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Food waste management innovations in the foodservice industry

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ABSTRACT

There is growing evidence that a significant share of global food is thrown away, with concomitant detrimental repercussions for sustainability. Reducing food waste is a key sustainability challenge for the food service industry. Despite the significance of this issue to the global foodservice industry, the link between innovation practices and food waste management has received limited attention in the academic literature. This paper uses innovation management and social constructionism to investigate interrelationships of food service provisions and innovations in waste management. It is based on the evaluation of food waste solutions and innovations that combine strategic dimensions of waste management with practice-driven initiatives, including incremental (processes and technologies) and radical innovations. The paper presents a range of waste management initiatives, showing that their implementation in the foodservice sector varies depending on management's beliefs, knowledge, goals and actions. The concepts discussed here could help practitioners to become more aware of the factors that drive the adoption of food waste innovations.

1. Introduction

Food waste is an ecological, economic and social problem. Every year some 1.3 billion tons of food are lost or wasted globally (FAO, 2013), representing a considerable share of the overall food produced (Lundqvist et al., 2008; Parfitt et al., 2010). Food wastage appears to be highest in developed countries (Buzby and Hyman, 2012), while on the other hand, there are an estimated 842 million people in poor countries experiencing chronic hunger (FAO, 2013). This raises the question as to whether food wastage could be reduced along food supply chains (Curtis and Slocum, 2016; Martinez-Sanchez et al., 2016; Muriana, 2017; Wilewska-Bien et al., 2016). In this paper, this is discussed for tourism, as a global food service industry, which is implicated in food consumption and waste generation (Betz et al., 2015). Focus is thus on the significant share of global food that is provided through food services in restaurants, fast food chains, cafés, cafeterias, canteens and dining halls, as well as event catering (Gössling et al., 2011; Hall and Gössling, 2013). The foodservice industry now employs more people than any single other retail business, including 14 million in the USA and 8 million in Europe (Euromonitor International, 2016) and serves billions of meals every year (Gössling et al., 2011). Therefore, the industry has a critical role in the global food waste challenge.

Food providers in gastronomy, catering and hospitality have recently come under increasing scrutiny over their food management practices, and specifically food waste, with evidence that considerable amounts of food are thrown away during preparation, or because they cannot be stored and reused (Betz et al., 2015; Hall and Gössling, 2013; Silvennoinen et al., 2015). Waste management has thus become a key priority, referring to all the activities related to avoiding, reducing or recycling waste, throughout the production and consumption chain (Papargyropoulou et al., 2016).

While there is a plethora of literature examining the antecedents affecting food waste management decisions (Arvanitoyannis, 2010; Bloom, 2010; Demen Meier et al., 2015; Hall and Gössling, 2013; Siorak et al., 2015), there have been limited investigations into the various practices and stages of waste innovation adoption by food service providers. This paper aims to examine two established theoretical paradigms jointly, facilitating an understanding of not only the several food waste innovations but also managers' propensity to adopt innovation. It is becoming increasingly evident that a waste management program, and especially a waste treatment innovation, that ignores social aspects of management and professional skills, is prone to failure (Heikkilä et al., 2016). This can be a barrier to the effective implementation of food waste innovations. As such, the overall aim of this paper is

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to determine innovative practices for food waste management in the food service sector, as there is limited empirical studies as to how food service firms address innovative management approaches to food waste (for an exception see Heikkilä et al., 2016). The study aims to reach its goal through the following two objectives:

1. Identification of innovative food management practices that contribute to the avoidance (reducing and rethinking), reuse or recycling of food waste in food service establishments.
2. Evaluation of food service manager's perspectives regarding the benefits of various food waste innovations.

In order to explore the innovative management practices for mitigating food waste, a qualitative method was employed in the study. Based on interviews with food service providers in Switzerland, the study offers a discussion of possible management practices in food waste and the range of incremental to radical innovations that can be found in the food sector. Such research is critical to better understanding how waste mitigation can be improved in the food service industry, in the sense that food waste is avoided, and a greater share of food reused or recycled.

2. Theory

2.1. Food waste management

Food waste epitomizes an unsustainable system of food production and consumption. Although food waste is a major global problem, there is not a consistent definition of food waste in the research literature. For the purpose of this study, food waste is defined according to the Food and Agriculture Organization of the United Nations (FAO) as the amount of food wasted in foodservice chains, with 'food' referring to "edible products going to human consumption" (Gustavsson et al., 2011). In food value chains, food can be lost or wasted during acquisition and storage, preparation, during and after serving (plate waste) (Betz et al., 2015). There is little agreement concerning the different categories of food wastage. Silvennoinen et al. (2015) divide food waste between originally edible and originally inedible, the latter referring to for example vegetable peelings, bones and coffee grounds. Beretta et al. (2013), divide food losses in avoidable, partially avoidable and unavoidable. Eriksson et al. (2017) distinguish source reduction (at the production level) and handling or management of "unplanned" food wastes.

Food loss and waste occur at each stage of the global food value chain, from agricultural production to final consumption, or what Papargyropoulou et al. (2014) define as the food waste hierarchy. Food production is linked to land conversion and biodiversity loss, energy consumption and greenhouse gas emissions, water and pesticide use (Cardinale et al., 2012; Tilman et al., 2001). At the post-harvest and processing stages, there is also waste in each step of the transport, storage, processing and distribution stages. Retail represents a considerable amount of waste in the food supply chain (Aiello et al., 2014). Yet, as Filimonau and Gherbin (2017) observe it is not seen as being of critical importance for grocery retailers. At the end of the food supply chain, final consumption including commercial and household accounts for as much as 40% of total food losses (Beretta et al., 2013). Current research on commercial activities focuses on the drivers of food waste generation and management (Betz et al., 2015; Eriksson et al., 2017; Silvennoinen et al., 2015). Finally, recent studies show that in the developed countries food is mainly wasted in the final consumer stage of the supply chain. Hence, extensive research has also addressed the relative importance of consumers' attitudes and behaviors toward food waste generation (for example Gaiani et al., 2018).

