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Food waste in an alternative food network – A case-study

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ABSTRACT

This paper investigates food waste dynamics in a retail alternative food network (AFN). We provide a first contribution to assess food waste in an AFN in terms of 1) food waste levels, 2) food waste causes, and 3) food waste management practices (i.e. food waste reduction and handling). We use an exploratory case-study to investigate food waste in a Polish AFN. We place the results of this case-study in the context of conventional retail, by reviewing retail food waste literature. Quantitative results show that food waste levels at the AFN are very low compared to conventional retail literature. Qualitative results show that food waste causes at the AFN are partly shared with conventional retail, and partly specific to the AFN. Possible explanations for low food waste are provided by the food waste management strategies, in which food waste prevention is a key component of the AFN practices.

Two other possible explanations are the degree of flexibility and the main drivers of the organization. Conventional retail is ruled by top-down policies, focusing on profit-maximization. The AFN we studied is small-scale, independently organized, and non-profit. Its main driver is to balance financial viability, accessibility and ethical guidelines. Looking beyond profit allows for a high concern with food waste, while the autonomy of the organization gives its members flexibility to develop ways to prevent and handle food waste. Future research can build on our approach of combining food waste estimations with qualitative investigation of food waste causes and management practices. Food waste dynamics should be further investigated in other (retail) AFNs, in small-scale conventional and organic food retail, and in small and large-scale cooperative supermarkets.

1. Introduction

The recently revised EU Directive on Waste (EU, 2018) restates the EU's commitment to meet the sustainable development goal (SDG) 12.3 of halving consumer and retail food waste by 2030 and reducing food losses in production and supply chains¹. Food waste in the EU is estimated at 20% of the total food produced. In 2012, 88 million metric tons of food were wasted, of which 53% occurred in households, and 5% in wholesale and retail (Stenmarck et al., 2016).

Food waste is problematic not only because of its environmental impacts and resources use (Priefer et al., 2016) that occur mainly during the production phase (Scherhauer et al., 2018), but also for the ethics of wasting food in a world with increasing food insecurity (FSIN, 2018). In recent years, many studies have focused on understanding food waste at the consumer level (Aschemann-Witzel et al., 2015; Stancu et al., 2016). Significantly fewer studies focus on retail (Cicatiello et al., 2017), while even fewer have studied the causes of food waste at the retail level (Teller et al., 2018).

Despite the small share of food waste attributed to retail, supermarkets are at the center of the modern food system. The food system is riddled with overproduction and overconsumption but also hunger, and other environmental and social ills (Patel, 2007). Responding to these problems, alternative food networks (AFNs) have developed in Europe and around the world (Forsell and Lankoski, 2014), including alternative forms of retail, e.g. food cooperative shops. The characteristics, operations and motivations of AFNs vary, but overall there is a preference for locally sourced, small-scale, organically produced food (Forsell and Lankoski, 2014). Although hailed as more sustainable ways of food provisioning, some authors question the sustainability claims of AFNs (e.g. Tregear, 2011; Born and Purcell, 2006). According to Forsell and Lankoski (2014) more studies should investigate the environmental impacts of AFNs, for example by looking at food waste. While research on AFNs has been prolific in the last decade, we are only aware of one paper (Turner, 2018) that addresses food waste in AFNs. In that paper, part of the focus is on the skills developed by participants in AFNs (e.g. dealing with food abundance, avoiding food waste).

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¹ https://ec.europa.eu/food/safety/food_waste/eu_actions/eu-platform_en

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In order to address this knowledge gap, this paper explores food waste dynamics in a retail alternative food network. The three research questions are: 1) What are the levels of food waste in the AFN?, 2) What are the food waste causes in the AFN?, and 3) What are the food waste management strategies in the AFN?

We use an exploratory case-study, for which we choose an AFN in Poland, one of the EU countries with the highest levels of food waste per capita (Bräutigam et al., 2014). To estimate food waste we had access to the food waste data of the AFN, and for information on food waste causes and management we interviewed the AFN shop manager and purchasing coordinator. We place the results of this case-study in the context of conventional retail by reviewing retail food waste literature.

This paper is organized as follows: a literature review of retail food waste (Section 2), methods (Section 3), results and discussion (Section 4), limitations and future research (Section 5), and conclusion (Section 6).

2. Literature review of food waste in retail

The analysis of food waste in retail has, so far, received little attention. Literature tends to focus on estimating food waste, or on qualitative understandings of food waste causes and management. We review four themes in retail food waste literature, which we will use as a frame of reference for the AFN case-study.

2.1. Quantifying food waste

Studies report a significant variation in the estimations of retail food waste (see Table 1). Variations can be partly explained by different food waste definitions (see Filimonau and Gherbin (2018) or Principato (2018) for a review) and by different methods. In this study we define food waste as measured by retailers, i.e. unsold food products. Although authors like Parfitt et al. (2010) distinguish between “food waste” (when occurring at the final consumer level) and “food losses” (occurring beforehand in the supply chain), we use these terms interchangeably.

The most common method to estimate food waste is using retailer data on unsold food, i.e. food that is taken out of stock. Retailers often have procedures to monitor the quantities of unsold food, and this data

is interpreted as food waste by retailers and researchers. Some authors use a different scope, e.g. Eriksson et al. (2012) estimated food waste in relation to food quantities delivered to a Swedish retailer. They found significant values of pre-store food waste, i.e. the food that is received from suppliers, but considered to have insufficient quality to be sold.

Comparability between studies is limited, as different indicators are used to present food waste (see Cicatiello et al. (2017) for a list of food waste estimations). Some authors present the food waste rate (as % of total sales, or % of total volume/mass), while others provide only absolute numbers of food waste, per food category, or they show how much each food category contributes to the total food waste.

Within studies, variation in food waste estimates is also found due to diversity in retailing shops. Lebersorger and Schneider (2014) investigated food loss in 612 shops of an Austrian retailer, and found a wide spread of food waste levels across their shops (range of total food waste between 0.8% and 10% across the 612 retailer outlets). The results of correlations with shop characteristics (type of retail shops, area, sales, number of transactions) did not explain the variability, leading the authors to suggest that variation must be also influenced by factors such as “organizational aspects, individual behavioral aspects of the staff and situation specific aspects” (Lebersorger and Schneider, 2014:1916).

