The value of food waste: an exploratory study on retailing

Clara Cicatiello
Research Assistant at the Department of Economics and Management
Università degli Studi della Tuscia, via del Paradiso 42, Viterbo, Italy
cicatiello@unitus.it - corresponding author
Tel. +39 761 357893

Silvio Franco
Professor at the Department of Economics and Management
Università degli Studi della Tuscia, via del Paradiso 42, Viterbo, Italy
franco@unitus.it
Tel. +39 761 357891

Barbara Pancino
Assistant Professor at the Department of Economics and Management, Università degli Studi della Tuscia, via del Paradiso 42, Viterbo, Italy
bpancino@unitus.it

Emanuele Blasi
Assistant Professor at the Department for Innovation in Biological, Agro-food and Forest systems, Università degli Studi della Tuscia, via san Camillo de Lellis snc, Viterbo, Italy
e.blasi@unitus.it

The value of food waste: an exploratory study on retailing

1. Introduction

In the food sector, waste is a major social, nutritional and environmental issue, affecting the sustainability of the food chain as a whole. In the EU alone, we waste 90 million tons of food every year, i.e. 180 kg per person (EC, 2011a). This is due, firstly, to climate and biological factors beyond the control of man and, secondly, to the behaviour of food chain participants, including all the operations concerning the food management at the stage of retailers.

Some of the products wasted simply cannot be consumed, as they are not fit for human consumption and thus they must be considered "losses" in all respects. Instead, others are still suitable for human consumption (Segré and Falasconi, 2011). Halving this edible waste is one of the goals in the Roadmap to a Resource-Efficient Europe, not least because the food value chain in the EU is responsible for 17% of Europe's direct greenhouse gas emissions and 28% of its material resource use (EC, 2011a). In order to prevent and reduce food wastage, the European Parliament declared 2014 the European Year against Food Waste, inspired by Last Minute Market[1] and its campaign "One year against waste".

The literature on food waste has so far focused on the quantification of the total food losses along the supply chain (Buzby and Hyman, 2012; Parfitt et al., 2010; Griffin et al., 2009) to highlight the negative implications of this phenomenon as well as its impact on the whole food system as a whole (Sonnino and McWilliam, 2011). However, the retail stage has long been neglected by such studies, although its contribution in limiting the implication of food waste might be consistent and, at the same time, sustainability is becoming an important business issue for retailers, as their practices may influence the whole supply chain process and its economic, environmental and social consequences (Claro et al., 2013).

This paper attempts to fill part of this research gap, by focusing on the extent of food waste at the retail stage of the supply chain. The aim of the research is to assess the impact of the food wasted in the retail stage, moving from the evidences of a case study in Central Italy. Namely, drawing from data collected during a project aiming to recover food waste for human consumption, we analysed the food waste at a supermarket by assessing its environmental, social and economic value.

To this purpose, the paper will first discuss the definition of food waste in order to clearly recognize, from a conceptual point of view, the proportion of food losses suitable for recovery. Then, we will focus on retailing, by analysing the state-of-the-art of the knowledge about food waste at this stage of the supply chain. In the empirical section of the paper, we will describe the design and implementation of a food recovery project in an Italian supermarket and, drawing on the data collected in this case study, we will perform an evaluation of the value of the food wasted at the supermarket. Such evaluation will encompass economic outcomes as well as the social and environmental impacts arising from the recovery process. These results, highlighting the scale and the causes of the food waste phenomenon at retailing stage, allow to draw some preliminary conclusions on the possible actions to be undertaken to reduce its dimension and potential impacts.

2. Background

2.1 Food waste: definition, causes and strategies for prevention

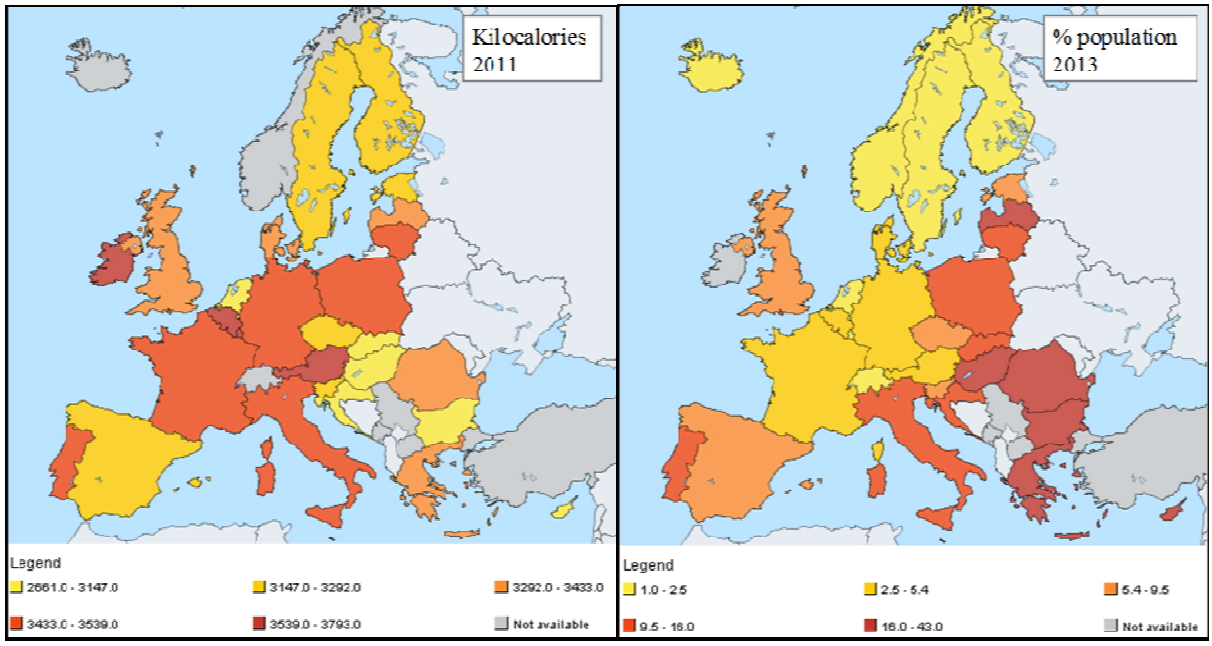
The growing concerns about hunger, preservation of the environment and the economic crisis have raised public awareness of food waste (Buzby and Hyman, 2012; Kantor, 1997). As several authors now assert, there is a need to investigate the social and environmental implications of waste at different stages of the

[1] Last Minute Market is a spin-off of the University of Bologna, Italy, whose aim is to reduce waste at all stages of the food chain. To do so, it promotes projects and campaigns to help firms and public administration to reduce waste. www.lastminutemarket.it

supply chain. Indeed, food waste has an impact on food security, on food quality and safety, on economic development and on the environment (Gustavsson et al., 2011).