The fact that food waste is perceived as a mounting yet avoidable challenge has driven the United Nations to adopt target 12.3 as part of the 17 Sustainable Development Goals to "by 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" (UN, 2017). There is some evidence that such goals may be feasible (Beretta et al., 2013), though waste avoidance will be closely interlinked with management and consumption practices. To date, the research has discussed the importance of quantification—measuring food waste in the food supply chain, in order to grasp the real dimension of the problem, to identify the various sources of food waste and to define a baseline to monitor reduction over time (Beretta et al., 2013; Betz et al., 2015; Papargyropoulou et al., 2016; Silvennoinen et al., 2015). Further research is necessary to better define effective managerial solutions for food waste mitigation in foodservice.

2.2. Food waste in the food service industry: Incremental and radical innovations

As a subsector of the food and beverage industry, the foodservice industry includes companies that serve meals for out-of-home consumption. Euromonitor International (2016) considers this to include full-service providers (offer full table service, focus on food rather than beverages), cafés/bars (focus on beverages, offer a variety of snacks), take-away & delivery (eating on site is not possible), fast food (offer quick, standardized food which is ordered, paid for and often served at the counter), self-service cafeterias (located in corporate or school environments and offering a varied menu at a low price point), street stalls and kiosks (small and potentially mobile outdoor or indoor outlets with a limited offer and a low price point), and event catering (temporary off-site catering). Food retailers are not included in the foodservice sector, even though they are increasingly infringing on this segment by offering ready-to-eat meals in addition to food products whose preparation must be finalized by the consumer (Xerfi, 2012).

Food waste management in the foodservice industry is a complex phenomenon and spans a wide range of factors and activities. Yet, studies of food service waste management have not used consistent definitions, with for instance food waste calculations in Switzerland measuring calories (Beretta et al., 2013), while in Sweden, focus has been on weight (e.g. Gustavsson et al., 2011). One comprehensive typology is offered by Papargyropoulou et al. (2014) who grouped food waste into three categories: avoidable food waste, unavoidable food waste and possibly avoidable food waste. Avoidable waste refers to food that could have been eaten at some point prior to being thrown away. Unavoidable food waste refers to the fraction of food that is not usually eaten (for example, banana peels and chicken bones). Possibly avoidable food waste refers to food that is eaten in some situations but not others (for example, potato skins).

While there is good evidence about food waste quantification in foodservice (Betz et al., 2015; Papargyropoulou et al., 2016; Pirani and Arafat, 2016), the literature to date provides little information on how foodservice professionals – rather than academics – define waste and how they approach food waste management practices (Heikkilä et al., 2016). There is limited available data on managerial attitudes to food waste and existing mitigation practices in food service contexts, and existing research often includes other sectors of the food and beverage industry, such as food producers, manufacturers and retailers (see for example Cicatiello et al., 2016; Hyde et al., 2001; Beretta et al., 2013). For example, Filimonau and Gherbin (2017) have clustered managerial approaches to food

waste mitigation in UK grocery retailers around food donation, price reduction, customer awareness campaigns, and labelling and packaging.

While these initiatives reflect institutional and economic pressure to engage in effective waste management, they also reflect the incremental character of most industries' waste management approaches. Incremental innovations are step-by-step improvements with regard to existing processes and specific activities related to waste minimization (Beise and Rennings, 2005). They are related to focusing on reducing waste by either introducing process and operational improvements or developments in current technology. For example, Wang et al. (2013) develop green restaurant management standards, including green foods, green environment and equipment and green management and social responsibility. These initiatives vary in the degree of newness to the adopting firm and, for the most part, require a low degree of new knowledge (Dewar and Dutton, 1986). Others, like those related to the application of the Internet of Things network technology for improving food waste management (collection and transportation), require sophisticated management systems and involve high-level technical skills (Wen et al., 2017). One of the key elements of incremental innovation is that it harnesses existing business processes and technology so it is relatively less complex than radical innovation.

In comparison, radical waste innovations explore opportunities to significantly change waste management approaches, usually aided by technology. They represent clear departures from existing practices (Carrillo-Hermosilla et al., 2010). Radical innovations require extensive knowledge depth, more time, resources and commitment, and they involve greater risks for market uptake; yet, they can make far more significant contributions to environmental sustainability. For example, pulp and paper companies transform part of their waste into energy to increase resource efficiency. A more radical innovation would be to transform waste into value-added products. For example, Lampikoski (2012) discusses the benefits of a radical green innovation on the basis of carpets made of recycled material.

Hage (1980) suggested that there is a continuum of innovations that range from incremental to radical, and research in various industrial systems and processes (e.g. pulp and paper, energy, chemistry) proves that decisions to engage in waste management innovations are based on the firm's ability to mobilize organizational resources, to gain managerial support and to overcome potential resistance (e.g., Depledge, 2011; Rutten et al., 2009). However, few radical innovations will be adopted unless the firm has the internal knowledge resources (complexity and knowledge depth) to interpret and absorb them (Souto, 2015).