For comparison purposes, Table 1 includes only studies of food waste rates in retail stores calculated as a ratio of unsold to sold food.

Table 1 shows that the waste of fruits and vegetables, by volume, is estimated in the range of 3–10%, the waste of bread and pastries at 4–7%, dairy at 1.1%, and eggs at 1.4%. The only accessible data for Poland is reported by one of the main retail chains. Their average food waste ratio, by volume, in 2017/18 equaled 1.1%, and after subtracting the 18% food donated to charities, the remaining food waste was equivalent to 0.9% of total food sales (TESCO, 2018). This is a low value when comparing with current literature.

2.2. Food waste causes and management

When reviewing literature on food waste causes and food waste management strategies in retail, we found that both causes and management strategies could be described by distinguishing among 1) the agents influencing food waste, 2) the products and infrastructure influencing food waste, and the 3) wider contexts influencing food waste.

Table 1
Rate of food waste as calculated in different retailers and countries.

Study	Scope	Geographic area	Rate of food losses in retail
Lebersorger and Schneider (2014)	612 outlets of a food retailer	Austria	<i>By value</i> Fruits and vegetables - 4.2%. Bread & pastry - 2.8% Dairy products - 1.3% <i>By volume</i> Fruits and vegetables - 4.2% Bread and pastry - 4% Dairy products - 1.1%.
Beretta et al. (2013)	Across food supply chain. Distinguishes between avoidable, potentially avoidable and unavoidable food waste.	Switzerland	<i>By volume</i> Fruits and vegetables: 8-9% Bread and pastries: 5.1% Eggs: 1.4% Total: 1.8%
Katajajuuri et al. (2014)	Across food supply chain.	Finland	<i>By volume</i> Total: 1-2%
Mena et al. (2011)	Supply-retailers interface.	UK and Spain	<i>By volume</i> Fruits and vegetables: 3-7% Bread: more than 7%
Gustavsson et al. (2011)	Global food supply chain.	Global, per continent	<i>By volume</i> Food waste in Europe at supermarket retail level Fruits and vegetables: 10%

* The “total” estimates given by Beretta et al. (2013) and Katajajuuri et al. (2014), refer to the complete (or almost complete, in the case of Beretta et al.) assortment of food products, and include non-perishable products.

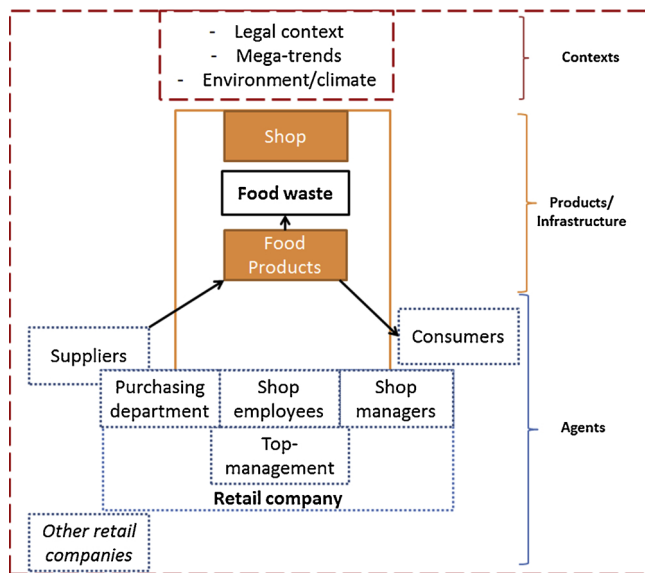


Fig. 1. Conceptual framework of the agents, infrastructure and contexts that influence food waste, adapted from Ribeiro et al., 2019.

These three factors are key when describing why food waste occurs, but also how it could be reduced.

To better portray these different elements, we adapted the conceptual framework from Ribeiro et al. (2019) that described the different actors and contexts that influence consumption. This conceptual framework serves well, because 1) food waste is a direct result of production-consumption systems, 2) the framework structured the different types of influences acting on production-consumption systems, and 3) the framework highlights the agency of different actors, and contextual factors acting at different levels/scales, going beyond the direct logistics management at the shop, for which other models are more appropriate (e.g. the instore logistics model by Kotzab and Teller (2005)).

Fig. 1 depicts the conceptual framework, in which food waste is pictured as influenced by the characteristics and/or actions of multiple elements: agents, products/infrastructure, and contexts. In terms of agents influencing food waste, the reviewed literature mentioned consumers, suppliers, and the different agents within the retail company (top management, shop managers, shop employees, buying department). We add also other retail companies, as competitiveness is a big factor in this sector. Food waste causes and strategies are influenced by the available infrastructure at the shop (e.g. cold storage). Also wider contexts influence food waste, and the ability of preventing it, such as legal requirements on food redistribution, global trends of food demand, and environmental conditions.

2.2.1. Food waste causes

Older studies have addressed general causes of retail food waste (e.g. Kantor et al., 1997), but recent studies have investigated causes of retail food waste in more detail, by interviewing (shop) managers. Teller et al. (2018) studied the root causes of food waste at store level comparing four different types of retail (i.e. hypermarket, supermarket, discount store and convenience store). Mena et al. (2011) reviewed causes of food waste at the supplier-retailer interface, comparing food waste levels and causes for different types of food (ambient, chilled, frozen) in the UK and Spain. They interviewed managers in food production, wholesaling and retail. They categorized root causes of food waste as 1) mega-trends, 2) natural constraints, and 3) management root causes. Gruber et al. (2016) investigated the attitudes of shop managers regarding food waste, in different types of retail (convenience and discount stores, super- and hypermarkets, and wholesale stores). They found that some shop managers appeared to feel a moral burden

regarding food waste, associated to two types of constraints:

“(1) the societal and regulatory settings in which they operate and (2) the systemic constraints associated with the retail and wholesale organization sector in general” (Gruber et al., 2016:6). Also through interviewing managers, Filimonau and Gherbin (2018) present barriers for food waste mitigation in retail as occurring at the level of consumers, corporate policies, suppliers, employees, and supermarket size. All these studies presented best practices, or strategies for food waste management (addressed in section 2.3). Holweg et al. (2016) researched the instore logistics associated to unsaleable products, and the barriers for redistribution of unsaleable products. To present the results of the different studies in a concise way, we include the barriers for food redistribution in “food waste causes”, as barriers to food redistribution also contribute to the levels of observed food waste.