Moreover, from an ethical perspective, food waste represents a great paradox. Figure 1a displays the average daily calorie supply per capita in European countries, showing that it greatly exceeds the actual needs of the people. Indeed, quite a large quota of this food supply is not used for feeding people, but it is wasted in different stages of the food chain. At the same time, the ranks of the poor are increasing, along with the quota of the people who are not able to provide for their basic needs (Figure 1b). This means that, even in developed countries, while tons of food are wasted every day, there are many people who cannot afford to provide meals for themselves and their family. Italy, Poland, Portugal and Lithuania are the European countries where this paradox is most evident, i.e. the food supply greatly exceeds the needs of the people but, at the same time, there is a remarkable quota of the population living in extreme poverty conditions. Indeed, it is important to note that food insecurity is often determined by a lack of access (purchasing power and prices of food) rather than a supply problem (Gustavsson et al., 2011).

Figure 1 – Daily calorie supply per capita (a) vs. severely materially deprived people in Europe (b)



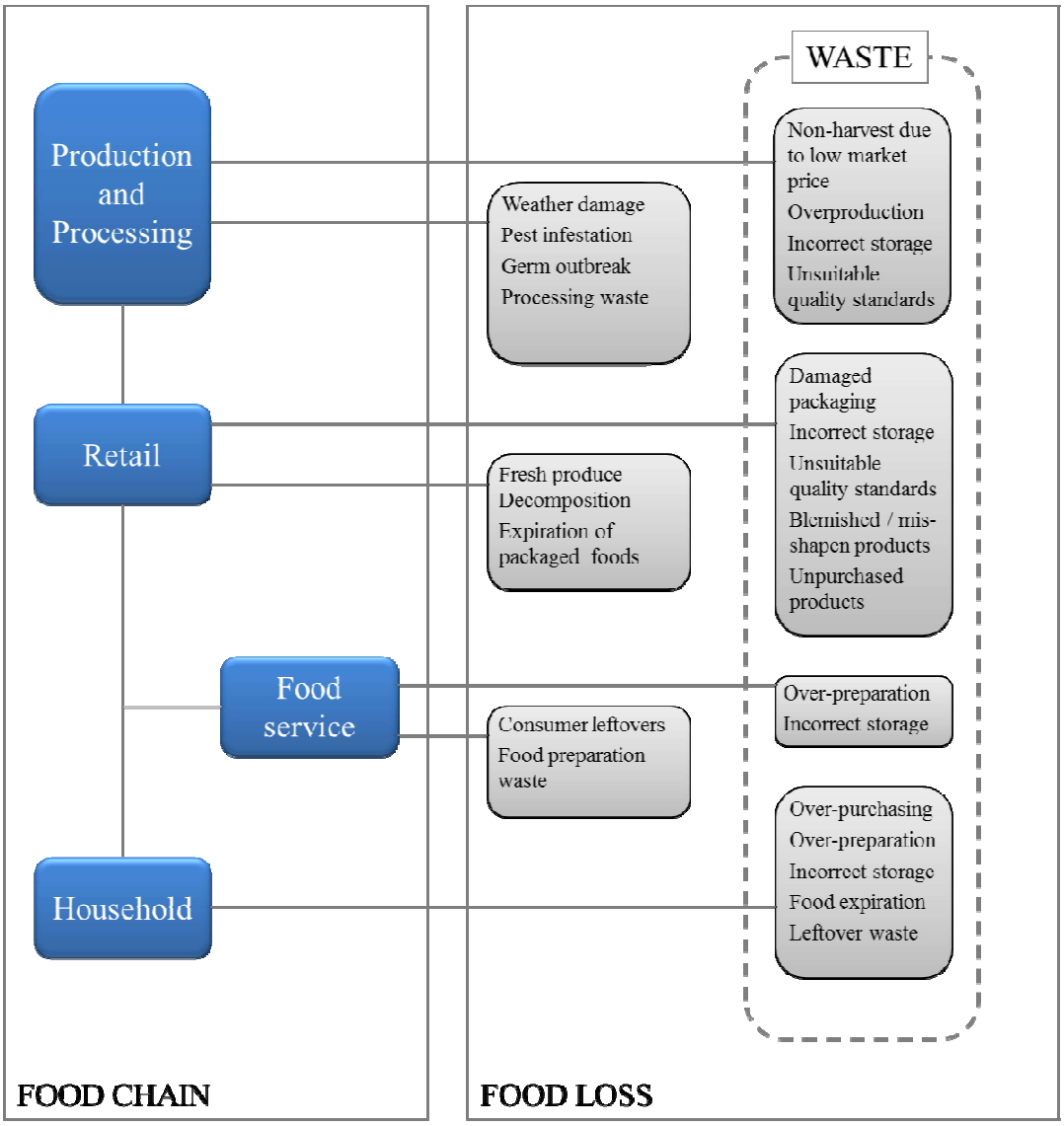
Source: Eurostat http://ec.europa.eu/eurostateurostat.eu

The causes of food waste are numerous and diverse, as they are highly influenced by both the local socio-economic context of a given country and the organization of its food system. In broad terms, the amount of food waste depends on crop production choices and patterns, the structure of the distribution channels, consumer purchasing behaviour and food use practices (Gustavsson et al., 2011). Buzby and Hyman (2012; p. 563) provide a comprehensive list of the causes of food waste at the three mains stages of the food chain, namely the production, retail and consumer levels. With the exception of a few (products damaged by insects, rodents, birds or microbes, losses due to unfavourable climate), all these causes may be traced to human intervention in the food chain, to how food is handled or marketed and to the consumption habits of people both at and outside the home (Sonnino and Mc William, 2011; Engstrom and Carlsson-Kanyama, 2004).

