead to high levels of food waste in industrialized countries (Stuart, 2009; Quested *et al.*, 2013; Secondi *et al.*, 2015; Principato, 2018; Secondi, 2019; Principato *et al.*, 2020, 2021).

Despite acknowledging the importance of following a supply chain perspective to investigate food loss and waste, literature fails to provide us with a comprehensive understanding of broader supply chain initiatives aimed at reducing and reusing FLW. In fact, De Laurentiis *et al.* (2020) highlight that food waste prevention strategies are still in an early stage of development and to date there are no appropriate methods for assessing their effectiveness.

Most studies focus exclusively on investigating the causes of the food waste (Göbel *et al.*, 2015) and the related challenges (Gokarn and Kuthambalayan, 2017) and often offer generic solutions that still require validation. These solutions should be based on sharing responsibilities and improving coordination throughout the supply chain through collaborative approaches (Göbel *et al.*, 2015).

To date the main focus has been at consumer level, however more extensive analysis concerning the upstream tiers of the agri-food supply chain are required. In a recent literature review, Goossens *et al.* (2019) revealed that relatively few studies reported on the amount of food waste prevented by an intervention while environmental, economic, and social impacts of food waste prevention interventions are seldom evaluated and their efficiency rarely assessed, thus limiting the scope for comparing interventions, identifying trade-offs and prioritizing actions that have proven successful.

Therefore, it is necessary to gain a thorough understanding of the entire food supply chain and its impact on FLW, to set appropriate sustainability strategies and goals in each stage of the chain, as highlighted by León-Bravo *et al.* (2019). In line with Alamar *et al.* (2018), it is expected that an interdisciplinary approach involving supply chain management would be beneficial for tackling the issue of FLW.

Bearing in mind the research limitations found in literature, our first Research Question (RQ1) is:

RQ1. How are FLW generated and what are the underlying causes along the food supply chain?

2.3 Circular economy and supply chain management perspectives: the need of an integrated and joint strategy

Supply chain management research is still in its early stages as regards how to advance supply chain theories and practices by taking full advantage of the CE potential (Farooque *et al.*, 2019). The recent introduction of the CE model – promoted at both European and global levels – is based on an alternative cyclical flow model which does not affect or destabilize the sustainable development of our planet (European Commission, 2015, 2020; Schulze, 2016; Ruggieri *et al.*, 2016). As highlighted by Korhonen *et al.* (2018, p. 37), the CE approach "*emphasizes product, component and material reuse, remanufacturing, refurbishment, repair, cascading and upgrading as well as solar, wind, biomass and waste-derived energy utilization throughout the product value chain and cradle-to-cradle life cycle*". In short, CE includes all the activities aimed at reducing, reusing and recycling materials along the food supply chain (Murray *et al.*, 2017). Therefore, minimizing waste (including FLW) by transforming it into a new resource that can be used as a new manufacturing input and/or as a raw material for other purposes, such as animal feed (Schulze, 2016; Topi and Bilinska, 2017) is one of the most important CE objectives From this perspective, CE provides various opportunities for recycling resources and waste within closed-loop systems (Mohan *et al.*, 2016; Romero-Hernández and Romero, 2018). As regards the CE framework, it is important to note that FLW management should follow a "waste management hierarchy" (Garcia-Garcia *et al.*, 2017; Ingrao *et al.*, 2018) by firstly preventing FLW generation and secondly, it by re-using inevitable FLW for human consumption or for to animal feed. FLW can also be recycled for industrial use, anaerobic digestion, composting and combustion for energy recovery and what remains can be landfilled. Consequently, following the CE pillars, waste management should not focus exclusively on waste prevention: since many types of FLW are unavoidable, FLW should be re-used and/or recycled to generate renewable energy and other materials (Jimenez-Rivero and García-Navarro, 2017; Valenti *et al.*, 2017a, b).

An increasing number of studies have recently focused on the effects of CE and supply chain perspectives on FLW. For instance, the Thünen Institute has actively investigated FLW quantification throughout the entire value chain in the context of the REFOWAS project [3]. Some studies have focused on food waste recovery and its transformation into energy (Ingrao *et al.*, 2018), while others have investigated the implementation of food sharing models aimed at food waste reduction without explicitly adopting a CE framework (Sarti *et al.*, 2017; Michelini *et al.*, 2018). Moreover, all of these studies only focused on food waste at retail and consumer levels and did not consider food losses. Contrastingly, Principato *et al.* (2019) and Secondi *et al.* (2019a) have recently initiated this research stream by analyzing specific supply chains (i.e., pasta and tomato sauce, respectively) and focusing mainly on the circular flow process of the intermediate and final outputs. A similar approach was used for investigating and mapping the tomato supply chain (Anastasiadis *et al.*, 2020).Therefore, the main studies available in the literature seem to focus more on FLW measurement while a more detailed understanding of organizational implications is still required.

However, when adopting a supply chain approach, it is essential to identify effective tools for measuring and analyzing FLW for determining its causes and proposing solutions for tackling food waste. Parfitt *et al.* (2010) highlighted the importance of gaining a better understanding of food waste at supply chain level and called for more accurate quantification and improved resource efficiency. Currently, supply chain management literature focused on food waste is still fragmented (Despoudi *et al.*, 2018) therefore an integrated approach for analyzing FLW throughout the entire supply chain is paramount.

In this perspective, Life-Cycle Analysis (LCA) (Roy *et al.*, 2009) considers the impact of waste throughout the entire life cycle of a product and the different stages of the supply chain. However, it is still not clear how to effectively implement LCA tools along the supply chain for

FLW analysis and reduction. Since 2013, the FLW protocol has been available and successfully used for the analysis of different case studies, as it provides a credible, practical, transparent, and internationally consistent basis for entities to account for and report on FLW. However, there are few examples of its application in academic literature (Principato *et al.*, 2019) which are mainly focused on quantitative measurement and a better understanding of the factors underlying its successful implementation is required.

Therefore, our second Research Question (RQ2):

RQ2. How can FLW identified at the supply chain level be effectively re-used according to a CE perspective?

3. Research design

3.1 Company selection and profile

With the aim of responding to our RQs, Barilla was selected as an exemplar case paying particular attention to its key supply chains. Barilla is widely recognized as one of Italy's leading food groups which has launched innovative supply chain management initiatives such as just-in-time distribution and continuous replenishment programs (Hammond, 1994). Barilla has focused on developing effective sustainability strategies through carefully planned implementation in line with the definition of "sustainability leader" provided by Formentini and Taticchi (2016), i.e. by adopting a structured sustainability strategy which focuses on the triple bottom line with an extended supply chain perspective. Some of Barilla's strategic supply chain sustainability initiatives have been reported in the literature, such as durum wheat supply chain contracts (Formentini *et al.*, 2016; Tang *et al.*, 2016).