Until recently food waste has not been part of managers' practices. Management of waste requires creativity, procedures, awareness (beliefs, knowledge, goals and actions) and a certain form of improvisation—some forms of waste are anticipated others are not, only some are avoidable, several are hardly ever considered (Chou et al., 2012). The professional practice of a majority of foodservice establishments, whether restaurants or chains or canteens, is socially constructed and, as such, it requires reflection in action (Fig. 1). According to Dewey (1944), "reflection is a meaning-making process that moves learners from one experience into the next, each time with a deeper understanding of its relationships with and connections to other experiences and ideas. It is the thread that makes continuity of learning possible" (quoted in Rodgers, 2002: 845).

A reflection-in-action theory of waste management is thus considered useful to explain the experimental nature of much of the food service industry's approach to food waste. Reflection-in-action argues that reflection as a meaning-making process and action (Boud et al., 1985) are constructed as experience-interaction reality. Managers frame their practical experience to make sense of the realities and to provide solutions to them (Schön, 1987, Boud et al., 1985). Such awareness or reflective approaches to waste management–where they exist–consider food service innovation initiatives to be mostly reflective or experimental approaches to waste reduction and management. This results in a wide range of different approaches to waste management innovation, which is the focus of this paper.

3. Method

Data for this study was collected as part of a larger cross-sectional research project of innovative practices (of varying degrees and scopes) in several foodservice and hospitality companies. This study thus draws upon a combination of qualitative data collected from semi-structured interviews in Switzerland (Table 1). Focus is on Switzerland because the country is among the most advanced countries in Europe in terms of waste management initiatives, recycling awareness, and public interest in the topic (Beretta et al., 2013; Betz et al., 2015; Duygan et al., 2018; Joos et al., 1999). Interviews were carried out on the largest cities in the main Swiss cities, including Zurich, Geneva, Lausanne, Bern, Basel, Sion and Lucerne. The selection procedure was a mix of convenience sampling, as well as snowball sampling, i.e. where possible, respondents were asked to provide contact details of other food service providers and experts.

A total of 110 semi-structured interviews were conducted in two rounds in 2015–2016. Interview procedures ensured anonymity and confidentiality, were digitally recorded, conducted through a semi-structured interview template, and lasted 50–100 min. The first round of interviews included 21 interviews with engineers and experts from public or private waste management companies, politicians and local authorities, food donation coordinators,

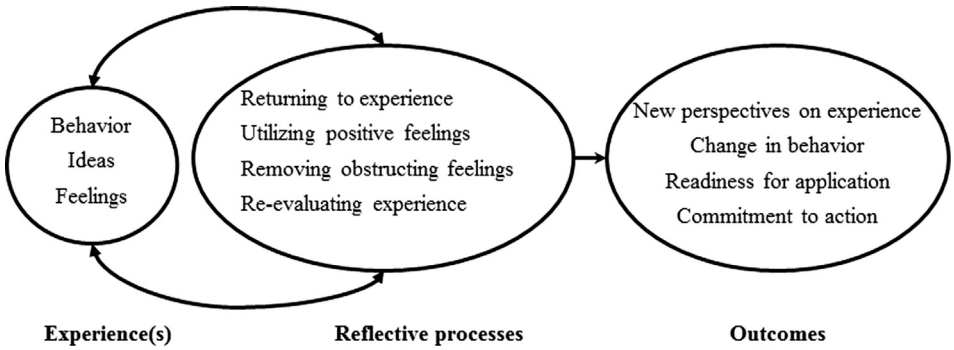

Fig. 1. Reflection as a meaning making process (Boud et al., 1985).

Table 1
Characteristics of interviewees.

Round 1		Round 2	
Stakeholders and experts	n = 21	Foodservice managers	n = 89
Engineers and experts from public and private waste management companies	(14.3%)	Independent restaurant (traditional full-service)	(49.4%)
Politicians and local authorities	(19.1%)	Chain restaurant (fast food and take away)	(19.1%)
Food donation coordinators	(9.5%)	Self-service catering (hospitals, schools & corporate)	(30.3%)
Experts in foodservice procurement & logistics	(19.1%)	Events (festival)	(1.2%)
Sustainability experts	(38.1%)		

Table 2
Data framing and elements identified through the analysis.

Food waste innovations	Food waste characterization	Waste management practices and logistics	Awareness of innovations
1. Incremental innovations – Process – Technology 2. Radical innovations	1. Sources of waste 2. Quantities of waste produced 3. Sorting and treatment of waste	1. Number and placement of bins 2. Storage spaces 3. Frequency of collection 4. Waste reduction measures 5. Waste management costs 6. Difficulties encountered 7. Staff (training, competences, commitment) 8. Supplier involvement	1. Financial costs and benefits 2. Changes in management practices 3. Disruption of business model. 4. Relationships with partners and stakeholders

experts in food service procurement and logistics, and sustainability. The interviews with the politicians focused on laws and regulations; they helped to clarify the existing legal framework and anticipate potential changes. The interviews with waste collection professionals explored logistics, technology, and restaurateurs' practices and challenges. Finally, the food donation coordinators answered questions related mainly to food waste-related practices in food processing companies, supermarkets and restaurants.

During the second round of interviews, food service professionals from 89 food service outlets across Switzerland identified innovations in waste management currently in use. Interviews included owners, managers and staff in independent companies, along with logistics, quality control and CSR specialists. All restaurant types were represented: full-service, fast food and take away, café/bar, self-service cafeterias (hospitals, schools, corporate), and events (Table 1). foodservice chains, catering, canteens and events. Both national groups and multinational chains were sampled. General questions concerned types of waste managed, challenges and innovations, client waste perceptions, and costs and barriers to food waste management. Another area of enquiry was management attitudes and motivations toward waste and whether introduction of different innovation practices resulted from the interaction of manager's behaviors-motivations-actions. Interview transcripts provided data on waste management innovative practices as well as on management strategic approaches to the complex sustainability challenges. Building on the work of Schön (1987), this work consequently draws on reflection-in-action theory of waste management to understand management's stance regarding waste-related innovation practices. Due to the reflective ("lived experience") nature of the foodservice industry's approach to waste management, a social constructivism approach sheds light on these experiences (Kukla, 2000).