However, beyond the stage of the food chain where the food is lost, it must be understood that food waste is not all the same: in some cases the food is no longer suitable for consumption, thus it has to be thrown away or turned in different products (e.g. compost); in other cases it may no longer be consumed by humans but can still be used as animal feed; quite often, it is still suitable for human consumption (Kantor et al, 1997).

To this end, a clear definition of what has to be meant by food waste is crucial. Some authors have addressed this issue by differentiating between the two concepts of "food loss" and "food waste". Food loss can be defined as a qualitative or quantitative drop in the food supply due to a reduced nutrient value of the food or to a decrease in its weight or volume (Buzby and Hyman, 2012). When an edible item is lost due to these processes, food waste occurs. From this perspective, food waste only concerns edible items, and it is directly linked to human action or inaction (Bloom, 2010). Food waste can therefore be conceived as the result of decisions made by consumers, supply chain actors or other stakeholders, and it represents a subset of the total food losses (Buzby and Hyman, 2012).
Figure 2 displays a diagram where the main causes of food losses generated all along the food chain are listed; in the figure, the causes linked to human action (or inaction) are pointed out as they are linked to the generation of a waste of food items.

Figure 2 – Conceptual model on the food losses generated all along the food chain



Source: own elaboration

Food waste has a direct and negative economic impact on the income of both farmers and consumers, as well as on the environment. Concerning this latter point, wasting food entails the exploitation of resources used

all along the food life cycle such as land, water, energy and inputs (Buzby et al., 2011; Gustavsson et al., 2011; Hall et al., 2009). Serious consequences for the environment and the health of the community are also reported, such as through air pollution from decaying food, water pollution from runoff or leaching, and rapidly growing landfills (Griffin et al., 2009). Reducing food waste is thus a means for enhancing the overall sustainability of food systems (Sonnino and Mc William, 2011).

How can we reduce food waste? As we have seen, there are many causes of food waste, and each of them needs to be addressed individually, so as to build up a comprehensive strategy to face this problem. Several studies have tackled the strategies for food waste prevention and reduction. By comparing the main studies in this domain, we have produced the synthesis provided in Table 1. It summarises the possible strategies to act against the main causes of food waste at different stages of the supply chain.

As can be observed, despite some specific inefficiencies or malfunctions within the supply chain, many of the causes of food waste can be prevented through a greater awareness and information, both among consumers and the participants in the food chain. Knowledge of the possible uses of sub-standard products, the accurate handling of food products all along the food chain stages and a correct understanding of food labels by consumers should may greatly reduce the extent of food waste in production, retailing, food services and households.

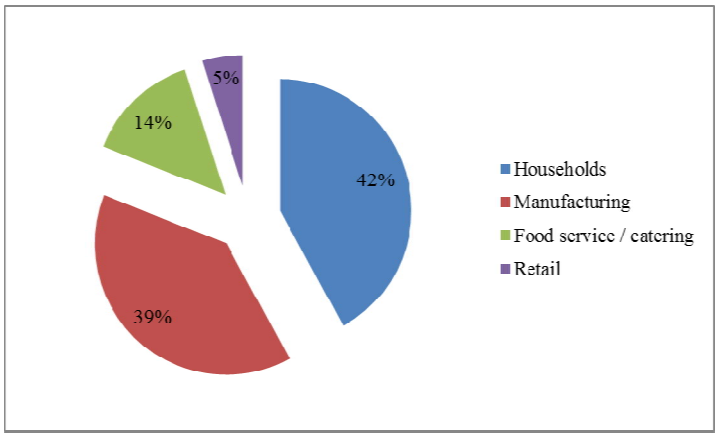
Some efforts have been made in this respect, through the promotion of programs aimed at fostering a cultural shift in the consumers' approach to food. Improved food labelling and innovative packaging that makes it possible to extend the shelf life of products (Parfitt et al., 2010), European initiatives such as the 2014 "Year against waste", efforts of companies like WRAP (www.wrap.org.uk) and Last Minute Market (www.lastminutemarket.it) to support institutions and food chain firms to reduce their food waste, are just a few examples of a wider movement against waste which is gaining interest and favour in the public opinion.

2.2 Food waste in retailing

Although the amount of food waste currently generated by retailers is considerable, it represents a minor fraction of all the food discarded along the supply chain. This is one of the reasons why, up to now, waste in retailing has not been studied in depth, unlike other stages of the food chain, such as household (Ventour, 2008) and food services (Sonnino and Mc William, 2011; Engstrom and Carlsson-Kanyama, 2004).

According to European Commission estimates, in the EU 27 as much as 4.4 million tons of food are discarded at retail stage, representing about 5% of total food wastage (Figure 3; EC, 2011b). However, this figure may be inaccurate as it is the result of Eurostat data extrapolation rather than direct measurements in the retail sector.

Figure 3 – Proportion of food discarded at different stages of the supply chain, EU 27



Source: EC, 2011b

Table 1 – Possible strategies to reduce and prevent food waste at different Food Supply Chain (FSC) stages[2]