Therefore, in this study a quantitative and qualitative FLW analysis was carried out on Barilla's soft wheat supply chain, thanks to the pioneering role played by Barilla in adopting novel approaches such as the FLW Accounting and Reporting Standard investigated in this study. Barilla's collaboration enabled us to investigate the implementation process in depth by granting us access to company reports, documentation as well as direct interaction with company representatives to improve transparency and the reliability of information.

Founded in 1877 in Parma, Barilla started its activity with a small bread and pasta store and today has become an iconic brand of the Italian food sector. Barilla is the leader in the pasta market in Italy and worldwide and controls the segment of ready sauces and offers also bakery products, that can be consumed for breakfast and snacks. The Group has become a leader due to the volume of its numerous types of products such as bakery products in Italy, soft bread in France and crisp bread in Scandinavian and Central-European countries. The Group operates in over 100 countries worldwide and has 30 production sites, 15 in Italy and 15 abroad, which in total produce over 2,099,000 tons of food products per year. In accordance with the results obtained from the Barilla Food and Nutrition Center (BFCN) Foundation studies and in line with its mission "Good for You, Good for the Planet" [4], Barilla has analyzed three of its supply chains (i.e., pasta, tomato sauce and soft wheat bread) in partnership with Last Minute Market (LMM), an accredited University of Bologna spin-off. Their objective was to evaluate the FLW along these supply chains and to determine their causes and potential FLW reduction activities.

Our analysis was structured in two different phases. Firstly, the generation of FLW was measured throughout the various phases of the supply chain by referring to the FLW Accounting and Reporting Standard and then by carrying out in-depth interviews with the aim of reviewing the implementation process, gaining valuable insights into FLW quantification as well as identifying the factors enabling organizational effectiveness and the key outcomes both at operational and strategic level.

3.2 The FLW Accounting and Reporting Standard

With the aim of defining and quantifying FLW throughout the soft wheat bread supply chain, we referred to the global FLW Accounting and Reporting Standard (hereinafter FLW standard) which was launched in 2013 (Hanson *et al.*, 2016). Indeed, the FLW standard "*is a global standard that provides requirements and guidance for quantifying and reporting on the weight of food and/or associated inedible parts removed from the food supply chain*" (Hanson *et al.*, 2016, p. 11) which was developed to support various actors (which include intergovernmental agencies, governments, industrial associations, companies and farmers) to prepare inventories in which a transparent and detailed FLW measurement is reported.

Five steps are required for implementing a FLW inventory following the guidelines recommended by the FLW standard:

(1) "*Goal definition*": the supply chain actor who is planning an inventory should explain why it is measuring FLW which may concern food security, economic results, environmental or social impacts or a mix of these goals.

(2) "*Accounting and reporting principles review*": as established by the FLW standard, the main principles for accounting and reporting (in terms of transparency, completeness, relevance, accuracy and consistency) must be followed for the effective implementation of the protocol.

(3) "*Scope definition*": as explained in depth in Table 1, it is necessary to clearly define the timeframe, the type(s) of material, destination(s) and the boundaries related to the FLW inventory.

1. Timeframe	The time period for which the inventory results are reported. It includes start and end dates
2. Material type(s)	This requires the clear distinction of material types removed from the process by differentiating into "food" and "inedible parts". "Food" refers to any substance (whether processed, semi-processed or raw) intended for human consumption. "Inedible parts" represent the components associated with food that are not intended for human consumption
3. Destination(s)	This refers to where the material removed from the food supply chain is redirected. The possible destination must be selected among 10 potential destinations: animal feed; biochemical processing/bio-based materials; anaerobic digestion/co-digestion; aerobic processes/composting; controlled combustion; land application; landfill; not harvested/plowed-in; refuse/discards/litter; biochemical processing wastewater/sewer treatment
4. Boundaries	(1) Food category: this defines the specific type of food included in the reported FLW by using the categories in the Codex General Standard for Food Additives (GSFA) system or the UN Centrale Production Classification (CPC). In addition, Global Product Category (GPC) and United Nations Standard Products and Service Code (UNSPSC) codes can be used (2) Lifecycle stage: this is related to the studied food chain stage(s) and for which inventory findings are described. The UN International Standard Classification of All Economic Activities (ISIC) codes are generally used (3) Geography: this is related to the geographical borders within which the reported FLW are generated. One or more UN regions or country codes can be adopted to identify specific countries or regions (4) Organizational unit: it demands to identify what specific organizational units (e.g. all sectors, entire firm, only selected business units) are responsible in the described FLW

Table 1.
FLW standard criteria

(4) "*FLW quantification method*": the method used for calculating the amount of FLW must be clearly defined irrespective of whether existing data are used or a new calculation is required. .

(5) "*Inventory results calculation*": after data collection and analysis, inventory results can be processed with the support provided by the FLW protocol.

In addition to these steps, the FLW standard requires three further procedures regarding the data collection process and performance review, for instance by carrying out an internal or external assurance process in order to ensure the accuracy and reliability of the FLW inventory (Hanson *et al.*, 2016).

The inventory implemented in accordance with the FLW protocol enables an actor to select which combination of material types and destinations can be considered "food loss and waste" according to the actor's declared aims. Consequently, the inventory presents and highlights the findings as a "standard credible, practical, transparent, and internationally consistent basis for entities to account for and report on FLW" (Hanson *et al.*, 2016, p. 5).

In order to apply the FLW standard successfully, the research team followed the structured action plan represented in Figure 1. The first step was to define the key actors to involve in the FLW study. Although this step may seem easy, a detailed knowledge and awareness of the internal and external roles is required in order to optimize the data collection process. As previously occurred for pasta and tomato supply chains, data collection was centrally managed by the head of Barilla's Health, Safety and Environment and Energy (HSEE) department who contacted the key respondents and supervised data aggregation. Subsequently the aggregated data were transferred to LMM so that the analysis and the implementation of the FLW standard could be carried out. The final step of the research process was to hold qualitative interviews in order to review and discuss the findings that emerged from the analysis.

As shown in Figure 1, quantitative data were mainly collected by Barilla G.&R. Fratelli S.p.A., which provided data and information related to steps of cultivation, milling, bread production, logistics/transportation while LMM provided data on retail distribution and consumption.