Data collection involved a range of sources to triangulate the data (Mathison, 1988) until a stage of theoretical saturation was reached (Glaser and Strauss, 2009). The combination of interviews from multiple stakeholders to study innovations in waste management developed a more complete understanding of the phenomenon under investigation. It also fostered a deeper understanding of the emerging and experimental nature underlying most managerial approaches linked with waste management innovations. Data collection also included secondary data, such as company archives, annual reports and other internal firm material. Additionally, numerous informal conversations took place over the one-year period of fieldwork.

Interview data was analyzed to reveal those innovations, as described by food service owners. Within the context of pattern-matching logic as a general analytical strategy (Yin, 2014), innovation and implementation initiatives in food services were then clustered by theme (Table 2). The qualitative data collected during the interviews was analyzed through coding—a series of analytical processes linked to the grounded theory (Corbin and Strauss, 2008). Coding aims to recognize and relate the concepts to a category, to compare categories with the collected data, and to conceptualize the core issues that are the building blocks of theory (Glaser and Strauss, 2009). The study adopted the strategy of coding (naming and categorizing) data building on pre-defined themes based on existing innovation literature, as recommended by Yin (2014) and Eisenhardt (1989). Using the distinction between incremental innovations (processes and technologies) and radical innovations as deductive guiding analytical framing for our analysis, we coded our data in terms of food waste characterization, food waste management practices and management awareness to identify practices that would suggest some type of innovation. Such an approach provided a well-defined focus, facilitating the systematic collection of data and serving as a guide for data analysis. If we were unable to identify any type of innovation in a workplace practice linked with food waste, we discarded it as 'non-innovative' in the coding process. Following this process of generating a grounded theory, emergent practices were identified through the processes of reduction and rearranging of the data into more manageable and comprehensible forms according to the principles of innovation theory. Finally, incremental initiatives (both process and technology) and radical initiatives were mapped, synthesized and presented in the innovation food waste management framework discussed next.

4. Results

4.1. Waste characterization by food service professionals

The findings indicate that there is a split in managerial definitions of food waste. This is of relevance, as food service providers have a wide range of business approaches, from fast food to all-

inclusive, to gourmet cuisine; from take-away to buffets and catering. Depending on the approach, food service providers deal with very different types of food (fresh, cooked, frozen, sous-vides), delivered in very different types of packaging (paper, cardboard, plastics, PET, glass, aluminum or tinplate). Findings suggest that, irrespective of the type of establishment, the waste management chain in food services consists of five main steps: collection, sorting, storage, disposal (public or private), including transport of waste that is not collected by a public or private third party, but has to be brought to a waste sorting/recycling center. According to our interviews (Fig. 2), waste is mainly produced in kitchens and back-offices (trimmings and peelings, bones, packaging) or front-office operations (plate waste). Another important food waste that was highlighted during fieldwork is used cooking oil. The difference between the two main types of waste generated by foodservice activities, front office and back office, is that restaurants have virtually complete control over the food waste they generate during storing, packaging, cooking and testing, whereas the front-office is handled by customers as well. Of the waste generated directly at independent and chain restaurants and catering some is unavoidable, including bones, skin, peelings and trimmings. However, other food waste, for instance from spoiled foodstuffs, mismanaged cold chain, plate waste, or buffet remains is partially avoidable, considering rules for purchases, preparation and presentation.

Interviews indicated that the top three drivers for adopting waste management initiatives are favorable cost-analysis, experimentation with existing management practices, and change in the existing business model. The relevance of the last two drivers differed depending on the manager's engagement orientation—the transition from an uninvolved or a reactive cost-driven strategy to a proactive innovative orientation. Cost-oriented initiatives include sequential and gradual alterations to the core business practices based on cost-saving analysis. A proactive approach involves a set of innovations through which a firm either attempts to introduce new management practices or to disrupt the existing business model by continuously building sustainable waste practices. In the process of introducing innovations, professionals must continuously modify their business practices, processes and technologies.

In the eyes of restaurant owners/managers or chefs, food waste is thus primarily a cost factor, and mostly in terms of working time and purchasing cost. As food waste has a direct impact on cost, it is the area in which managers and chefs are likely to take steps to minimize waste. Similarly, there was consensus with regard to the effect of cost on managers' decision making. One common characteristic of managers in full service, take away and self-service establishments is that they prioritize price and quality over sustainability when choosing suppliers and products, and a majority of professionals do not know how much waste (non-) management costs them. The majority of interviewees reported that they did not measure waste quantities. Also, awareness is highest when establishments must comply with legislation, such as taxed bin bags (i.e. pay-per-volume charging systems). Most managers reported, however, that it is increasingly common to build partnerships for innovation by co-operating with other stakeholders such as suppliers, associations, local authorities, and waste management companies. These partnerships have the main purpose of minimizing costs, but they can also be driven by environmental principles.