Following the structure of Fig. 1, we can say that food waste causes occur at the level of agents, infrastructure/products and contexts.

Agents:

- Retail company

Top-management

Many top-down policies influence the generation of food waste: 1) high quality standards by parent organization (Teller et al., 2018; Filimonau and Gherbin, 2018); 2) focus on cost, efficiency and availability is sensed by managers as pressure to maximize revenues, which can prevent them from donating food (Filimonau and Gherbin, 2018; Gruber et al., 2016; Mena et al., 2011); 3) policy of rejecting products with less than 70% of their shelf life left (Mena et al., 2011); 4) lack of responsibilities and processes for food waste prevention and reduction (Mena et al., 2011); 5) policies that warn against giving food away to employees (Filimonau and Gherbin, 2018), 6) promotions are imposed from the top (Gruber et al., 2016) leading to higher product allocations during promotional periods, making demand more unpredictable (Teller et al., 2018; Mena et al., 2011; Filimonau and Gherbin, 2018).

Purchasing departments

Purchasing departments cause food waste when 1) insisting on 100% on-shelf availability of a large width and depth of product range (Teller et al., 2018); 2) allocating products in excess to a shop, as it is more affordable to order in larger quantities (Filimonau and Gherbin, 2018; Gruber et al., 2016; Teller et al., 2018); 3) size and frequency of products delivered are not adjusted to characteristics of specific shops (Filimonau and Gherbin, 2018; Gruber et al., 2016); 4) forecasting difficulties result in poor ordering (Mena et al., 2011); and 5) sometimes supply chains take longer routes for the purposes of cheaper transport, requiring more handling (Mena et al., 2011), and can further deteriorate products.

Shop employees

Employees might not follow best practices in handling products at the shop due to lack of training and commitment (Teller et al., 2018; Mena et al., 2011). High turnover of personnel due to low wages can also result in improper handling of products, leading to lower shelf-life (Gruber et al., 2016).

- Consumers

Consumers influence food waste through 1) their unpredictable demand, creating forecasting difficulties (Teller et al., 2018; Gruber et al., 2016); 2) their expectations regarding range, availability and aesthetic qualities of products (Filimonau and Gherbin, 2018; Teller et al., 2018; Gruber et al., 2016); and 3) their behavior when selecting or handling products at the shop (Teller et al., 2018).

- Suppliers

Food waste is created directly through interruptions in the cold chain and poor handling during transportation (Teller et al., 2018;

Filimonau and Gherbin, 2018; Mena et al., 2011). Indirectly, food waste is caused due to impossibilities to order small quantities (Teller et al., 2018), and due to lack of information sharing between retailers and suppliers (Mena et al., 2011).

Contexts:

- Legal system

Legal aspects are mentioned mainly as barriers for food redistribution (Holweg et al., 2016). They are: 1) requirements for products to have “best before” dates (Filimonau and Gherbin, 2018; Gruber et al., 2016); 2) liability on donors for donated food (Filimonau and Gherbin, 2018; Holweg et al., 2016) and 3) legal restrictions for processing food, which prevents retailers from processing food on its premises (e.g. fruit into juices) (Gruber et al., 2016).

- Mega-trends

Increasing demand for fresh produce, and for reduced use of preservatives in food, which results in shorter shelf-life (Mena et al., 2011).

- Natural constraints/environment

Seasonality plays a big role, through temperatures and weather, in how long products last fresh (Mena et al., 2011).

Products/Infrastructure:

Products that are more sensitive to handling are wasted in greater quantities (Gustavsson and Stage, 2011). The locations of shops (Lebersorger and Schneider, 2014) might also influence the levels of food waste. Contrary to Lebersorger and Schneider (2014) who have not found a significant correlation between food waste and shop size, some studies suggest that smaller retail shops have higher food waste rates than larger stores (Gustavsson and Stage, 2011; Beretta et al., 2013; Parfitt et al., 2010). This difference could be due to demand being more difficult to predict in smaller shops, as these shops are used for “top-up” (Parfitt et al., 2010), and because they might have less advanced methods to predict demand.

2.2.2. Food waste management

Food waste management refers to strategies to reduce and handle food waste. Most of the strategies reviewed are to be implemented by the retail company, e.g. by influencing consumers, changing practices of agents within the company, and adapting shops and products. Some strategies aim to change the legal context, which implies actions by legislative bodies, or by the retail company (through lobbying).

Agents:

- Retail Company

Top-management: 1) making food waste a key performance indicator (Teller et al., 2018); 2) encouraging redistribution of edible food waste to charities (Teller et al., 2018; Filimonau and Gherbin, 2018; Gruber et al., 2016); 3) allowing flexibility to local shop managers in deciding how to reduce food waste (Filimonau and Gherbin, 2018; Mena et al., 2011); and 4) adapting product offers to consumer demand, e.g. not restocking fresh produce shortly before the store closes (Gruber et al., 2016). Companies can also 5) rethink pricing and promotion strategies, by making products cheaper that are closer to the end of shelf life (Teller et al., 2018; Filimonau and Gherbin, 2018; Mena et al., 2011); and 6) reduce availability during promotions to avoid waste (Mena et al., 2011). In terms of handling food waste, Filimonau and Gherbin (2018) suggest recycling food waste into compost, biomass, bioenergy or animal feed.

Purchasing departments: 1) Improve forecasting and communication with suppliers (Mena et al., 2011); 2) adapting offer of food products (e.g. reducing product range, see section on Products/Shops).

Shop employees: Training employees to better handle products (Teller et al., 2018; Filimonau and Gherbin, 2018; Mena et al., 2011).

- Consumers

Influencing consumers' behavior through education on food labels, food waste, the resources involved in food production, and that more choice is not always better. Using marketing and nudging to promote the “right choices” (Teller et al., 2018; Filimonau and Gherbin, 2018; Gruber et al., 2016).

- Suppliers

The strategies reviewed do not target suppliers specifically, although changes in products will affect suppliers.