The following data related to the various stages of the "Pan Bauletto" soft wheat bread supply chain were collected in order to gain a detailed and comprehensive understanding of:

(1) Cultivation stage: research conducted by HORTA [5] was analyzed in order to obtain a summary of field loss, particularly during the harvesting stage. Average field loss

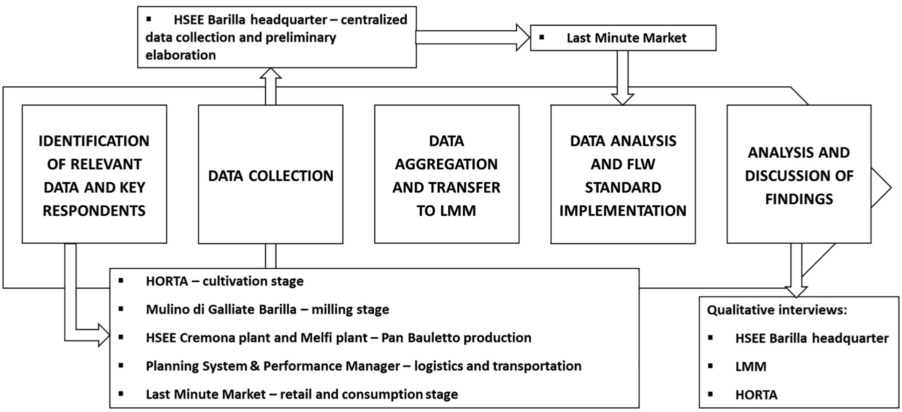

Figure 1.
Research process and key actors involved

was estimated by comparing various studies. In particular, we referred to 2011 FAO report on "Global Food Losses and Food Waste" (Gustavsson *et al.*, 2011) and to an internal study on loss in primary production by Barilla.

(2) Processing stage (milling and bread production): we referred to data provided by Barilla and by the Italian primary and secondary processing plants that were considered in our study. The primary processing data were collected from one mill while the secondary processing data were collected from two production plants. The data included information on internal inventories, logistics and transportation.

(3) Distribution: we referred to data provided by Italian retail establishments. The data were gathered by Last Minute Market by conducting a survey on 5 Italian large-scale retail and distribution brands involving 1,700 sales outlets located on Italian territory and ranging from small supermarkets to larger hypermarkets.

(4) Consumption: the data were obtained from an estimate carried out by Last Minute Market. The percentage was computed as the ratio between two data sources: domestic bread waste per capita provided by the Department of Agri-Food Sciences and Technologies of Bologna University (unpublished data) and the average bread consumption per capita in Italy provided by the National Coldiretti [6] confederation.

At the end of the research process, the research team interviewed the various actors involved in the process in-depth, i.e. Barilla's HSE&E (Health-Safety-Environment and Energy) department, HORTA and LMM in order to gain a detailed understanding of the activities and outcomes of this process. The interviews were conducted according to a semi-structured protocol in order to cover the main aspects of the FLW standard implementation process. The key elements of this protocol (available as additional material) are represented by:

(1) the detailed description of the FLW standard implementation process within the company in order to identify the main actors involved and their responsibilities; the principle activities performed during the implementation process and their duration; the key resources deployed in the implementation;

(2) the identification of the enabling factors and how they have facilitated the implementation process;

(3) the main barriers to the implementation process;

(4) the main results obtained thanks to the implementation of the FLW standard at different levels (strategic, operational)

(5) comparative performance evaluation of previous Barilla FLW implementations (e.g. improvements, unexpected results, etc.).

4. Results – FLW standard implementation

4.1 Definition of the scope

The scope of this FLW inventory is to measure the FLW generated in bread production by analyzing the life cycle of 1 Kg of soft wheat "Pan Bauletto" bread (Mulino Bianco – Barilla) produced in Italy. As highlighted in Figure 2, the total FLW generated by the production process amounts to 1,711 grams per 1,000 grams of soft wheat bread. Bearing in mind the distinction between food loss and food waste, it was observed that approximately 95% (corresponding to 1,626 grams) of the total FLW are lost during the cultivation, milling and bread production phases while, only 5% of the total FLW are generated in the distribution and consumption phases.

Product analysed: Pan Bauletto (Mulino Bianco – Barilla) produced in Italy.

Lifecycle stage(s): Entire food supply chain.

Total FLW: 1.71 Kg di FLW for 1kg of bread produced, of which:

- 95% (1,626 g) in cultivation, milling and bread production;
- 5% (85 g) in the distribution and consumption phase;

Figure 2.
Overall data

Moreover, when the total amount of FLW was divided into edible and inedible parts it was observed that approximately 91% of the total FLW was composed of inedible straw and milling co-products and waste. The remaining edible parts are represented by field loss, bread scraps unsold retail products and waste generated by final consumers, which account for approximately 9% of the total FLW (Figure 3a).

It is important to note that approximately 97.8% of the total FLW is valorized by other sectors while only around 2.2% is destined to landfill. Therefore, on comparing FLW in absolute terms by distinguishing between edible *versus* inedible, and valorized *versus* not valorized (Figure 3b), most of the overall edible parts are recovered and re-used in alternative sectors.

4.1.1 Timeframe. The study began in January 2019 and was completed in September 2019.

4.1.2 Material type. The total weight of the FLW was equal to 1,711 grams for 1,000 grams of bread produced. The total amount of FLW is obtained by adding 159 grams of foodstuff intended for human consumption – irrespectively of whether it is processed, semi-processed, or raw-to 1,552 grams of inedible parts referring to those components not intended to be for human consumption.

4.2 Destination of FLW

4.2.1 Destination. For "destinations" we intend where materials are directed when removed from the food supply chain, the details of which are shown in Table 2. Animal feed and energy recovery are the most frequent destinations.

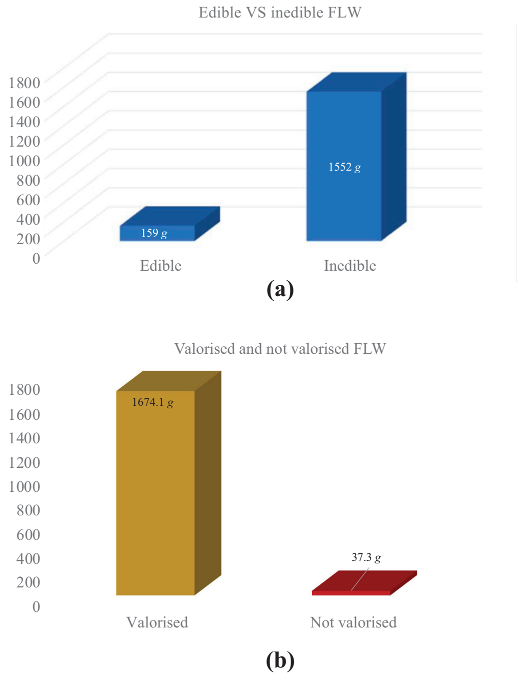

Figure 3.
(a) Edible and Inedible FLW; (b) valorized and not valorized FLW (amount of FLW in grams)

Table 2.
Destinations of waste

Destination	Weight of FLW (grams)	%
Human consumption	7.0 g	0.4%
Animal feed	593.2 g	34.7%
Composting/aerobic processes	36.0 g	2.1%
Landfill	37.3 g	2.2%
Not harvested/plowed-in	472.7 g	27.6%
Energy Recovery	565.2 g	33.0%
Total FLW	1,711.4 g	100%

4.2.2 Boundary. The boundaries of the FLW inventory were reported according to food category, lifecycle stage, geography and organization (see Table 3).