FSC stage	Causes of food waste	Strategies for prevention / reduction	References
Production	Damage to the products by equipment malfunction or inefficiencies during production and processing	Investment in infrastructure and transportation	Kantor et al., 1997 Choudhury, 2006
	Unharvested crops due to low returns in the market	Marketing cooperatives and improved market facilities	Kader, 2005
	Overplanting and overproduction	Communication and cooperation among farmers	Gustavsson et al., 2011 Stuart, 2009
	Products rejected due to food safety regulation	Knowledge among food chain operators about safe handling of food products	Gustavsson et al., 2011
	Products rejected due to mismatch with quality standards of the buyers	Direct sales to consumers Markets for sub-standard products	Stuart, 2009 Segré & Falasconi, 2011
Retail	Damaged packaging	Markets for sub-standard products	Parfitt et al., 2010 Segré & Falasconi, 2011
	Unpurchased holiday foods	Markets for sub-standard products Greater public awareness through education	Segré & Falasconi, 2011 Gustavsson et al., 2011
	Inadequate storage, technical malfunction	Investment in infrastructure and transportation	Ziegler and Floros, 2011 Choudhury, 2006
	Overstocking due to difficulty in predicting the number of products purchased	Research on consumer preferences	Stuart, 2009
	Blemished, wrong-sized, mis-shapen products	Direct sale to consumers Greater public awareness through education	Stuart, 2009 Gustavsson et al., 2011
Food service	Inadequate storage, technical malfunction	Investment in infrastructure and transportation	Ziegler and Floros, 2011 Choudhury, 2006
	Over-preparation due to difficulty in predicting the number of customers	Research on consumer preferences	Stuart, 2009
	Products rejected due to food safety regulation	Greater knowledge within the food chain operators about safe handling of food products	Gustavsson et al., 2011
Household	Inadequate storage, technical malfunction	Greater public awareness through education	Ziegler and Floros, 2011 Gustavsson et al., 2011
	Excessive trimming, spillages, abrasion, bruising	Greater public awareness through education	Parfitt et al., 2010 Gustavsson et al., 2011
	Consumer confusion over “use by” and “best before” dates	Greater public awareness through education	Parfitt et al., 2010 Gustavsson et al., 2011
	Lack of attention about food waste issues (e.g. disposing damaged products which could be used in preparations)	Greater public awareness through education	Buzby et al., 2009 Gustavsson et al., 2011
	Socio-demographic factors (age, gender, composition of the household)	Greater public awareness through education	Buzby and Guthrie, 2002 Gustavsson et al., 2011
	Uneaten holiday foods	Markets for sub-standard products	Segré & Falasconi, 2011

Source: own elaboration on Buzby and Hyman, 2012

[2] In line with the definition of food waste here adopted, we only consider causes linked to human action, e.g. damage by weather, insects, microbes etc. meals that have not been consumed not considered.

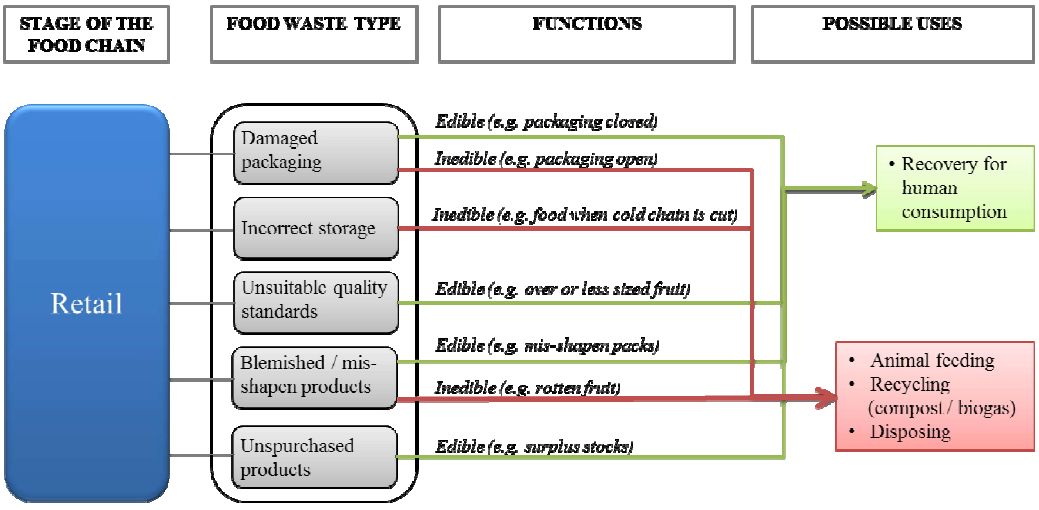
Precisely quantifying the food wasted in retailing is a difficult task, as accounting methods and local policies vary, with the latter highly influencing the behaviour of retailers in this domain, e.g. by supporting efficiency measures to maximize the rate of reuse (Parfitt et al., 2010).

Different retail sectors produce different amounts of waste, although the studies conducted so far are inconclusive: Alexander and Smaje (2008) argue that large retailers may waste more fresh products than small outlets because they only accept first class standard fruit and vegetables; instead, in Parfitt et al. (2010) small grocers are considered to produce more waste, as they have greater difficulty planning food provisions for wild fluctuations in demand. Indeed, as we have pointed out in Table 1, waste in retailing is often the consequence of inappropriate ordering based on incorrect sales forecasts for food products. Surplus products that cannot be sold by the expiration date or fruit and vegetables undergoing natural deterioration must be withdrawn from sale and disposed of. Gustavsson and Stage (2011) studied the horticultural waste produced in large-and-small-scale Swedish retailing and found that the amount of waste greatly varies according to the type of vegetable. According to Eriksson et al. (2012), about 4.3% of the fruit and vegetables delivered to Swedish retailers is wasted during delivery or at the store.

As for products requiring refrigeration, quite often the supplier–retailer relationship includes contractual agreements involving take-back systems, giving distributors the right to return unsold products when their shelf life is nearing an end (Segrè and Falasconi, 2011). This means that large quantities of foodstuffs are withdrawn from sale – and often disposed of – several days before the expiration date is reached. Therefore, in retailing much of food waste may still be edible when discarded.

Figure 4 shows some alternative uses of the food items wasted at the retail stage, either edible or not. Namely, edible items can be recovered and destined to human consumption; one possible solution to pursue this intent is to set up food waste recovery projects aiming to collect products withdrawn from sale - at supermarkets and other stores - and to donate them to charities, so that they can be used to feed the poor (Segré and Falasconi, 2011). Many examples of such projects have been established, both in the retail and in food service (Alexander and Smaje, 2008), and this process has proved to be successful in recovering the value and the usefulness of food waste and in countering the imbalance among the excess of food available and the poor's lack of access to it.