Context:

- Legal system

Legal measures include 1) exempting products from labelling requirement (Gruber et al., 2016); 2) check for quality of individual products in a batch, even if one product is spoiled (Gruber et al., 2016); 3) exempt donors from liability for donated products (Gruber et al., 2016; Teller et al., 2018). Also, more flexibility in 4) labelling to make it easier to donate food (Gruber et al., 2016); and 5) product quality assessment, as different appearances do not necessarily mean lower quality (Gruber et al., 2016; Gustavsson et al., 2011).

Products/Infrastructure:

Changing the selection of products to reduce food waste: 1) reduce product range, particularly in products with limited shelf life (Teller et al., 2018); and 2) use local products to reduce transportation times, and offer long-lasting varieties (Mena et al., 2011). Changes in the shops can also help: 1) having in-store butchers can preserve meat for longer (Mena et al., 2011); and 2) processing less fresh food at the shops (e.g. into juice).

2.3. Views of shop managers

Gruber et al. (2016) were the first to explore the personal views of store managers on food waste, finding that many managers seemed to struggle with the quantities of food wasted at the shops. Despite concerns with the levels of food waste, shop managers felt constrained by policies and practices that contribute to food waste but are beyond their control - this tension was described by Gruber et al. (2016) as a “moral burden”, and echoes the notion of widespread social norms that regard food waste as unethical (Gjerris and Gaiani, 2013).

3. Methods

We use a case study approach to explore the issue of food waste in an alternative food network.

3.1. Case-study: Raven co-op

We examine the Raven² Food Co-op, a consumer food cooperative based in Warsaw, Poland (see key figures of Raven in Fig. 2). Raven has been established in 2013 as a bottom-up initiative aimed at providing a practical alternative to what is perceived as low-quality products from supermarkets, and to expensive organic stores. Raven is seen by some of its members as a response to growing domination of multinational, standardized retail chains. In Poland the market share of top 10 retailers in fast moving consumer goods has grown from 42% to 58%, between 2010 and 2015 (Roland Berger, 2016).

² We use a fictitious name of the initiative for the sake of anonymity.

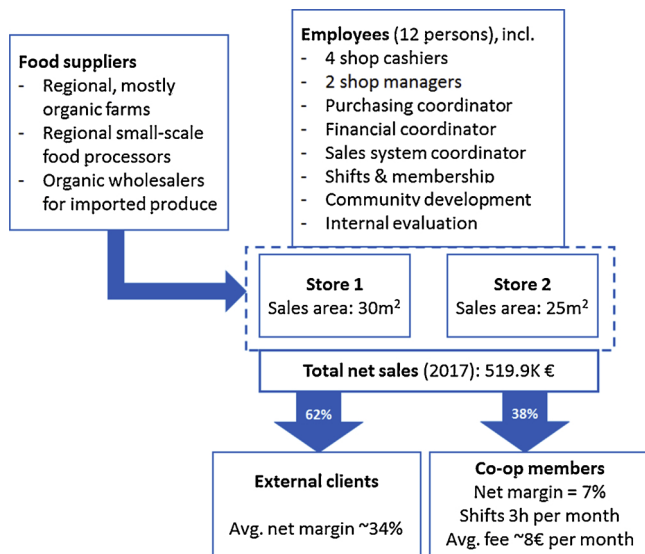


Fig. 2. Key figures of AFN Raven.

In 2014, after being registered as a non-profit association, Raven opened its first grocery store, and in 2016, a second store. The co-op stores are shared property of its members, who govern it according to international cooperative principles (ICA, 2018). The selling area is roughly 30 m² per store, and is mostly used for fresh produce. The stores are accessible both to members and external clients, but the former pay reduced prices, a monthly fee, and work obligatory shifts (3 h per month) helping with everyday store management, e.g. accepting deliveries, stacking and storing goods, and cleaning. The reduced price means that profit margin³ in members' prices is set at 7% for all products, while profit margin for clients' prices is higher, averaging 34%, and more flexible, reflecting the general market prices for organic food.

Food is ordered according to a list of criteria that emphasize seasonality, locality, and excludes meat, palm oil, and products from industrial farming. The products are sourced from about 20 small-scale farms, most of which are certified organic, from regional food processors, and from organic wholesalers in case of imported goods. Apart from food, Raven offers also a limited number of household care products and cosmetics. In total, around 1500 products are on offer throughout the year, many of them only during a relatively short season. As of February 2019, the co-op has 305 member households and 12 employees (10.0 in full-time equivalent). Total net sales in 2017 amounted to 519.9K EUR, with external clients contributing 62% of this value.

3.2. Quantitative research

We assess both the scale and structure of food waste at Raven. The standard daily routine implemented in the co-op requires that all in-store food loss is weighted and written down by cashiers, and later entered manually in the store inventory management system. From this inventory, we obtained data on food loss and total sales for both stores from January, 1st 2017 up to June 30th, 2018. We used this time period because from July 2018 the procedures of food waste accounting were changed. For estimations of food waste scale and structure we use only 2017 data. For the temporal analysis (section 4.1.3), we follow food waste dynamics over the whole period (18 months). In the store inventory system, food waste data is available in mass/volume and corresponding net sales value, and is presented for each product (357

products in total) and product group. The sales database contains data on net and gross sales value, cost price, and volume/mass for over 1500 products, presented according to product groups and type of buyer (member or client).

We operationalise food waste in monetary terms as net sales value of unsold food compared to total net food sales, or - in physical terms - compared to total volume of food sold, as is commonly calculated in literature (e.g. Lebersorger and Schneider, 2014; Beretta et al., 2013). Products that are close to the end of shelf life are marked with a 50% discount, and promptly added to the food waste inventory, independently of being sold or not. The recorded food waste covers only in-store waste, i.e. articles accepted at the delivery that were neither sold nor returned to the supplier. Unlike Eriksson et al. (2012), we do not include estimations of pre-store waste as Raven lacks specific criteria of food quality at delivery, so the level of pre-store waste is insignificant.

We place our results in the context of food waste in conventional retail. For detailed food waste rates per product, we use Eriksson et al. (2012) as a reference, the only study we found that presents food waste rates at product level.