It is important to note that packaging and other non-FLW materials were excluded from the inventory results, which reflect the conditions under which the FLW was generated (i.e., before water is added or before intrinsic water weight of FLW is removed). Moreover, pre-harvest losses were also excluded from the inventory results as they were irrelevant for the purpose of this study.

A comprehensive overview of the FLW analysis is provided in Figure 4, in which destinations for each phase within the supply chain are highlighted by indicating the flows of primary raw and secondary (by-product) materials. The flow of primary raw materials starts with grain, followed by milling and then flour to bread production which is delivered to the distribution and consumption phases.

Contrastingly, the flow of secondary raw materials in each step of the supply chain is quite complicated and highlights the need for a circular supply chain approach. This is the case of straw and its co-products during the cultivation and milling phases which are used for energy recovery and animal feed, as well as bread scrap that are recovered for food banks and for producing animal feed. Indeed, food banks redistribute surplus food which are perfectly edible products that are then donated to charitable associations and to individuals and families in need. Ultimately, households are responsible for large amounts of FLW generated during the consumption phase.

4.3 Causes of food loss and waste

Table 4 summarizes the causes of FLW generated by bread production, starting from the cultivation phase up to final consumption. As regards wheat cultivation, straw is inevitably generated, however it will not be discarded and will be used for manufacturing animal feed and litter.

Table 3.
Boundary

Boundary	
Food category(ies)	Cereals Products – Not Ready to Eat (Shelf Stable) (GPC codes: 10000285)
Lifecycle stage(s)	Bread and other Bakery Products, except Cookies and Crackers (SIC Code, 2051)
Geography	Italy (UN code: 380)
Organization	All sectors in company

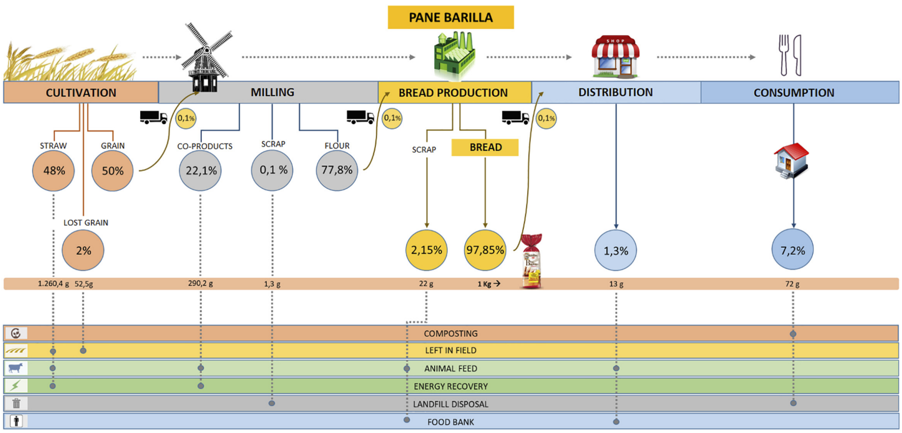

Figure 4.
Overview of FLW analysis at the supply chain level

Table 4.
FLW types and related causes

FLW type	Weight (g)	% FLW on the whole	FLW causes for bread supply chain
Cultivation-Straw	1260.4	73.6%	Physiological
Cultivation-Field losses	52.5	3.1%	Combine harvester failure
Milling-Wheat co-products	290.2	17%	Wheat pre-cleaning
Milling waste	1.3	Neg.	Wheat pre-cleaning
Bread production scraps	21.5	1.3%	Equipment cleaning
Bread production scraps	0.5	Neg.	Equipment cleaning
Retail unsold	13.00	0.8%	Damage
Consumption	72.00	4.2%	Expired, purchase higher than necessary
Total	1711.4	100.0%	

4.4 Inventory results

Table 5 shows FLW according to food category and lifecycle stages. As regards the edible FLW parts which only amount to 9.32% of the total FLW it was observed that FLW are mainly generated in the consumption stage. In fact, consumption accounts for 4.2% when total FLW are considered while it accounts approximately 45.1% if only the edible parts are considered.

During the primary and secondary production stages (i.e., milling and bread production), FLW only amount to 13.8% of the edible parts. All of the waste generated by the milling process is considered to be non-edible and the majority is valorized as animal feed. More importantly, almost all of the edible FLW parts generated during the production stage are re-used for other purposes, such as animal feed or donating them for human consumption. However, with the exception of the recycling of surplus household FLW for charitable purposes, most FLW are generally destined to landfill.

5. Discussion

5.1 The proposed decision-support tool

The entire lifecycle of Barilla's soft wheat bread supply chain was analyzed from field to table and it was observed that this value chain is an interesting CE model since almost nothing is wasted or lost and the value of resources is recovered through reuse and redistribution, as shown in Figure 4.

Lifecycle stage	Material type removed from food supply chain	Total all food categories (in grams)	% on total FLW	% on total edible part	Product (by-product) "obtained" at the end of each phase
1. Soft wheat cultivation	Food + associated inedible parts	1312.9	76.7%	–	–
	Food only	52.5	–	32.9%	Grain
	Inedible parts only	1260.4	–	–	–
2. Milling	Food + associated inedible parts	291.5	17.0%	–	–
	Food only	–	–	–	–
	Inedible parts only	291.5	–	–	–
3. Bread production	Food + associated inedible parts	22.0	1.3%	–	–
	Food only	22.0	–	13.8%	Bread
	Inedible parts only	–	–	–	–
4. Retail and markets	Food + associated inedible parts	13.0	0.8%	–	–
	Food only	13.0	–	8.2%	Bread
	Inedible parts only	–	–	–	–
5. Consumption	Food + associated inedible parts	72.0	4.2%	–	–
	Food only	72.0	–	45.1%	Bread
	Inedible parts only	–	–	–	–
TOTAL ALL LIFECYCLE STAGES	Food + associated inedible parts	1711.4	100%	100%	–
		of which	–	–	–
	Food only	159.5	9.32%	–	–
	Inedible parts only	1551.9	90.68%	–	–

Table 5. Inventory results

Our study provides valuable insights for advancing the literature on circular supply chain management, intended as "*the integration of circular thinking into the management of the supply chain and its surrounding industrial and natural ecosystems*" (Faaroque *et al.*, 2019, p. 884). As shown in Figure 3, the main contribution of our study is the detailed analysis of FLW from a supply chain perspective by using the FLW standard as a means to link a LCA approach with specific quantitative indicators. This supply chain perspective provides the basis for adopting CE concepts for the reuse and distribution of FLW.