In general, innovative prevention and management initiatives within the food service industry can be interpreted as being constructed around business imperatives rather than an ongoing commitment to sustainability. An important factor in the introduction of innovations relates to whether waste is perceived as avoidable (increasing motivation to manage it) and takes place in the front-office (customer's leftovers or big portions), back office (storage and manipulation) or kitchen (cooking and food management). Depending on these factors, managers approach food waste management differently by attempting incremental or radical innovations (examples are shown in Table 3). Specific process-oriented and technology-based innovations were frequently identified as suitable strategies for reducing waste production and improving waste management.

4.2. Incremental innovations: process and technology

The great majority of innovations discussed by managers are incremental innovations, including operational improvements and technological advances. The most common type of process innovation encountered were operational improvements, i.e. modification of one or more of the restaurant's processes – menu creation, ordering, and serving, including attempts to reduce and recycle waste. Not all process innovations are suitable for all types of restaurants, however. One example of a process improvement that reduces food waste is offering different (smaller) portion sizes. Rethinking the menu creation and ordering processes can be an

Where / Type	Front-office	Kitchen	Storage
Avoidable	- Plate waste - Unsold food (buffets)	- Poor cold chain management - Water and cooking food (e.g. burn food) - Food spoilage	- Food inventory (overstocking) - Production methods and storage
Unavoidable	- Non-edible waste (peelings, bones, skins, shells)	- Manufacturing or packaging defects - Unavoidable preparation waste	- Food scraps - Deficiencies in packaging and equipment

Waste management chain in foodservice:

Fig. 2. Examples of waste according to foodservice professionals.

Table 3
Summary of innovations in food service waste management identified.

Food waste innovation	Main goals	Management's awareness	Examples of innovations
Incremental • Processes	Food waste reduction and recycle	– Cost-oriented	– Offering different portion sizes – Training & development – Doggy bags – Composting – Landspreading – Inventive ways of using kitchen leftovers
• Technologies		– Investment relative to management practices	– Monitoring through careful ordering and planning – Applications and online platforms (food donations and end-of-day sales) – Tools and technology (intelligent trashcans and self-service equipment) – Zero-waste restaurants
Radical	Food waste rethink and reuse	– Disruption of existing business model	– Water (electrolyzing tap water) – Recycling of used water – Energy (luminescent carbon dots) – Packaging (hydrosoluble, edible packaging) – Food waste recycled into pharma, hair care products – Food waste transformed into additives, gasoline, fertilizer and ingredients

effective way to reduce food waste; but it requires coordination between the front-office and back-office. Allowing clients to adapt their order – and the price they pay – to their appetite is another way to reduce waste, and is in line with customers' growing expectations of personalized services. This is a strategy already in place in some fast food and take-away restaurants. It is a less suitable practice for traditional full-service restaurants, however, as incorporating this concept requires anticipation and inventory control, creativity and a well thought-through price scale.

In self-service cafeterias, interviews show that innovation is primarily driven by companies' desire to respond to their customers and to reduce cost and environmental impact. For example, a French mass catering company has created a set of rules to reduce plate waste in schools, where children benefit from its educational value. The children help themselves to starters and side dishes, and can ask the staff to adapt the meat and fish portions they are served; they are free to come back to the buffet as many times as they want. Cheeses and desserts come in pre-determined sizes. To progress from one course to the next, the children must have eaten everything on their plate; both their plate and their glass must be empty when they bring them to the washing station. Managers, however, did not discuss that buffet-type restaurants usually have high food waste levels due to losses in serving (e.g. Papargyropoulou et al., 2016).

An example of an innovation mentioned in independent, à la carte restaurants are 'doggy bag' offers, to take away whatever is left on plates at the end of the meal. A successful practice to reduce waste, doggy bags are commonplace in North America, but largely unknown in most European countries. In France, where seven million tons of food are thrown away every year, the government passed new legislation in 2016, and restaurants are now legally obliged to provide doggy bags if requested by customers. Interviews with managers with experience in French food services revealed that customers are not reluctant to take leftovers back home, and the bottlenecks have been restaurant-specific policies refusing doggy bags. Several restaurant associations have for this reason developed guidelines (DRAAF, 2014) or launched consumer awareness raising initiatives such as 'Good here and at your home, ask for your leftovers' ["*Bon ici et bon chez vous, demandez vos restes*"] to improve the image of doggy bags and to overcome psychological barriers. Respondents mentioning this practice did not discuss whether food would be consumed or not, and doggy bags might simply transfer a waste-related problem from establishments to consumer households, while also adding to packaging waste.

Finally, drawing inspiration from the trash-to-table movement and culinary practices developed by zero-waste restaurants around the world, restaurant staff can reuse parts of products that are traditionally considered waste. By means of reusing waste in the kitchen, for example, it is possible to use bones and seafood shells to make broth and to turn some peelings and trimmings into soups, juices, compotes or purees. Together with composting and landspreading (distributing food waste on land), such initiatives were reported by a number of restaurants interviewed. Besides process improvements, incremental innovations include technological developments related to composting like, for example, the use of technologies for food waste-to-energy conversion involving biological, thermal and thermochemical technologies (Pham et al., 2015).

Other technological developments deal with new kitchen appliances and social media for waste management solutions (see Table 3). Many of these innovations have now become central elements in food service sustainability strategies. Compared to process innovations, technological innovations are met with greater resistance by food service managers; as evident from interviews with managers and chefs, restaurants perceive technological and IT tools as foreign to their business and they are reluctant to embrace and incorporate them in their daily operations.