3.2.1. Data limitations

The data on food waste obtained from the inventory management system has some limitations. First, there is no consistent data on the mass of products. Products are quantified in kilos, packages or pieces. While it hampers the direct comparability across studies, this data might still be useful when expressed as a value relative to total amounts sold. In order to provide basic comparability across studies on mass of fresh fruit and vegetables (FFV), we assigned an unit weight to every product in the category sold per piece/package. For packages, we used the exact weight from the product description. For products sold per piece, we estimated the average weight based on products currently accessible in the Raven stores.

Raven has a policy of reducing food waste that includes a 50% discount for produce that is either one day before expiry date or fresh produce that lost its freshness or attractive appearance but are still edible. Such products are put on the food waste list the moment they are discounted and thus included in the inventory irrespectively of being sold or not. Unfortunately, there is no separate data on the amount of products sold this way, so the values of food waste presented in the following chapter are overestimated. Also, all monetary values assigned to recorded food waste is according to (higher) clients' prices, thus its calculated share in total sales is overestimated, as the latter value includes also reduced members' prices. In the presentation of food waste value, we apply a coefficient (see footnote 5) that accounts for this discrepancy. Finally, a significant share of produce recorded on the food waste list is not wasted but informally distributed among co-op members and clients. We have no evidence to assess the scale of this process, but we describe it more thoroughly in our qualitative research.

3.3. Qualitative research

We investigated Raven's food waste management practices by interviewing the shop manager (A) and the purchasing coordinator (B) of Raven. Two semi-structured interviews were conducted (in total 1h30 min), with four months in between. The questions were based on the interview guide used by Teller et al. (2018) to interview shop managers. The first interview with A focused on the strategy to handle food waste. The second interview with A and B focused on the causes of food waste and the strategies to prevent food waste. Inspired by Gruber et al. (2016), we also interviewed the shop manager about her views on food waste. From the degree of concern and the presence of feelings of constraint in handling or reducing food waste, we interpret whether the shop manager feels a moral burden.

³ Profit margin is calculated as a ratio of net profit to revenue.

4. Results and discussion

4.1. Measuring food waste at Raven

4.1.1. Scale of food waste

Total net sales in Raven in 2017 amounted to 2 239.3 K PLN⁴ (519.9 K EUR), of which 90.8% is food sales. The food waste recorded in 2017 equals 18.2 K PLN (4219 EUR), or 0.85% of total value of food sales. After adjusting for the double pricing system for members and clients⁵, the final value is lower, at 0.78% of total value of food sales. In terms of physical units - 1.09% of total volume of food sales is wasted. This value is low, compared to the reported losses of conventional retail. Beretta et al. (2013) report total food waste by mass (across all food categories) at the level of 1.8%, and Katajajuuri et al. (2014) - between 1 and 2%. For a more in-depth insight of how Raven performs in terms of food waste, we study the losses among different categories of products.

4.1.2. Structure of food waste

Fruits & vegetables, bread & pastry, and dairy products are the categories most often used to assess levels of retail food waste. Table 2 shows that at Raven, monetary values of food loss across these categories do not exceed 1%. These values are very low comparing to conventional retail (see Table 1 in section 2.1).

The volume of fruit & vegetables wasted at Raven is 1.9%, almost two times higher than its monetary value. This result indicates that cheaper products from this category have higher probability of being wasted, which conflicts with the results by Eriksson et al. (2012) for conventional retailers.

Food waste can be analysed also on per product basis, both in terms of absolute quantities wasted and waste percentages, like in Eriksson et al. (2012). In terms of largest waste percentage recorded across the fresh fruits and vegetables (FFV) category, Eriksson et al. (2012) found that Swedish hypermarkets are wasting mostly highly perishable and rather expensive exotic fruits (8 out of top 10 products, by percentage wasted). In case of Raven, the FFV products with highest waste percentage are root vegetables (4 out of 10) and soft, seasonal fruits (3 out of 10). The highest percentage of waste - 18% of the delivered quantity - was found in Raven for black turnip and black raspberry, while in conventional stores studied by Eriksson et al. (2012) it was Tamarillo - 57%.

In Table 3 we present the top 10 most wasted FFV per absolute quantity at Raven. In Raven, 6 out of 10 products generating the largest quantities of FW are root vegetables, less perishable than most other FFV products, but marked with a relatively high average waste ratio that exceeds 5%. In Eriksson et al. (2012) only two root vegetables - potato and carrot - are on the equivalent list, with waste ratios not exceeding 1%. This finding may seem contradictory to earlier notions of relatively low level of FW in Raven. But the high level of waste across root vegetables might be due to Raven's distinct policy of ordering vegetables from regional suppliers (see "Suppliers" in section 4.2). Thus, just before a new season starts stores are stocked with few-months old root vegetables, more prone to spoiling than fresh imported produce, offered in conventional retail.

⁴ PLN stands for Polish zloty and equals 0.232 EUR as for 9th of October 2018

⁵ Given that all food waste is calculated according to higher clients' prices, we re-estimated this value, taking into account that members' price is on average lower by 27 pp. and members' share in total food sales is 40%. Adjusted monetary value of food waste is thus lower, equaling 0.78% of total value of food sales. We use this ratio ($0.78 / 0.85 = 0.92$) as a coefficient to adjust monetary values of food waste recorded in the Raven co-op reported in this chapter.

Table 2

Rate of food waste among key categories of products in Raven*.

	Rate of food waste by value	Rate of food waste by volume
Fruits & vegetables	1.0%	1.9%
Bread & pastry	0.3%	0.4%
Dairy products	1.0%	0.6%

* Ratio between unsold food and sold food.

Table 3

Products generating the largest quantities of recorded food waste in Raven, FFV category.

Product	mass [kg]	Mass [%]
Carrot	234	2.9
Potato	137	1.6
Root parsley	130	7.6
Beetroot	99	2.4
Tomato	92	3.2
Pumpkin	75	2.4
Apple	68	0.4
Onion	60	2.8
Parsnip	58	13.5
Lemon	51	2.9

* Ratio between unsold food quantity and sold food quantity.