Although edible parts can be lost at every stage of the bread supply chain, in line with existing literature (Gustavsson *et al.*, 2011), this study – in response to our RQ1 - confirms that most waste occurs during the cultivation and consumption stages therefore quantifying agricultural, agri-industrial waste and food waste which represent biomass streams that can be used as renewable energy sources may contribute to reducing our current dependence on fossil fuels (Volpe *et al.*, 2016). The edible parts lost during milling and bread production amounted to approximately 13.8% on the total edible parts. However, our study has revealed that the greatest wastage of edible products occurs in the distribution and consumption phases, which amounted approximately to 53.3% of the total edible parts.

These results enabled us to define a decision support tool through which companies can select appropriate CE practices aimed at reducing, reusing and recycling FLW which would result in more transparent reporting and disclosure. A further contribution of our study is represented by the qualitative analysis of the implementation process of the FLW standard obtained by holding in-depth interviews with Barilla's HSE&E specialists together with the HORTA and LMM actors for the specific analysis of field/cultivation, consumption data collection and processing. To the best of our knowledge, this is one of the first studies to discuss the organizational factors required to successfully apply the FLW standard and lay the foundations for obtaining a more detailed understanding of CE implementation from a supply chain perspective.

By merging both qualitative and quantitative information – therefore addressing our RQ2 – we developed the decision support tool described in Figure 5 which includes the key aspects emerging from our findings.

As shown in Figure 5, the main factors that enabled and supported Barilla's implementation of the FLW standard are represented by the supply chain manager competences and the knowledge gained in previous FLW protocol implementation cases (Principato *et al.*, 2019; Secondi *et al.*, 2019a).

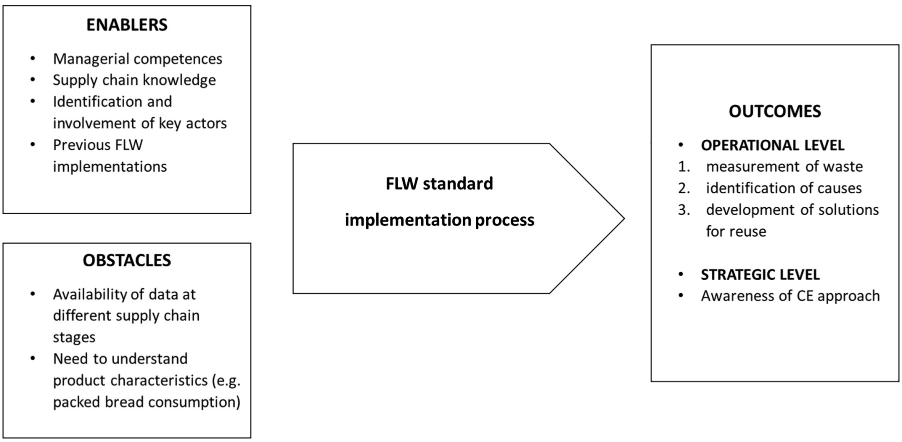

Figure 5.
Decision-support tool for the analysis of the FLW standard implementation process

The implementation of FLW protocol "*has been facilitated by the identification of the appropriate respondents to involve in data collection which accelerated the collection process and guaranteed the reliability of data sources. Moreover, the process has been simplified thanks to the availability of several information systems available in the company (i.e., production waste, transportation phase and overall internal data collection system)*".

According to the HSE&E perspective, another key enabling factor is represented by the participation of "*Last Minute Market (LMM) and its continuous support, on the basis of its experience developed in other studies on FLW along various supply chains. The implementation of the FLW protocol in the Pan Bauletto supply chain has been optimized and facilitated thanks to the support and the experience of the LMM in applying the FLW Standard in the pasta and tomato supply chains*".

Moreover, "*the previous applications of the FLW standard by Barilla lead to the optimization of the implementation process, especially in accelerating data collection. The previously developed awareness and competences enabled us to rapidly identify the most appropriate actors to involve and to ask more targeted questions. In general, the entire implementation process was faster and more reliable*" as confirmed by the HSE&E division.

Contrastingly, there were two main obstacles in the implementation process: the availability of data at various stages of the supply chain stages and the specific characteristics of the analyzed product (i.e., packed bread).

As regards data collection in the cultivation stage, since soft wheat primary data were not available, Barilla relied on the link between HORTA and its President and Founder. As the President of HORTA confirmed in our in-depth interview "*it was possible to include data from previous scientific studies (. . .) thanks to the experience in field analysis acquired by HORTA and the long-standing collaboration between HORTA and Barilla*". More specifically "*bibliographic information was used for field losses which were HORTA confirmed with some on-field measurements concerning both durum and soft grain wheat with the aim of quantifying losses caused by ordinary management and not by extraordinary atmospheric events*". Although it may seem to be a limitation, the reliability between the bibliographic (secondary) sources and the HORTA direct (on-field) partial measurements represents another novelty of the study and an opportunity for future improvements.

In contrast to the pasta and tomato supply chains, as regards the data collection at the consumption stage, that the interviews suggested that "*the quantification of waste in the consumption stage is more complex, since it is difficult to compare and differentiate the consumption of fresh bread and packed bread*". *The company faced this challenge by adhering to previous research performed by LMM which successfully estimated the waste percentage at the consumption stage on the basis of scientific models*".

5.2 Organizational, academic and managerial implications

Our tool for supporting decisions proposed in Figure 5 enabled us to illustrate the outcomes obtained at various levels.

At organizational level, Barilla highlighted the importance of the results obtained in this study, especially those concerning the need for a structured approach which is able to measure and minimize the amount of FLW and determine how it is valorized in line with the CE pillars. Bearing in mind our RQ2, the proposed FLW standard gives value to the company thanks to three main properties: (1) measurement of waste; (2) identification of causes (an opportunity to connect with specific risk identification techniques); (3) finding solutions for recycling and reuse and discussing the impact for improvement FLW management.

Our findings on bread production lifecycles, showed that the FLW occurring along this production chain can be effectively reused for other purposes, thus providing us with valuable operational insights on the application of CE pillars aimed at reducing FLW.

FLW standard outcomes are also important from a strategic perspective. In fact, Barilla implements specific projects aimed at improving food waste awareness at household level which is one of the key areas of significant food waste creation, as highlighted in this study.

From an academic point of view, this study also provides a contribution to sustainable supply chain management literature (Formentini and Taticchi, 2016) as it provides valuable insights on the role of the supply chain in generating FLW and the implementation of a specific accounting and reporting method. This aspect represents an important governance mechanism to translate a sustainability strategy into practice.