Figure 4 – Possible uses of retail food waste



Source: own elaboration

3. Food waste recovery projects in retailing: description of the case study

Among the several examples of cooperation between retailers and charities (Ellen et al., 2000), food waste recovery stands out for its potential of limiting the extent of food waste. Indeed, as shown by Alexander and Smaje (2008), a remarkable amount of the food wasted in retailing can be recovered for human consumption just by donating it to charities.

As it has been argued, the main causes of food waste in retailing are linked to inappropriate product handling (damage of the products, inadequate storage) or to a mismatch between supply of food on the shelves and consumer demand. Much of the waste is thus perfectly edible and still suitable for human consumption. Every day, these products are withdrawn from sale and most of times they are discarded.

The recovery process can steps in at this point, when these products, instead of being thrown away, are collected and prepared for donation. Operators from the charity go to the food store to pick the recovered products up every day, so as not to allow them to perish. Once the products are brought to the premises of the charity, they are used as soon as possible, in most cases on the same day, to prepare the meal for the poor at the soup kitchen.

This process requires the charity and the supermarket to sign a mutual agreement where they declare under their responsibility that the recovered products are safe and that they will be used only for charitable purposes. However, despite some bureaucratic arrangements in order to guarantee the final utilizers of the recovered products, the process is quite simple and it mostly depends on the efforts of operators involved both at the supermarket and at the charity.

Many recovery projects were started in Europe, involving supermarkets and charities in different countries. In particular, literature reports recovery practices in the UK (Alexander and Smaje, 2008) as well as in Italy (Segrè and Falasconi, 2011).

In this research, we examine a recovery project operating since 2011 in a medium-size town in Central Italy, involving a supermarket of 5,300 square meters and the local soup kitchen. The recovery process is daily based (except Sundays and bank holidays) and it consists in seven steps:

1. every morning, the edible items withdrawn from sale are collected and stocked in a dedicated area of the supermarket;
2. shortly after, products are picked up by volunteers of the charity;
3. a transport document certifying the items recovered and their quantity is produced to accompany each delivery;
4. the products (bread, vegetables, packed meat and dairy products, biscuits, pasta, cans and some beverages), placed in appropriate containers, are transferred to the soup kitchen by a small van;
5. the products are selected on the base of their expiry date: most are cooked for the same day lunch, others are stocked for the next days;
6. the meals prepared with the recovered products are served to the soup kitchen users;
7. every month, the supermarket provides an invoice where all the donated items are registered.

Such process allows the charity to reduce the amount of food to be purchased, by providing the kitchen with a daily delivery of perfectly consumable food items for free. The money saved is used to fund other activities of the same charity, e.g. provision of a counseling service to the users, renovation of the soup kitchen and so on.

4. Methodology

In this research, we analyse the food waste stream of a supermarket, by measuring its extent and estimating its environmental, social and economic value. To this purpose, the data retrieved during the food recovery project described in section 3 were considered.

Following the aim of the paper – to estimate the extent and value of the food waste in the retail stage of the food chain – we take the supermarket involved in the recovery project as a case study, where the edible

fraction of the food waste stream is closely observed and evaluated, thus providing the necessary data to perform the estimations. Namely, the available data obtained from the food recovery project include:

- a description of each food item recovered;
- the weight of each food item recovered;
- a classification of the food items recovered into 12 product categories (fruit, bread/bakery, vegetables, cans/preserves, wheat/coffee/sugar, pasta/rice, dairy products/eggs, baby food, biscuits/snacks, meat, beverage, other);
- a monthly record of the total buying price of the recovered items.

Basing on these data, an evaluation of the environmental, social and economic value of the food recovered at the supermarket has been carried out.

The challenge of measuring the environmental impact of food waste has already been faced in the literature by considering the embodied greenhouse gas emissions (WRAP 2008, 2009a) or the use of water linked to food production (Lundqvist et al. 2008). Therefore, recovering food means to avoid the wasteful use of the fresh water, carbon fossil fuels and ecological services employed to produce the food (Hall et al., 2009). Keeping such approach, we provide an estimate of the ecological savings related to the recovery project by calculating the water footprint (Hoekstra and Chapagain, 2007) and the ecological footprint (Wackernagel and Rees, 2000) of the food recovered in the year 2012. This has been done applying the conversion factors provided by the two methodologies to the different categories of products recovered, and by adding up the results in order to obtain an overall estimation of the environmental value of the recovered food waste.

An estimation of the social impact of food waste has been rarely attempted, at least for what it concerns the retail stage of the food chain. Several studies that have investigated the extent of waste in the food service have raised this issue through a discussion of the implication of food waste for social justice (Sonnino and McWilliam, 2011), or the role of education in the amount of plate waste at school (Engstrom and Carlsson-Kanyama, 2004). Here, since the research concerns the edible fraction of food waste, and its recovery for human consumption purpose, the number of meals that it is possible to prepare with the regained products was analysed. To assess the number of portions of each product that could be served at the soup kitchen the calories per weight unit of each item recovered were considered.

The economic impact of avoidable food waste is usually estimated basing on the current retail prices for all the food commodities. Indeed, in the establishment of the retail price the value added of agriculture, processing, packaging, and distribution processes is taken into account, therefore it provides a very good measure of the total economic value embedded in a commodity as delivered to consumers. For example, Venkat (2011) uses retail prices to assess the economic impact of avoidable food waste occurring after the production/processing stages – specifically waste at the distribution, retail and consumer levels – in the US.

In this research, a budget assessment was performed to assess the economic value of the food recovered counterbalanced by the costs linked to the recovery process.