4.1.3. Temporal approach to food waste

The impact of seasonality is examined by looking at the changes in levels of food waste between January 2017 and June 2018 (Fig. 3). The food waste ratio in Raven varied from 0.4% to 1.8% of total value of sales per store. Throughout 2017 there were three spikes, experienced similarly in both stores - around February, July and December. The early summer spike corroborates the assumption that the beginning of a new season leads to relatively high waste ratios of root vegetables stocked in the previous season. The upward trend starting from November 2017 might be attributed to a change in ordering policy that aimed at sales expansion, and entailed broadening the product range.

The food waste levels at Raven are low when compared to most food waste data on conventional retail. Below we explore the qualitative factors behind these food waste values, to better understand the different approaches between AFNs and conventional retail, regarding food waste.

4.2. Food waste causes at Raven

Several reasons for food waste were mentioned in the interviews with the shop manager (A) and the purchase coordinator (B).

Co-op:

Shop employees and volunteers: Products deteriorate faster if they are not properly handled at the shop. Despite hiring the cashiers and a shop manager, most of the cooperative members who help at the shops do so voluntarily, as part of their monthly 3 h duty. There are many detailed instructions (further explained below), but they are not always strictly followed, as mentioned by the purchasing coordinator: "[sometimes] it is not properly sprayed during the day when it is exposed outside the fridge, and the cashiers or the members don't remember to go and spray it with a mist...My opinion is that it should be done more often than it is." (B)

Purchase coordinator: It is difficult to predict demand for some products, especially dairy. This difficulty is reflected in the estimations showing a 1.0% waste ratio for dairy products, 0.2% percentage points higher than the average food waste value at Raven.

Suppliers: Products are ordered directly from farmers who, although mostly from the region of Warsaw, can still be at a significant distance, which means they will deliver to the shop once a week. Ordering for the whole week involves some risk, and might result in ordering higher quantities to ensure that there is sufficient stock until the next delivery.

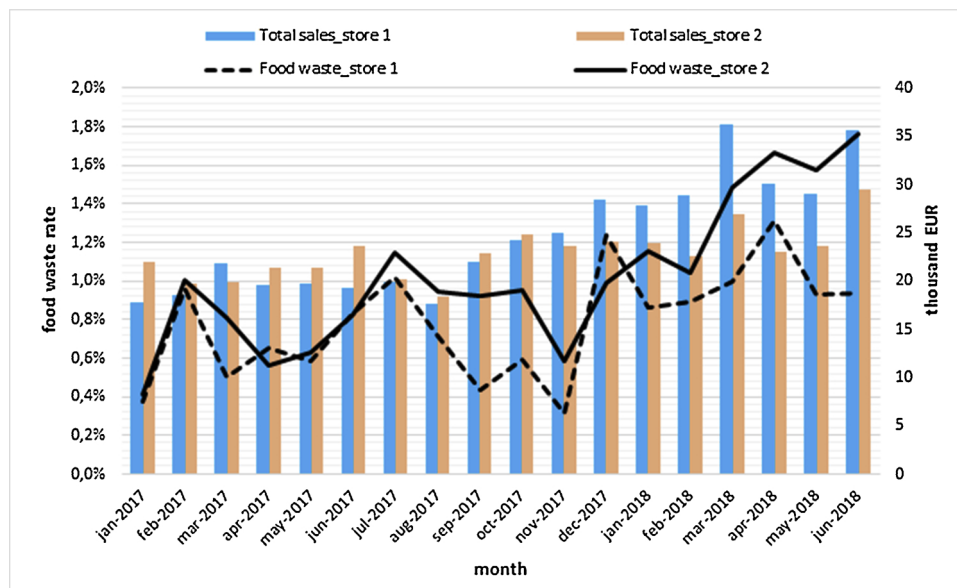


Fig. 3. Food waste rate by value and total sales at Raven's two stores.

This also necessitates to store products for the whole week.

Shops and products:

Cold storage space at the shops is sometimes insufficient for the amount of products, especially during the warmer seasons, with high temperatures, and large amounts of fresh, perishable produce on sale. In one of the shops cold storage space is very limited, which will result in some products aging faster. This is visible in Fig. 3 (section 4.1.3), where store 2, the one with less cold storage space, has higher values of food waste rate in 13 out of the 18 months.

Products are always seasonal. At the end of the season, products are more likely to be delivered already too ripe, or too old, resulting in shorter shelf life. Less familiar products are more likely to be wasted, as consumers do not know how to use them.

4.3. Food waste management at Raven

4.3.1. Food waste reduction strategies

There are different stages in the prevention of food waste at Raven: predicting demand, caring for products in the shop in a way that lengthens its shelf life, promoting the sale of products approaching their best before date (active selling, discounts). When products are not sold, they are accounted as food waste, but if they are still edible, they are informally redistributed.

Purchasing coordinator:

Predicting demand: As Raven is a young project that has grown in membership and in sales, it is not very useful to use previous years to forecast demand. However, the purchasing coordinator is daily at the shops and observes the sales of products directly. Also, Raven's stores are embedded in a community of suppliers, clients and members. The strong social and economic bonds between co-op members and the shops is a way to overcome the unpredictability of consumer demand. This approach fits the concept of community economy, as put forward by Douthwaite (1996).

Shop employees and co-op members:

Caring for products at the shop: There are specific guidelines for how each product needs to be handled to last longer in the shops. As the shop manager explains, it requires a lot of detailed attention: "There are many many instructions. (...) What needs to go to the fridge, what needs to go to the fridge in plastic bags, what needs to get out of the plastic bags because it is going to get humid or moldy. (...) There are many vegetables coming throughout the year, so we have to really think about how to take care of each of them, and what is the best for them." (A)

Promotion policies: When products are losing freshness, or approaching the "best before" date, a few strategies are used. A few days before, products are sold with 20% discount, which is raised to 50% on the day before expiring. This practice is consistently observed. The purchasing coordinator explains it: "we definitely try as much as we can to discount stuff before it is too bad to be sold. So, profit second in this case, obviously." (B).