Reporting good CE implementation practices and initiatives may help researchers and practitioners to acquire new knowledge on CE sustainable business models (Kirchherr *et al.*, 2017) and on responsible consumption and production patterns. Moreover, researchers should continue to provide and share interesting results obtained by applying CE concepts (Reike *et al.*, 2018) thus supporting firms in their FLW reduction.

In this way a stronger relationship is formed between sustainable supply chain management and CE literature on circular supply chain management, which is in line with the recommendations proposed by Faaroque *et al.* (2019).

We believe our study also offers useful advice for company managers who wish to apply the FLW standard thus facilitating its diffusion as a tool for food waste reduction. In this light, our decision support tool provides the basis for the effective and systematic implementation of the FLW standard, thus assisting companies to include more sustainable and circular processes in their supply chains. By adopting our decision support tool, managers will be able to identify the key enablers and obstacles and to adopt the FLW standard with a more focused approach in order to take specific actions towards reusing and redistributing valuable food resources in line with CE pillars.

The results obtained by empirical studies represent an important knowledge base for policymakers and companies that should concentrate their efforts on identifying better and shorter loop retention options, like remanufacturing, refurbishing and repurposing taking into account feasibility and overall system effects (Reike *et al.*, 2018). Our study provides valuable insights on the implementation process as it facilitates and supports the application of the FLW standard in other food supply chains.

6. Conclusions

This study focused on Barilla's soft wheat bread supply chain, with the aim of quantifying FLW throughout the entire food chain and identifying the causes using the FLW Accounting and Reporting Standard emphasizing its reuse potential in line with the CE perspective.

As regards the limitations of this study, the issues involved in collecting data at various supply chain stages have been discussed by relying on scientific data provided by HORTA. It is hoped that our decision support framework will help practitioners and researchers to identify reliable sources of data in future applications of the FLW standard.

In the future scholars should continue to analyze diverse food production chains and report on good practices and initiatives in production processes adopting circular approaches, in line with the circular supply chain perspective proposed by Farooque *et al.* (2019). Moreover, future studies on other food supply chains may help us to acquire further knowledge which can be used to strengthen, support, adapt and refine methodologies for measuring and quantifying FLW thus giving companies the opportunity to become "sustainability leaders" (Formentini and Taticchi, 2016) and facilitate the achievement of the UN Sustainable Development Goal n. 12.3.

We believe that interesting area for future research which can enhance our contribution could be to investigate digital transformation and "data-driven" food supply chains (Zhong *et al.*, 2017). Adopting new technologies, such as Internet of Things (IoT) (Yadav *et al.*, 2020) could lead to the development of effective FLW measurement and accounting methods to drive company engagement towards more circular supply chains.

Notes

1. https://sustainabledevelopment.un.org/
2. Quantitative data were integrated and processed by the University of Bologna's spin-off Last Minute Market.
3. www.refowas.de
4. www.goodforyougoodfortheplanet.org
5. Available on request.
6. https://www.coldiretti.it/coldiretti-it/consumi-coldiretti-svolta-a-tavola-giu-pane-e-pasta-vola-riso

References

Alamar, M.D.C., Falagán, N., Aktas, E. and Terry, L.A. (2018), "Minimising food waste: a call for multidisciplinary research", *Journal of the Science of Food and Agriculture"*, Vol. 98 No. 1, pp. 8-11.

AL-Dalaeen, Q.R., Sivarajah, U. and Irani, Z. (2021), "Determining sustainability key performance indicators for food loss reduction", *Journal of Enterprise Information Management*, Vol. 34 No. 3, pp. 733-745, doi: 10.1108/JEIM-04-2021-424.

Anastasiadis, F., Apostolidou, I. and Michailidis, A. (2020), "Mapping sustainable tomato supply chain in Greece: a framework for research", *Foods*, Vol. 9 No. 5, p. 539.

Barreiro-Gen, M. and Lozano, R. (2020), "How circular is the circular economy? Analysing the implementation of circular economy in organisations", *Business Strategy and the Environment*, Vol. 29 No. 8, pp. 3484-3494.

Bassi, F. and Dias, J.G. (2019), "The use of circular economy practices in SMEs across the EU", *Resources, Conservation and Recycling*, Vol. 146, pp. 523-533.

Beckmann, A., Sivarajah, U. and Irani, Z. (2020), "Circular economy versus planetary limits: a Slovak forestry sector case study", *Journal of Enterprise Information Management*, December, doi: 10.1108/JEIM-03-2020-0110.

Champions 12.3 (2018), "Road map to achieving SDG target 12.3", available at: https://champions123.org/wpcontent/uploads/2018/09/18_WP_Champions_ProgressUpdate_final.pdf (accessed 29 June 2020).

Cicatiello, C., Secondi, L. and Principato, L. (2019), "Investigating consumers' perception of discounted suboptimal products at retail stores", *Resources*, Vol. 8 No. 3, p. 129.

Ciccullo, F., Cagliano, R., Bartezzaghi, G. and Perego, A. (2021), "Implementing the circular economy paradigm in the agri-food supply chain: the role of food waste prevention technologies", *Resources, Conservation and Recycling*, Vol. 164, 105114.

Corrado, S., Caldeira, C., Eriksson, M., Hanssen, O.J., Hauser, H.E., van Holsteijn, F. and Stenmarck, Å. (2019), "Food waste accounting methodologies: challenges, opportunities, and further advancements", *Global Food Security*, Vol. 20, pp. 93-100.

De Laurentiis, V., Caldeira, C. and Sala, S. (2020), "No time to waste: assessing the performance of food waste prevention actions", *Resources, Conservation and Recycling*, Vol. 161, 104946.

Despoudi, S., Papaioannou, G., Saridakis, G. and Dani, S. (2018), "Does collaboration pay in agricultural supply chain? An empirical approach", *International Journal of Production Research*, Vol. 56 No. 13, pp. 4396-4417.

Dora, M. (2019), "Collaboration in a circular economy: learning from the farmers to reduce food waste", *Journal of Enterprise Information Management*, Vol. 33 No. 4, pp. 769-789.

European Commission (2015), *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Closing the Loop—An EU Action Plan for the Circular Economy 2015*, European Commission, Brussels, Belgium.

European Commission (2020), *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A New Circular Economy Action Plan. For a Cleaner and More Competitive Europe*, European Commission, Brussels, Belgium.

Food and Agriculture Organization of the United Nations (FAO) (2013), *Food Wastage Footprint: Impacts on Natural Resources: Summary Report*, FAO, available at: http://www.fao.org/docrep/018/i3347e/i3347e.pdf (accessed 29 June 2020).

Farooque, M., Zhang, A., Thürer, M., Qu, T. and Huisingh, D. (2019), "Circular supply chain management: a definition and structured literature review", *Journal of Cleaner Production*, Vol. 228, pp. 882-900.