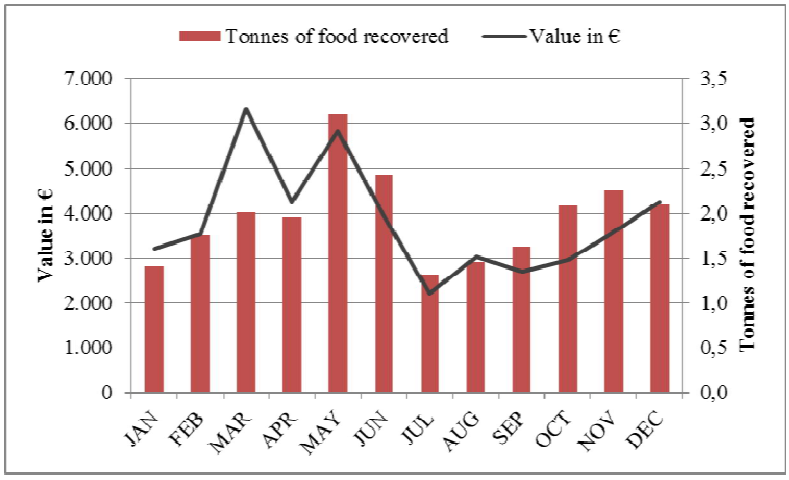
It should be emphasized that the estimation of the environmental, social and economic value of the food recovered is not exhaustive of all the food waste stream of the supermarket. Indeed, as pointed out in figure 4, the whole food waste stream of a supermarket also includes many inedible items, which are not tracked by the data collected during the recovery project. Nonetheless, the estimation conducted in this paper seems reasonably able to get close to the objective, for the extent to which it provides a first magnitude scale of the phenomenon of the food waste in the retail. Of course, for a complete analysis, an assessment of the environmental value of the inedible fraction of food waste, as well as its social and economic value – which are indeed very much influenced by the final uses of the products – should be provided. The results of our analysis should thus be conceived as a rounded down estimation of the total value of the food waste of the supermarket.

5. Results and discussion

5.1 Quantity of food recovered

In the year 2012 food recovery took place on 300 days, with an average of 25 deliveries per month. In total, 23.5 tons of food, which were perfectly fit for consumption and would otherwise have been discarded, were recovered. In economic terms, these products had a total value of about € 46,000.
The average quantity recovered on a daily basis was about 80 kg, with peaks of more than 100 kg in summer, when more food is wasted (Buzby and Hyman, 2012) (Figure 5).

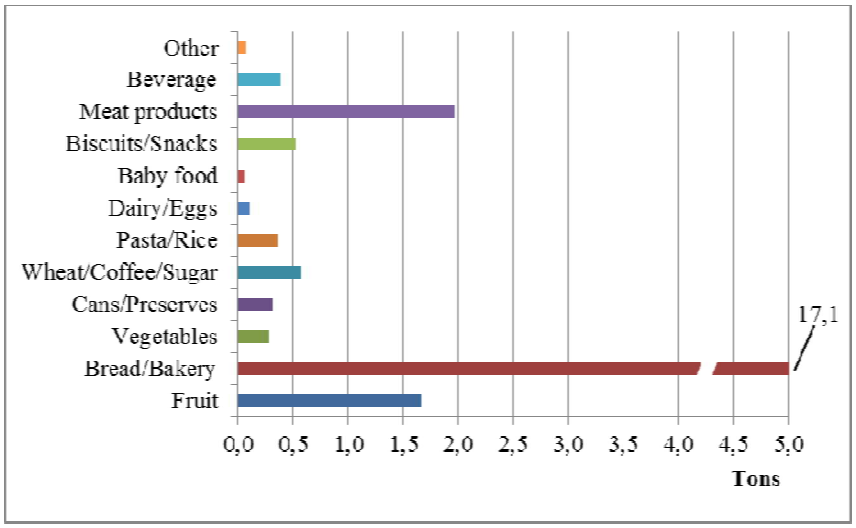
Figure 5 – Weight and value of the food recovered in 2012



Source: own elaboration

The value of recovered products (shown by the line in Figure 1) generally fluctuated with quantity. Indeed, the value was particularly affected by the number of items coming from the butchery of the supermarket, i.e. products with a higher price that greatly increased the total value of the food recovered.
Regarding the products categories, much of the recovery consisted of bread produced in the supermarket bakery and in excess of consumer demand (Figure 6). In 2012, bread accounted for more than 70% of the weight of the total recoveries, with about 17 tons in total, for an average of more than 50 kg per day. Actually, the huge amount of bread withdrawn every day from the supermarket shelves was the main motivation for the supermarket managers to join the project. At the same time, this remarkable supply of bread was greatly appreciated by the charity, which only a few months after the start of the project no longer needed to buy it. In addition to bread, fruit and meat products were recovered almost every day; vegetables, dairy products, preserves, cakes and biscuits were also collected quite often.

Figure 6 – Types of products recovered in 2012 (data in 1,000 kg)



Source: own elaboration

5.2 The environmental value of the recovered food waste

The data collected during the recovery project made it possible to assess the environmental value of the supermarket's food waste by estimating the natural resources used in the food production. When products are wasted, so are these resources.

Table 2 shows the evaluation of the environmental value of two representative products recovered within the project – bread and meat – by calculating their water footprint and ecological footprint by means of standard coefficients of environmental impact.

Table 2 – Environmental value of the food waste recovered

Item		**Water footprint**		**Ecological footprint**	
		Cubic metres of water	Source	Global square metres	Source
Bread	*per kg of food waste*	1.608	Mekonnen and Hoekstra, 2011	5.0	Collins and Fairchild, 2007
	Total in 2012	27,545		85,649	
Meat	*per kg of food waste*	15.400	Mekonnen and Hoekstra, 2012	157.0	Collins and Fairchild, 2007
	Total in 2012	30,294		308,540	

Source: our elaboration of data retrieved from the cited documents

Obviously, animal products have a much more significant impact on the environment, although the quantity wasted is much lower. As a consequence, the environmental value of the meat products recovered is very relevant and the recovery of meat and other animal products entails a significant saving of natural resources.

Moreover, it should be considered that the landfilling of 23.5 tons of food products was avoided in just one year of operation of the project. This amount is undoubtedly significant, especially considering that the quantity of food recovered shows an increase during the year and that the data concern a single supermarket. The environmental value of the waste recovered should therefore be interpreted in terms of potential: how many tons of potentially recoverable waste end up in landfills today? Assuming that the extent of recovery depends on the size of the supermarket, in our project we observed an annual potential of about 4.5 kg of

food recovered per square meter of supermarket, per year. This means that, as a result of a rough estimate, in Italy it would be possible to avoid discarding over 40,000 tons of food every year[3].