Yet, technology can help in reducing or recycling packaging waste include smart trash cans, with examples including Canibal, LemonTri, or R3D3. Intelligent trashcans are able to sort and compact several types of packaging waste linked to beverages: PET bottles, plastic cups and aluminum cans. Some models can sort up to 30 items per minute, the material is stored in the machine and regularly collected by the company to be recycled. Other kinds of trash cans do not sort waste by material, but separate liquids from the solid waste (e.g. 'Superlizzy'), thus enabling better waste treatment and recycling practices. These trash receptacles are especially suited to fast food restaurants and self-service cafeterias. As an incentive for customers to recycle, some of these devices reward users, for example by offering vouchers for free or discounted drinks.

Other technological innovations aim at reducing waste on the clients' end of the chain. Manufacturers in commercial kitchen equipment like Vollrath, ITW Food Equipment Group in the US or AB Electrolux in Europe race to commercialize innovative cooking

and serving equipment. These innovations include biodegradable and compostable self-service equipment and utensils (including plates, bowls, cups, napkins and cutlery organizers and dispensers for cup, lid and straws) as well as of certain portion-control products like sweeteners, toppings and spreads. These products are also fully recyclable which helps reduce the amount of waste in landfills (Fieschi and Pretato, 2017). Behind these equipment and procedure innovations there is a desire for sustainability paired with inventory control.

Technology may also help in reducing food waste by dealing with leftovers, and in doing so reduce the amount of food waste restaurants have to manage, increase profits, and develop a new customer base by promoting a positive image of the establishment. These innovations are tools that facilitate two already existing, but rarely exploited, options: food donations and end-of-day sales. Donating food is more common in the F&B retail industry than in restaurants; interviews revealed that restaurant managers and chefs considered food donations unfeasible because of health-related issues, as well as potential legal or reputational setbacks. However, food that has left a restaurant is no longer its legal responsibility in many countries (e.g. Switzerland), indicating that barriers may be perceived rather than real, and more likely linked to branding and reputation concerns. Newly developed applications and online platforms simplify the food donation process and can help to improve perceptions of donations. Examples include Zero Percent, Food Cowboy and Copia, which make logistics easier, including product listing, communication between stakeholders, pick-up and delivery of donations. They also keep track of the food donated so that restaurateurs can benefit from tax deductions. Moreover, because these professional support systems must comply with legal restrictions, they are likely to reassure food service professionals that health issues are adequately considered.

End-of-day sales are not a recent innovation: they are common in supermarkets and in some F&B retail companies in Europe and the United States. Some independent and chained restaurants have for instance implemented daily price reductions before closing time to incite customers to buy the remaining products. As an example, the British chain Itsu discounts all food products 30 min before closing, in both its shops and its restaurants. In this case, technology simplifies an already available measure: there are now many software applications like PareUp (USA), FoodLoop (Germany), Optimiam (France), Justoclic (France), MOGO (USA), or Foodzor (Belgium, exclusively for event caterers) that allow restaurants to list products that they are about to throw away so that consumers can buy them, usually at a discounted price. Information and communication technologies thus facilitate and increase the attractiveness of pre-existing but impractical or unpopular food waste reduction measures.

4.3. Radical innovations

All measures outlined in preceding sections are incremental innovations, i.e. they rely on marginal process and operational improvements, or take on solutions from related sectors. In contrast, radical innovations have the potential for more substantial change, as they can be disruptive in the sense of fundamentally changing an approach to a given task or issue (see Table 3). The number and variety of radical innovations were reported by experts from public and private waste management companies, food donation coordinators and sustainability experts. Only 15% of food service managers were aware of radical innovations. Most of these more radical innovations appear to be supplier-driven, because they rely on new technologies or processes that have been developed by companies specializing in such innovation. In what follows, we will explain examples of radical innovations taken from interviews during the two phases of data collection. Experts mentioned a variety of possible innovations ranging from transforming coffee grounds into hair care products, food waste transformed into ingredients and additives, LEDs or fertilizers (through means other than anaerobic digestion) to organic waste transformed into fodder additive or into gasoline. Experts observed that most of these innovations could probably be applied more widely at catering facilities and take-away establishments than in full service or event organizations.

An example of a radical innovation that can be implemented by food services is electrolyzed water (Fig. 3). Electrolyzing tap water containing dissolved sodium chloride results in two kinds of water: alkaline water, which is an effective cleanser, and acidic water, which can be used as a disinfectant/sanitizer. These two types of water can be used for very different purposes: in a restaurant, they can be used to clean and disinfect floors, work surfaces, utensils, food products, or to wash hands. There are electrolyzers made specifically for restaurants (e.g. Hoshizaki's ROX system, Tennant's ec-H_2O and ec-H_2O NanoClean, Enagic's LeveLuk series); the smaller models connect to the kitchen sink, while the larger ones have their own connection to the water supply. Electrolyzed tap water has been available on the market since the 1990s, but has not been used in the foodservice industry, and is considered a radical innovation because it makes a whole group of substances, i.e. cleaning detergents, superfluous. A problem common to most of these radical innovations is that they are time consuming—the entire process must be monitored frequently to ensure the quality and reliability of the innovation.

Another radical innovation mentioned during the interviews that is already available on the market is hydrosoluble packaging. As an example, MonoSol has created Vivos® Films, an edible pre-portioned delivery system for a wide variety of food products: spices, pasta, flour, instant coffee, or food coloring. This type of packaging protects food products like traditional packaging, but dissolves in water and other aqueous solutions (milk, alcohol, or juices), and thus reduces packaging in need of disposal. The material is robust, transparent, odorless and tasteless; since it is made from starch it can be consumed without health consequences. As pre-portioned pouches can also accelerate and simplify preparation, this packaging has the additional advantage of saving time.