Formentini, M. and Taticchi, P. (2016), "Corporate sustainability approaches and governance mechanisms in sustainable supply chain management", *Journal of Cleaner Production*, Vol. 112, pp. 1920-1933.

Formentini, M., Sodhi, M.S. and Tang, C.S. (2016), "The evolution of Barilla's durum wheat supply chain contracts for triple bottom line benefits", *Organizing Supply Chain Processes for Sustainable Innovation in the Agri-Food Industry (Organizing for Sustainable Effectiveness)*, Vol. 5, pp. 109-126.

Garcia-Garcia, G., Woolley, E., Rahimifard, S., Colwill, J., White, R. and Needham, L. (2017), "A methodology for sustainable management of food waste", *Waste and Biomass Valorization*, Vol. 8 No. 6, pp. 2209-2227.

Göbel, C., Langen, N., Blumenthal, A., Teitscheid, P. and Ritter, G. (2015), "Cutting food waste through cooperation along the food supply chain", *Sustainability*, Vol. 7 No. 2, pp. 1429-1445.

Gokarn, S. and Kuthambalayan, T.S. (2017), "Analysis of challenges inhibiting the reduction of waste in food supply chain", *Journal of Cleaner Production*, Vol. 168, pp. 595-604.

Goossens, Y., Wegner, A. and Schmidt, T. (2019), "Sustainability assessment of food waste prevention measures: review of existing evaluation practices", *Frontiers in Sustainable Food Systems*, Vol. 3 No. 90, pp. 1-18.

Grizzetti, B., Pretato, U., Lassaletta, L., Billen, G. and Garnier, J. (2013), "The contribution of food waste to global and European nitrogen pollution", *Environmental Science and Policy*, Vol. 33, pp. 186-195.

Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R. and Meybeck, A. (2011), *Global Food Losses and Food Waste*, Food and Agriculture Organization of The United Nations, Rome, available at: http://www.fao.org/3/a-i2697e.pdf.

Halloran, A., Clement, J., Kornum, N., Bucatariu, C. and Magid, J. (2014), "Addressing food waste reduction in Denmark", *Food Policy*, Vol. 49, pp. 294-301.

Hammond, J.H. (1994), *Barilla SpA (A), Harvard Business School Case 694-046*, Boston, CA.

Hanson, C., Lipinski, B., Robertson, K., Dias, D., Gavilan, I., Gréverath, P., Fonseca, J., Van Otterdijk, R., Timmermans, T. and Lomax, J. (2016), "Food loss and waste accounting and reporting standard", available at: https://flwprotocol.org/wp-content/uploads/2017/05/FLW_Standard_final_2016.pdf (accessed 29 June 2020).

Ingrao, C., Faccilongo, N., Di Gioia, L. and Messineo, A. (2018), "Food waste recovery into energy in a circular economy perspective: a comprehensive review of aspects related to plant operation and environmental assessment", *Journal of Cleaner Production*, Vol. 184, pp. 869-892.

Jaeger, B. and Upadhyay, A. (2020), "Understanding barriers to circular economy: cases from the manufacturing industry", *Journal of Enterprise Information Management*, Vol. 33 No. 4, pp. 729-745, doi: 10.1108/JEIM-02-2019-0047.

Jiménez-Rivero, A. and García-Navarro, J. (2017), "Best practices for the management of end-of-life gypsum in a circular economy", *Journal of Cleaner Production*, Vol. 167, pp. 1335-1344.

Kader, A.A. (2004), "Increasing food availability by reducing postharvest losses of fresh produce", *V International Postharvest Symposium 682*, pp. 2169-2176.

Kirchherr, J., Reike, D. and Hekkert, M. (2017), "Conceptualizing the circular economy: an analysis of 114 definitions", *Resources, Conservation and Recycling*, Vol. 127, pp. 221-232.

Korhonen, J., Honkasalo, A. and Seppälä, J. (2018), "Circular economy: the concept and its limitations", *Ecological Economics*, Vol. 143, pp. 37-46.

Lahane, S., Kant, R. and Shankar, R. (2020), "Circular supply chain management: a state-of-art review and future opportunities", *Journal of Cleaner Production*, Vol. 258, 120859.

León-Bravo, V., Caniato, F. and Caridi, M. (2019), "Sustainability in multiple stages of the food supply chain in Italy: practices, performance and reputation", *Operations Management Research*, Vol. 12, pp. 40-61, doi: 10.1007/s12063-018-0136-9.

Michelini, L., Principato, L. and Iasevoli, G. (2018), "Understanding food sharing models to tackle sustainability challenges", *Ecological Economics*, Vol. 145, pp. 205-217.

Mohan, S.V., Modestra, J.A., Amulya, K., Butti, S.K. and Velvizhi, G. (2016), "A circular bioeconomy with biobased products from CO2 sequestration", *Trends in Biotechnology*, Vol. 34 No. 6, pp. 506-519.

Murray, S. and Koehring, S. (2018), *Fixing Food 2018: Best Practices towards the Sustainable Development Goals*, The Economist Intelligence Unit, and Parma: Barilla Centre for Food and Nutrition, London, available at: https://www.barillacfn.com/en/publications/fixing-food-2018/ (accessed 29 May 2021).

Murray, A., Skene, K. and Haynes, K. (2017), "The circular economy: an interdisciplinary exploration of the concept and application in a global context", *Journal of Business Ethics*, Vol. 140 No. 3, pp. 369-380.

Parfitt, J., Barthel, M. and Macnaughton, S. (2010), "Food waste within food supply chains: quantification and potential for change to 2050", *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol. 365 No. 1554, pp. 3065-3081.

Principato, L., Ruini, L., Guidi, M. and Secondi, L. (2019), "Adopting the circular economy approach on food loss and waste: the case of Italian pasta production", *Resources, Conservation and Recycling*, Vol. 144, pp. 82-89.

Principato, L. (2018), *Food Waste at Consumer Level: A Comprehensive Literature Review*, Springer, Cham.

Principato, L., Mattia, G., Di Leo, A. and Pratesi, C.A. (2021), "The household wasteful behaviour framework: a systematic review of consumer food waste", *Industrial Marketing Management*, Vol. 93, pp. 641-649.

Principato, L., Secondi, L., Cicatiello, C. and Mattia, G. (2020), "Caring more about food: the unexpected positive effect of the Covid-19 lockdown on household food management and waste", *Socio-Economic Planning Sciences*, 100953.

Quested, T.E., Marsh, E., Stunell, D. and Parry, A.D. (2013), "Spaghetti soup: the complex world of food waste behaviours", *Resources, Conservation and Recycling*, Vol. 79, pp. 43-51.

Reike, D., Vermeulen, W.J. and Witjes, S. (2018), "The circular economy: new or refurbished as CE 3.0?—Exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options", *Resources, Conservation and Recycling*, Vol. 135, pp. 246-264.