These products are also sold through "active selling", meaning actively asking consumers if they would like to take a product, that would be wasted otherwise. The shop manager describes how new cashiers are taught to do active selling: "Once you see that there is someone nice, and you are having this bond, and you feel there is good interaction, just give it to him, ask him whether he wants it or not, because we don't want to keep it in here. It is not in terms of being a good seller, it is just in terms of taking care of waste, and not keeping anything that is not needed at the shop". (A)

Informal redistribution: Once products have passed the "best before" date, or are in a state that is not saleable, but still edible, there are different ways to redistribute them. One way is active selling: "very often if there is something past the [best before] date, like dairy which is not vegan, and we have mostly vegans and vegetarians, we give it away directly. "Would you like to take some milk?" (...) So it is just talking to people. It is named active selling but it is just talking to people." (A)

Both co-op members, doing their duty, and clients are invited to eat or take these products: "There is no instruction for eating stuff that is going to waste, but people are really eager to take care of that, because they don't want it to go to waste. Because I think we share the same values and they just feel bad about food being wasted." (A)

Products without "best before" dates such as fruits, vegetables and bread, are placed in a "free" box, which is located at the entrance or outside the shop, and there are specific instructions about this process: "once you are closing up [the shop], if there is some stuff that is not saleable, and you are not taking it with you, (...) you have to take it out, and give it out for free. (...) "It [the "free" box] really works well at the second shop, because there are lots of homeless people and lots of really old people there, who just cannot afford. (...) I was observing the process of the local community getting used to this. At the beginning I think they were ashamed. You needed to close the shop and leave, and after dark the food was gone." (A)

Raven seems committed and concerned with preventing food waste, using a variety of strategies to use food before wasting, and it has no problems with redistributing products to employees, co-op members, clients, and local communities. Could such a strategy also work in conventional retail? While Filimonau and Gherbin (2018) mention that

Table 4
Different characteristics of AFN Raven and conventional retail.

Agents	Company/Co-op	Main drivers of the organizations	Conventional Retail	AFN Raven
Degree of flexibility Promotions Redistribution			Top-down corporate policies (Gruber et al., 2016). Imposed from the top, can lead to food waste (Gruber et al., 2016; Teller et al., 2018). Some retailers are involved in external redistribution, but it does not seem to be a standard generalised practice (Filimonau and Gherbin, 2018). Both refer that better handling of products is needed at the shops, by employees (and co-op members at Raven).	Non-profit organization. Balance between ethical guidelines, accessibility, financial viability and minimizing negative environmental impacts. Autonomous. Implemented to prevent food waste. Includes active selling. Internal, external and informal redistribution. Part of daily instructions.
Shop personnel			Regular consumers.	Co-op members and external consumers. Particularly co-op members are likely to share co-op values.
Consumers			Sometimes products arrive not fresh due to cold chain interruptions, poor handling in transportation, or longer transportation routes due to cost-efficiencies (Mena et al., 2011).	Direct relations with farmers and insufficient capacity to organize own deliveries' system result in limited frequency of deliveries. Less fresh products delivered in the end of seasons, reflecting a loyal relation to suppliers.
Suppliers			Managers feel constrained by legal aspects (Gruber et al., 2016; Holweg et al., 2016). Typically larger shops.	Legal issues were not mentioned.
Legal system			Large assortment of food products.	Smaller assortment of products, and no selling of meat or tropical fruits.
Shop size				
Products				
Infrastructure/ Products				

surplus food is sometimes donated to employees, they also explain that this goes generally against corporate policies, fearing that employees would be less motivated to sell the products, and also that this would be against staff health and safety. However, employees in conventional retail are not usually involved in selling the products to consumers, so it is not so clear how they could actively undermine sales.

Note that while the shop manager makes no references to legal concerns regarding food redistribution, usually legal issues are significant barriers to food redistribution in conventional retail, as mentioned in the literature review (e.g. Holweg et al., 2016). For retailers to donate unsaleable food to charities or other organizations, often legal arrangements have to be made between the organizations, so that retailers are no more liable for the food quality. In the case of Raven, the redistribution is not directed at other organizations or charities, but is directly done to employees, co-op members, clients, or passersby, who are duly informed if the products are expired. Recent legal arrangements at EU level also aim to make it easier for food donations to take place, as the Guidelines on Food donations attest: “Redistribution of surplus food and engagement in food donation activities may therefore be carried out by food business operators at each stage of the food supply chain. Food business operators (e.g. farmers, food manufacturers and retailers) may donate surplus food through redistribution organisations (such as food banks), gleaning networks and other charity organisations or directly to consumers themselves (e.g. employees).” (EU Commission, 2017)

4.3.2. Handling food waste

Raven has developed strategies to reduce food waste, but when food waste still occurs, it does not end up in municipal solid waste, but is composted (a handling method also mentioned by Filimonau and Gherbin (2018)). Three strategies were attempted: creating a local community compost, providing it to a supplier, or to a local permaculture garden.

The local community compost would be placed in the inner courtyard of buildings close to one shop. This idea was not accepted by the residents of the buildings, because they feared the compost would attract rodents and diseases.

The second strategy was to give away the food waste to a supplier, i.e. an organic producer. The co-op members knew that he collected organic matter for composting, and asked him if he could take the food waste from the shop, in his deliveries. This strategy worked well, except for the low-season in which the producer did not visit the shop. Hence, a third strategy was developed. One member of the cooperative knew someone who had a permaculture garden and was willing to take the food waste. So, throughout the year there are always one or two persons collecting the food waste to produce compost. This solution, especially the collaboration with the supplier, can be considered a “closed-loop” as the farmer retrieves food waste from the shop he supplies.

4.4. Personal views of shop managers

The shop manager at Raven declares that food waste at the shop is actually quite low, and that avoiding it is a concern shared by most members: “I don't feel that we are wasting food, so that's good. Because if I did... It is really heartbreaking for us once anything goes to waste. All the members, even not the workers, are also like "oh my god, I am going to eat it, I don't want it to go to waste", and we are cutting out the rotten stuff and we just eat it all together. We really care about that.”(A)

While the shop manager appears to refer to a moral burden (“It is really heartbreaking for us once anything goes to waste”), contrary to many shop managers in conventional retail (Gruber et al., 2016), the shop manager of Raven does not feel constrained when striving to reduce and handling food waste. Without strict corporate policies (often motivated by maximizing revenues), there is flexibility and autonomy to organize the prevention and management of food waste. In fact, it is mentioned that “profit is not really the priority” (A), something that makes sense coming from a non-profit cooperative.