Yet another example of a radical innovation that affects the other most common type of waste in the food service industry is the possibility to transform food and beverage remains into lumi-

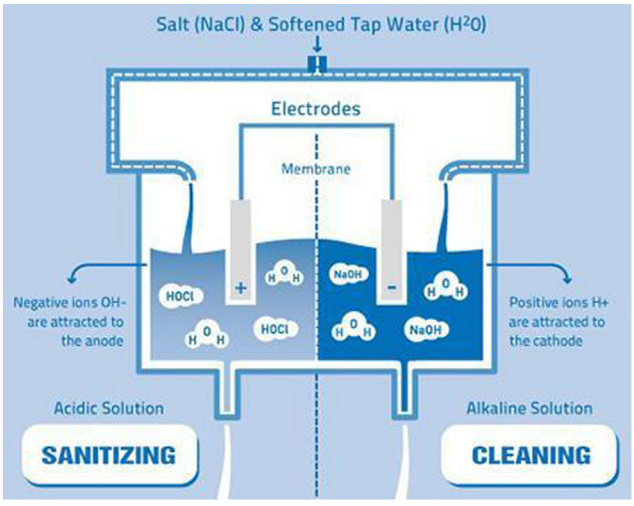

Fig. 3. Example of radical innovation: Electrolyzed water. Source: Food Safety Magazine, 2014.

Table 4
Analysis of constraints to adoption of innovations.

Constraint factors		Independent (56)	Chain (17)	Collective (15)	Event (1)	Total (89)
Internal	Lack of space	19	4	5	0	28
	Infrastructure	0	0	1	0	1
	Amount of waste	1	0	0	0	1
Human capital	Lack of time or staff	8	2	3	1	14
	Lack of motivation/skills among staff	7	8	3	1	19
External	Uncollaborative customers	5	2	6	1	14
	Attitude of suppliers	11	3	3	1	18
	Organization of collection	4	0	0	1	5
	Costs	13	1	4	1	19
	Recycling technologies available	0	1	2	0	3
	Image	3	1	0	1	5
Legal	Sorting issues	7	1	1	0	9
	Hygiene	6	2	1	0	9

Note: Numbers in parentheses are the total number of interviews on which the answers are based.

nescent carbon dots and their subsequent transformation into light-emitting diodes (Sarswat and Free, 2015). LEDs transform electricity to light by using quantum dots with luminescent properties. Quantum dots can be made with numerous materials. Scientists have successfully turned food waste such as meat or pasta into quantum dots, and subsequently, LEDs (Sarswat and Free, 2015). While large-scale applicability is uncertain at this point, the approach can serve as an example of a radical innovation in the food service sector.

4.4. Practicality and impact of innovations

As illustrated in Table 4, interviews showed discrepancies regarding the practicality and feasibility of innovations described by experts and food service professionals. Interviews reveal that constraints vary depending on several aspects, including external and legal factors (e.g. local, city-specific legislation) and internal and human capital factors (e.g. restaurant type and size, and staff's lack of skills and motivation). Specifically, the most frequently cited problems by managers were: lack of space (by 28 out of 89 restaurant managers, the majority of which were independent suppliers), lack of time or staff (14 restaurant managers, both independent and chain suppliers), lack of competence or motivation amongst the staff (19 managers of chain restaurants and catering), customers being uncooperative (mentioned by 14 managers of restaurants and event organizations), suppliers' attitude (18 restaurant managers), and high costs (19 managers from independent and chained restaurants).

5. Discussion

This study has sought to identify management practices and innovations in food waste minimization currently used by food service firms, including reuse and recycling, and discussed them in terms of their contribution to incremental or radical innovation. Results show that interest in innovation as a systematic process to minimize waste and facilitate waste management is limited. Foodservice providers implement innovations based on a cost-saving analysis. Interviews highlighted a general lack of concern and knowledge about waste management and confirmed the principles derived from social constructionism and reflection-in-action theory (Schön, 1987) that food service professionals face an array of daily organizational and financial challenges linked to waste sorting, storage and disposal, and that they mostly count on their practical experience to cope with them (see also Hall and Gössling, 2016). Findings suggest that management teams within foodservice firms approach waste reduction from a practical, experience-based approach, but there is no systematic implementation of waste reduction strategies based on forms of institutional knowledge. This type of reflective approach hinders the development of innovations with the potential to challenge the business model and/or disrupt current management practices. Foodservice establishments face a "dual transformation" to address the major operational dilemma for incumbents on whether to innovate to improve value propositions to existing customers or to innovate to create disruptive revenue streams for the future.

In order to implement food waste innovations organizational changes must be made regarding not only what is managed, or how it is managed, but the goals the organization is seeking to achieve. According to Schön (1987), observation and experience provide a continual flow of information through which one can come to reflect on one's goals and actions. Schön highlights the relationship between learning and action, that is, between thinking and doing, as the necessary steps that an innovative manager must take to provoke changes in the theories-in-use that underlie current 'non-sustainable' wastage actions. It is clear that the introduction of radical innovations around a disruptive business model requires shifts in the level of resources allocated to food waste management, combined with the establishment of higher sustainable standards to organize service delivery around principles of waste minimization (Evans et al., 2017). As such, all discussion of sustainability in the foodservice sector, including sustainable innovation, is socially constructed and reflects three specific spheres: intellectual concerns, organizational priorities and policy agenda choices (Redclift and Woodgate, 2000). One major obstacle in introducing innovations is the difficulty in reconciling the tensions between these three diverse and often contradictory objectives.