Rolle, R.S. (2006), "Improving postharvest management and marketing in the Asia-Pacific region: issues and challenges", *Postharvest Management of Fruit and Vegetables in the Asia-Pacific Region*, Vol. 1 No. 1, pp. 23-31, APO, ISBN: 92-833-7051-1.

Romero-Hernández, O. and Romero, S. (2018), "Maximizing the value of waste: from waste management to the circular economy", *Thunderbird International Business Review*, Vol. 60 No. 5, pp. 757-764.

Roy, P., Nei, D., Orikasa, T., Xu, Q., Okadome, H., Nakamura, N. and Shiina, T. (2009), "A review of life cycle assessment (LCA) on some food products", *Journal of Food Engineering*, Vol. 90 No. 1, pp. 1-10.

Ruggieri, A., Braccini, A.M., Poponi, S. and Mosconi, E.M. (2016), "A meta-model of inter-organisational cooperation for the transition to a circular economy", *Sustainability*, Vol. 8 No. 11, p. 1153.

Sarti, S., Corsini, F., Gusmerotti, N.M. and Frey, M. (2017), "Food sharing: making sense between new business models and responsible social initiatives for food waste prevention", *Economics and Policy of Energy and the Environment*, Vols 1-2, pp. 123-134.

Schulze, G. (2016), *Growth within: A Circular Economy Vision for a Competitive Europe*, Ellen MacArthur Foundation and the McKinsey Center for Business and Environment, Chicago, pp. 1-22.

Secondi, L. (2019), "Expiry dates, consumer behavior, and food waste: how would Italian consumers react if there were no longer 'best before' labels?", *Sustainability*, Vol. 11 No. 23, p. 6821.

Secondi, L. (2021), "A regression-adjustment approach with control-function for estimating economic benefits of targeted circular economy practices: evidence from European SMEs", *Studies of Applied Economics*, Vol. 39 No. 3, pp. 1-13.

Secondi, L., Principato, L. and Laureti, T. (2015), "Household food waste behaviour in EU-27 countries: a multilevel analysis", *Food Policy*, Vol. 56, pp. 25-40.

Secondi, L., Principato, L., Ruini, L. and Guidi, M. (2019a), "Reusing food waste in food manufacturing companies: the case of the tomato-sauce supply Chain", *Sustainability*, Vol. 11 No. 7, p. 2154.

Secondi, L., Principato, L. and Mattia, G. (2019b), "Can digital solutions help in the minimization of out-of-home waste? An analysis from the client and business perspective", *British Food Journal*, Vol. 122, pp. 1341-1359.

Sehnem, S., Jabbour, C.J.C., Pereira, S.C.F. and de Sousa Jabbour, A.B.L. (2019), "Improving sustainable supply chains performance through operational excellence: circular economy approach", *Resources, Conservation and Recycling*, Vol. 149, pp. 236-248.

SEPA (2008), *Svinn I Livsmedelskedjan – Möjligheter till Minskade Mängder*, Swedish Environmental Protection Agency, Bromma, ISBN: 978-91-620-5885-2.

Stuart, T. (2009), *Waste: Uncovering the Global Food Scandal*, WW Norton & Company, London.

Tang, C.S., Sodhi, M.S. and Formentini, M. (2016), "An analysis of partially-guaranteed-price contracts between farmers and agri-food companies", *European Journal of Operational Research*, Vol. 254 No. 3, pp. 1063-1073.

Teigiserova, D.A., Hamelin, L. and Thomsen, M. (2020), "Towards transparent valorization of food surplus, waste and loss: clarifying definitions, food waste hierarchy, and role in the circular economy", *Science of the Total Environment*, Vol. 706, 136033.

Topi, C. and Bilinska, M. (2017), "The economic case for the circular economy: from food waste to resource", in *Food Waste Reduction and Valorisation*, Springer, Cham, pp. 25-41.

Tseng, M.L., Chiu, A.S., Liu, G. and Jantaralolica, T. (2020), "Circular economy enables sustainable consumption and production in multi-level supply chain system", *Resources, Conservation and Recycling*, Vol. 154, 104601.

Ünal, E., Urbinati, A. and Chiaroni, D. (2019), "Managerial practices for designing circular economy business models: the case of an Italian SME in the office supply industry", *Journal of Manufacturing Technology Management*, Vol. 30 No. 3, pp. 561-589.

United Nations General Assembly (2015), *Transforming Our World: The 2030 Agenda for Sustainable Development*, Division for Sustainable Development Goals, New York, NY.

Valenti, F., Porto, S.M.C., Chinnici, G., Cascone, G. and Arcidiacono, C. (2017a), "Assessment of citrus pulp availability for biogas production by using a GIS-based model: the case study of an area in southern Italy", *Chemical Engineering Transactions*, Vol. 58, pp. 529-534.

Valenti, F., Porto, S.M., Cascone, G. and Arcidiacono, C. (2017b), "Potential biogas production from agricultural by-products in Sicily. A case study of citrus pulp and olive pomace", *Journal of Agricultural Engineering*, Vol. 48 No. 4, pp. 196-202.

Vargas-Lopez, A., Cicatiello, C., Principato, L. and Secondi, L. (2021), "Consumer expenditure, elasticity and value of food waste: a quadratic almost ideal demand system for evaluating changes in Mexico during COVID-19", *Socio-Economic Planning Sciences*, 101065.

Volpe, R., Messineo, A. and Millan, M. (2016), "Carbon reactivity in biomass thermal breakdown", *Fuel*, Vol. 183, pp. 139-144.

Walker, A.M., Vermeulen, W.J., Simboli, A. and Raggi, A. (2020), "Sustainability assessment in circular inter-firm networks: an integrated framework of industrial ecology and circular supply chain management approaches", *Journal of Cleaner Production*, Vol. 286 No. 1, 125457.

Winkler, T. and Aschemann, R. (2017), "Decreasing greenhouse gas emissions of meat products through food waste reduction. A framework for a sustainability assessment approach", in *Food Waste Reduction and Valorisation*, Springer, Cham, pp. 43-67.

Xu, F., Li, Y., Ge, X., Yang, L. and Li, Y. (2018), "Anaerobic digestion of food waste–challenges and opportunities", *Bioresource Technology*, Vol. 247, pp. 1047-1058.

Yadav, S., Garg, D. and Luthra, S. (2020), "Development of IoT based data-driven agriculture supply chain performance measurement framework", *Journal of Enterprise Information Management*, Vol. 34 No. 1, pp. 292-327.

Zhong, R.Y., Tan, K. and Bhaskaran, G. (2017), "Data-driven food supply chain management and systems", *Industrial Management and Data Systems*, Vol. 117 No. 9, pp. 1779-1781.

Corresponding author
Luca Secondi can be contacted at: secondi@unitus.it