5.3 The social value of the recovered food waste

As explained in the methodology section, the social value of the supermarket's food waste has been estimated as the number of servings that can be prepared with the food recovered. To this purpose, the products rescued have been classified according to the courses of the standard menu in the soup kitchen they are intended for. Then, the amounts available for each course was translated into portions by applying the nutritional tables provided by the Italian National Institute of Food and Nutrition (INRAN, 2003), representing the correct portion of each type of food to be used in the preparation of a single meal. The result is displayed in table 3.

Table 3 – Estimate of the social value of the food recovered in 2012

Dish	**Quantity recovered (kg)**	**Number of portions in the year**	**Average daily portions available**
Starter (pasta or rice)	361	4,517	12
Main course (meat or dairy products or eggs)	2,072	17,251	47
Side dish (vegetables)	601	4,296	12
Bread	17,130	171,298	469
Fruit	1,664	11,092	30
Dessert	531	26,545	73

On average, as much as 12 full meals every day can be prepared by relying only on the food recovered. Since the recovery takes place 302 days/year (every day except Sunday and 11 bank holidays officially established in Italy). This means 3,624 meals per year, from a single supermarket.
Moreover, recoveries provide additional portions of the main course and fruit. As many as 73 dessert portions every day are also made available to the users of the canteen. Finally, regarding bread, over four hundred portions are available every day: this may even exceed the needs of the soup kitchen, although, in our case study, people were given additional portions of bread to take home, to be consumed in the evening, when the soup kitchen is closed.

5.4 The economic value of the recovered food waste

From the economic point of view, the value of the food waste recovered at the supermarket is twofold.
First, it has to be considered that the food waste recovered in the year 2012 is worth about € 46,000, considering the sum of the retail price of the food items recovered (Table 4). This is certainly a remarkable result in absolute terms, although it should be considered that it only represents a tiny fraction of the total sales of the supermarket. However, it should be stressed that this is actually a "re-produced" value, coming from goods that were worthless on the market. Moreover, this figure gives a measure of the savings that the charity achieves in its food procurement.
Secondly, the economic return on the investment made to start the recovery process and keep it functioning should also be taken into consideration. The project was funded by the Social Policy Department of the Town Council with € 10,000. This amount was used to pay the person in charge of monitoring the recovery process and collecting the related data, as well as to purchase some materials and to provide an external assistance to fulfil the project bureaucratic requirements.

[3] This result comes from a gross estimate of the potentially recoverable food waste (4.5 kg/m^2) in all the Italian supermarkets (about 9 million m^2 of sales area; data from the National Observatory of Commerce http://osservatoriocommercio.sviluppoeconomico.gov.it/).

Table 4 – Benefit-cost analysis of the recovered food waste

Benefits	
retail price of recovered items	
January	3,214 €
February	3,532 €
March	6,318 €
April	4,267 €
May	5,841 €
June	3,960 €
July	2,220 €
August	3,025 €
September	2,709 €
October	2,956 €
November	3,588 €
December	4,266 €
Total	45,896 €

Costs	
funding from the Council	
Personnel for data collection	3,500 €
Personnel for data elaboration	3,000 €
Materials	500 €
External assistance	3,000 €
Total	10,000 €

This investment generated a return of € 46,000, thus producing a multiplier effect of about 4.5; it represents a positive example of an efficient use of public funding whose benefits are returned to the local community.

5. Conclusions

The reduction of food waste has become a fundamental responsibility involving the entire community, from international institutions to individual citizens. Indeed, besides symbolising the contradictions of a society where opulence and extreme poverty live side by side, food waste also has negative implications in terms of resource allocation efficiency and environmental impact.

The food waste in the retail stage is an issue that is gaining more and more attention from the public opinion since, unlike most of the other stages, much of the food wasted is still fully fit for human consumption.

In this study, a food waste recovery project carried out in an Italian supermarket was used as a magnifying glass to understand the nature of food waste in retailing and evaluate its extent. Basing on the data collected during the project, the extent of the edible fraction of food waste has been measured, and its environmental, social and economic value has been estimated.

The results show that, despite the extent of retail food waste is underestimated in this research, because the inedible food waste is not considered, the environmental savings linked to the recovery of food waste are very significant. Noteworthy is also the social outcome of the food recovered, measured through the number of meals which is possible to serve at a soup kitchen with the deliveries coming from the supermarket. As for the economic value, a simple cost-revenue analysis has shown a multiplier effect of the food recovery process, which has been able to generate a return over 4 times larger than the investment needed to start and run the project.

In our view, the study can provide useful information for policy implementation as well as helping to improve knowledge of the phenomenon of food waste. The evidence that not all the food waste is lost, as has been shown in the case of retailing, should push policy makers to match interventions for reducing the amount of food wasted with actions aimed to recover its economic, social and environmental value.

In evaluating the findings of the study, the limitations of the survey should be kept in mind: first, it must be underlined that the novelty of the research does not allow for any comparison with evidence from other studies; moreover, the results are strongly influenced by the particular features of the store selected in the case study, namely the supply management practices and the marketing strategies.

Despite these limits, the study confirms the role that retailers may assume in reducing the impact of food waste by participating in project able to recover the food items that, for many reasons, remain unsold but are still perfectly suitable for human consumption. Moreover, retailers may have a key role in showing to consumers virtuous practices to reduce the extent and the impact of food waste, with the aim of improving their sensitiveness towards the phenomenon. Beside the direct positive environmental, social and economic issues, this effort may also result in a more-careful behaviour at the household where the greatest quota of food waste is generated.

References

Alexander, C., & Smaje, C. (2008). Surplus retail food redistribution: An analysis of a third sector model. Resources, conservation and recycling, 52(11), 1290-1298.

Bloom, J. (2010). American Wasteland. Da Capo Press, Cambridge, MA.

Buzby, J. C., & Guthrie, J. F. (2002). Plate waste in school nutrition programs: Final report to Congress. Economic Research Service, US Department of Agriculture.

Buzby, J. C., Hyman, J., Stewart, H., & Wells, H. F. (2011). The Value of Retail-and Consumer-Level Fruit and Vegetable Losses in the United States. Journal of Consumer Affairs, 45(3), 492-515.