4.5. Comparing AFN Raven with conventional retail

From a single case-study we are not able to evaluate the exact reasons for the low food waste rate in the studied AFN. However, juxtaposing the main differences and similarities between the AFN and conventional retail might shed some light on this issue. When juxtaposing food waste causes and management in Raven with those of conventional retail (section 2) a few characteristics stand out. The characteristics represented in Table 4 are structured along the elements of the conceptual framework of Fig. 1, i.e. they belong to the agents involved (company or co-op, consumers and suppliers), to the contexts, and to the infrastructure/products. The characteristics can influence food waste in different ways, and it is likely that the low values of food waste at Raven are explained by a combination of these elements.

The only characteristics shared by Raven and conventional retail is the handling of food products at the shop level. The main drivers of the organizations are different, and determine how priorities are set throughout the organization. The scale of conventional retail organizations is typically also much bigger than Raven, which results in top-down policies for promotions and orders, and provides only a small degree of flexibility for shop managers, aside from profit maximizing goals. The legal context was the only context explicitly mentioned as a barrier to food redistribution in the review of conventional retail, but it was not mentioned in the interviews with Raven. The small size of the shops might also contribute to reduced food waste, combined with a smaller inventory, and the fact that 40% of the food sales are done to co-op members, suggesting some loyalty of demand. However, the influence of the shop sizes might contradict current literature which has not found a significant correlation between shop size and food waste levels (Lebersorger and Schneider, 2014), or which suggests that smaller shops have higher food waste levels than bigger shops (Gustavsson and Stage, 2011; Beretta et al., 2013; Parfitt et al., 2010). Another possible explanatory factor is the fact that Raven does not offer meat products. For conventional retail, Mena et al. (2011) indicate refrigerated meat as one of the food categories with the highest food waste rates.

5. Limitations and future research

As we present a first exploratory research of food waste in an AFN, various limitations apply. First of all, there is an obvious need for future research to compare the results with other AFNs, both retail food co-ops and other types of AFNs.

Secondly, we compared Raven to conventional retail. However, Raven is more analogous to small-scale independently owned fruits and vegetables shops, also because of the independence that shop owners have in those contexts. While Gruber et al. (2016) and Teller et al. (2018) do study different types of shops, they do not provide quantitative data on food waste, focusing instead on food waste causes and management. Also, the smallest shops studied in these papers - convenience stores - are still about ten times larger than Raven's shops (areas up to 197m² (Teller et al., 2018) or 400m² (Gruber et al., 2016) in convenience stores versus Raven's areas of 25m² and 30m²). More research is needed on food waste quantities in small-scale independent shops.

Third, our research design did not allow to discern the impact of two key factors, i.e. the small scale of the initiative (which entails a certain level of autonomy) and its alternative approach to retail, based on co-op principles, involvement of members, and policy of direct orders. Thus, more research should be carried out both in large co-op supermarkets, and in small scale independent organic shops.

Fourth, there are no figures for the total amount of food redistributed at Raven, which leads to an overestimation of total food waste. While some studies refer to amounts of donated food by retailers to charities (Alexander and Smaje, 2008; Cicatiello et al., 2017), we did not find literature estimating informal redistribution within the shop

(to employees or clients).

Fifth, there is also an important question of self-selection. Members of the co-op are most probably more concerned with reducing food waste, which may partially explain their decision to join and their dedication to act. It would be interesting to examine to what extent participating in the co-op influences members' approach to food waste. On the other hand, even concerned consumers have very little impact on food waste practices in conventional stores.

Sixth, retail is only one of the stages where food losses occur. It would be interesting to study the losses in the full supply chain, to examine how AFN influences food waste on farms (with its emphasis on direct relations, but also on good food quality) and in households.

Finally, the definitions and methods used for food waste accounting significantly influence the levels of measured food waste. The composition of the food on offer is important. Conventional retail typically offers a higher share of processed non-perishable food than Raven, but also (fresh) meat, which does affect the total food waste rate.

6. Conclusion

In this case-study we have explored the food waste dynamics in the AFN Raven. Quantitative results showed that Raven had very low food losses, when compared to most studies of conventional retail. Specific reasons for this result are difficult to discern. Food waste causes show that Raven shares some food waste causes with conventional retail (e.g. unpredictability of demand), while its reliance on loyal relations to regional farmers can contribute to food waste, when products are delivered too ripe in the end of the seasons.

Possible structural explanations for the low food waste values could be the loyalty of customers which guarantees demand and the exclusion of some perishable products (e.g. meat, tropical fruits) from the assortment. Food waste management practices at Raven show a high degree of autonomy and flexibility, not often seen at the shop level in conventional retail. In Raven, when products are marked as food waste, they might still be sold with a 50% discount, or informally redistributed among the co-op members and clients. When the products are not taken nor redistributed they are collected for composting by a farmer and a permaculture gardener.

While structural reasons and food waste management strategies cannot solely explain the low food waste levels, two other factors might provide additional explanations: the degree of flexibility and the main drivers of the organization. In conventional retail, the lack of flexibility experienced by shop managers, and the overarching pressure and focus on maximizing revenues make it difficult to make food waste a priority. On the contrary, at Raven, there is autonomy, and the main driver of the organization is to balance financial viability, accessibility and ethics (including minimizing environmental impacts).

Looking beyond profit allows for a high concern with food waste, and the autonomy of the organization gives co-op employees and members flexibility and freedom to reduce and handle food waste. AFNs might be considered an institutionalized reflection of a societal need to reduce food waste. In times of growing complexity of various structures, where moral burden is a result of tension between personal values and imposed regulations and practices, AFNs create an opportunity for agency and ownership.

It should be emphasized that these results are based only on a single case-study. Future research is needed to assert the general food waste performance of AFNs. Our results suggest, however, that conventional retail would benefit from giving their shop managers more freedom to address food waste, and reducing the overall predominance of revenues as main concern for company decisions and practices. Social and environmental concerns, which are commonly endorsed in companies' CSR reports, should influence decision-making to reduce food waste, even if potentially impacting revenues.

Declaration of interest

Jakub Rok is a member of the association that has been studied in this paper. He is also partly employed there, working on the topic of internal evaluation systems. His participation in the studied organisation did not bias in any way the opinions presented in the manuscript.

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