Results indicate that effective waste treatment and reduction requires a comprehensive approach to foodservice waste management that may include process, technological and radical innovative actions. This approach is linked to a growing awareness of the importance of this topic among professionals, if only because of recent public policy changes, such as the introduction of taxed garbage bags or by-weight payments for garbage collection in many regions. Most professionals in our study therefore appear to welcome waste management innovations and initiatives that help them to reduce the variety, volume and weight of waste, and hence its range of direct and indirect costs. However, food service providers in our study are not aware of the benefits of radical innovations mainly due to incomplete information, coordination and organizational problems. This is consistent with existent research on the topic (Mousavi and Bossink, 2017; Porter and Van der Linde, 1995). Table 5 summarizes the opportunities of

Table 5
Opportunities for implementing food waste innovations.

Innovations		Type of establishment			
		Independent restaurant	Chain restaurant	Catering (self-service)	Events
Incremental	Operational	++	++	++	++
	Technological	+	++	+	+
Radical		+	++	++	+

implementing food waste innovations by different types of food establishments. In general, high costs and low levels of adoption hinder the development of food waste management systems, particularly among independent suppliers and event (festival and tourism) organizers (Hottle et al., 2015).

By applying the innovation level framework in the context of food waste, this study suggests that the incremental-radical nature of food waste innovations is central in the process of identifying the most appropriate approaches and initiatives for addressing the food waste challenge. From an experience-based perspective, these two different rationales to innovations are dynamically stable: waste management innovation still occurs but is of an incremental nature, leading to cumulative operational and technical initiatives. Innovation in the foodservice industry is mainly incremental, due most probably to the fact that in general firms are more inward-looking with regard to improving their food waste initiatives and related technology. Current low levels of involvement in waste management are reflected in behavioral and managerial engagement. Motivations, attitudes and values related to waste are more present among professionals, with price and cost reduction being one of the most powerful motivating factors. Radical innovations usually emerge from outside the industry, require the largest initial investment, extensive coordination between stakeholders and significant changes in management behavior. Their implementation also usually take longers than that of incremental innovations, which means they require more planning and making a conscious effort to align them with other sustainable practices.

One important finding the study highlights is the importance of a closer collaboration between traditional food service providers and the collaborative economy. This has been illustrated on the basis of several specific initiatives. The examples underline the importance of bringing together different (and sometimes competing) stakeholders, and combining between them innovation types and innovation generation and adoption with greater efficiency. This is consistent with existing research that refers to waste management as a global issue and a political priority that requires multiple stakeholders to take responsibility (Wilson and Velis, 2015). Case studies indicate opportunities for building alliances that can develop and implement technological and disruptive innovations, with anticipated benefits for food service providers. Specifically, firms in the collaborative economy hold key roles as partners that may facilitate food & beverage firms to proactively approach waste avoidance, reuse and recycling. As examples show, the collaborative economy provides tools and opportunities for co-operation in waste management, especially in areas of technological innovation, like food donations (for a review see Schneider, 2013). In the near future, technological innovations are expected to become increasingly relevant for effective waste management. These innovations aim to provide faster responses to market/customer demands and, to do so, will rely on the wider use of IT tools, social media, and digital approaches for food service issues.

There are sizable differences in how collaborative firms and traditional firms in foodservice approach the waste management challenge. The collaborative economy is targeting the food waste problem and offering initial solutions to it (Belk, 2014). Mobile apps develop new services to reduce domestic food waste, while, in alignment with their marketing strategy, they hold the traditional hospitality industry responsible for the overall waste management problem (Farr-Wharton et al., 2014). These apps intend to influence consumer knowledge and encourage change toward more sustainable behaviors to reduce food waste. Sharing and collaborative consumption firms have diversified the problem by offering a social media system integrated in consumers' daily activities for efficient food waste prevention.

Foodservice is a labor-intensive activity where innovation has tended to be slower. Hence, food service establishments can benefit from other firms and institutions by sharing knowledge, insights and experiences. According to the reflection-in-action theory, such collaboration would imply a reduction in the learning curve, enhancing cost effective waste solutions, reducing duplication of effort and resources, and leveraging opportunities for further developing innovative tools. As most experts contended during our interviews, involvement from all stakeholders is required to channel and solve the food waste challenge, particularly in producing effective incremental and disruptive innovations for waste management.

There are several limitations that can serve as motivations for future research. First, the sample size is limited to restaurant managers and experts in Switzerland. Yet, findings and analysis offer generalizability beyond the limited country scope. We believe additional research that examines different innovative practices regarding waste management would be fruitful for this line of research. Finally, more research needs to examine different types of waste management innovations and sources of collaboration between collaborative firms and traditional organizations.

6. Conclusions

The objective of this article was to review approaches to waste management in the foodservice industry with the aim to identify innovations and to discuss their implications for waste management. A key finding is that many companies are not actively innovating in the waste domain. They are however increasingly aware of the economic and social importance of waste management. Organizations taking waste management seriously might gain significant efficiency by partnering with third-party companies or by borrowing solutions from other industries that can be adapted to food service establishments relatively easily. On the downside, the foodservice industry is not leading the way when it comes to innovation. As the study shows, there are only a few low- or zero-waste restaurants, a few chefs who are creating meals with food scraps. This paper consequently provides managers with a set of tools (i.e., practices from several companies committed to adopting waste initiatives) to deliver a reflection-in-practice approach to waste issues pertaining to food service firms.

This lack of clear, common definitions and consistency across studies might be one of the reasons for which the foodservice sector lags behind other industries when it comes to food waste management. It also calls for tools and concepts to design the innovative practices supporting effective waste management systems. Future research may address such tools and concepts, as well as different types of innovations and sources of co-operation

between collaborative firms and traditional food service organizations.

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