Buzby J.C., Hyman J. (2012). Total and per capita value of food loss in the United States. Food Policy 37, pp. 561–570.

Choudhury, M.L. (2006). Recent developments in reducing postharvest losses in the Asia-Pacific region. From: Postharvest management of fruit and vegetables in the Asia-Pacific region, APO, ISBN: 92-833-7051-1.

Claro, D. P., Neto, S. A. L., & de Oliveira Claro, P. B. (2013). Sustainability drivers in food retail. Journal of Retailing and Consumer Services, 20(3), 365-371.

Collins, A., & Fairchild, R. (2007). Sustainable food consumption at a sub-national level: an ecological footprint, nutritional and economic analysis. Journal of Environmental Policy & Planning, 9(1), 5-30.

Ellen, P. S., Mohr, L. A., & Webb, D. J. (2000). Charitable programs and the retailer: do they mix?. Journal of retailing, 76(3), 393-406.

European Commission (EC) (2011a). Roadmap to a resource efficient Europe. White Paper from the Commission to the European Parliament, the Council, the European Economic and Social Committee and Committee of the Regions., COM (11) 571 Final.

European Commission (EC) (2011b). Industry, Preparatory Study on Food Waste across EU 27. Publication of the European Commission, DG Environment, Directorate C.

Engström, R., & Carlsson-Kanyama, A. (2004). Food losses in food service institutions examples from Sweden. Food Policy, 29(3), 203-213.

Eriksson, M., Strid, I., & Hansson, P. A. (2012). Food losses in six Swedish retail stores: Wastage of fruit and vegetables in relation to quantities delivered. Resources, Conservation and Recycling, 68, 14-20.

Griffin, M., Sobal, J., & Lyson, T. A. (2009). An analysis of a community food waste stream. Agriculture and Human Values, 26(1-2), 67-81.

Gustavsson J., Cederberg, C., Sonesson, U., Van Otterdijk, R., & Meybeck, A. (2011). Global food losses and food waste: extent, causes and prevention. Rome: FAO.

Gustavsson, J., & Stage, J. (2011). Retail waste of horticultural products in Sweden. Resources, Conservation and Recycling, 55(5), 554-556.

Kader, A.A. (2005). Increasing food availability by reducing postharvest losses of fresh produce. Proceedings of the 5th International Postharvest Symposium. Acta Hort. (ISHS) 682.

Kantor, L. S., Lipton, K., Manchester, A., & Oliveira, V. (1997). Estimating and addressing America's food losses. Food Review, 20(1), 2-12.

Kwak, W. S., & Kang, J. S. (2006). Effect of feeding food waste-broiler litter and bakery by-product mixture to pigs. Bioresource technology, 97(2), 243-249.

Hall, K. D., Guo, J., Dore, M., & Chow, C. C. (2009). The progressive increase of food waste in America and its environmental impact. PLoS One, 4(11), e7940.

INRAN – Istituto Nazionale per la Ricerca degli Alimenti e della Nutrizione (2003). Varia spesso le tue scelte a tavola. Linee guida INRAN per una sana alimentazione italiana, n.8.

Lundqvist, J., de Fraiture, C. & Molden, D. (2008). Saving water: from field to fork—curbing losses and wastage in the food chain. In SIWI Policy Brief. Stockholm, Sweden: SIWI.

Mekonnen, M. M., & Hoekstra, A. Y. (2011). The green, blue and grey water footprint of crops and derived crop products. Hydrology and Earth System Sciences Discussions, 8(1), 763-809.

Mekonnen, M.M. and Hoekstra, A.Y. (2012) A global assessment of the water footprint of farm animal products, Ecosystems,15(3): 401-415.

Segrè A., Falasconi L. (2011). Il libro nero dello spreco in Italia: il cibo. Edizione Ambiente, Milano.

Sonnino, R., & McWilliam, S. (2011). Food waste, catering practices and public procurement: A case study of hospital food systems in Wales. Food Policy, 36(6), 823-829.

Stuart, T. (2009). Waste – uncovering the global food scandal. Penguin Books: London.

Venkat, K. (2012). The climate change and economic impacts of food waste in the United States. International Journal on Food System Dynamics, 2(4), 431-446.

Ventour, L. (2008). The food we waste (Vol. 237). Banbury/Oxon: WRAP.

Zhang, R., El-Mashad, H. M., Hartman, K., Wang, F., Liu, G., Choate, C., & Gamble, P. (2007). Characterization of food waste as feedstock for anaerobic digestion. Bioresource technology, 98(4), 929-935.

Ziegler, G., & Floros, J. D. (2011). A future perspective to mitigate food losses: The role of food science and technology. In IFT 2011 Annual Meeting & Food Expo (New Orleans, LA).

http://ec.europa.eu/eurostateurostat.eu

http://osservatoriocommercio.sviluppoeconomico.gov.it/

www.lastminutemarket.it

www.wrap.org.uk

The value of food waste: an exploratory study on retailing

Acknowledgements
The authors wish to thank the Social Policy Department of the Council of Viterbo, which funded the recovery project, as well as the Fondazione Carivit which supported the research and the elaboration of the data retrieved. We also thank Alberto Giraldo, Caterina Valeri and Alberto Pasquini for their effort in the implementation of the project at the IperConad supermarket, Aldo Piermattei and the staff of the Caritas soup kitchen, Massimiliano Chindemi who collaborated in the data retrieval.

The value of food waste: an exploratory study on retailing

Author contribution

Although the paper is the result of a collaborative effort by the authors, they contributed specifically as follows:

- Clara Cicatiello for §4
- Silvio Franco for §1 and §5
- Barbara Pancino for §2
- Emanuele Blasi for §3

The value of food waste: an exploratory study on retailing

Highlights

- Increasing concern over food waste
- Few research exists on retail food waste
- This paper aims at estimating the environmental, social and economic value of retail food waste
- A project of edible food waste recovery held in an Italian supermarket is taken as a case study
- The environmental value of the food recovered is assessed basing on the consumption of natural resources
- The social value is estimated as the number of meals which can be prepared with the food recovered
- The economic value is based on the analysis of the revenues and costs of the project