

How to Manage HoReCa Food Waste by Using Digital Technologies?

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Abstract

The hospitality, restaurant and catering (HoReCa) sector is one of the largest producers of food waste globally. This paper aims to identify how digital technologies can be used to manage food waste in the HoReCa sector as well as the digital tools available. Digital tools powered by Artificial Intelligence, Internet of Things and Big Data, such as smart software solutions for storage spaces, cameras, sensors, along with mobile apps, are able to improve foodservice units management regarding food waste. Significant quantities of food can be saved by automating waste tracking, inventory management and delivery times, kitchen processes and redistribution. Many technology providers developed a large variety of digital tools addressed to different activities inside the restaurants. The paper concludes that adopting digital technologies is very important in food waste management and HoReCa sector can use various digital tools.

Key words: food waste, HoReCa, digital technologies, digital tools, management

J.E.L. classification: E30, L66, M10, M11, M12, M54, Q01, Q50

1. Introduction

Food waste (FW) has become a global concern for practitioners, policymakers and academics from a variety of academic fields in the previous decade (Reynolds *et al*, 2019, p.7). Particularly for consumption stage, FW can be found in households or in HoReCa industry (home eating and dining out) (Betz *et al*, 2015, p.218). A considerable amount of the 1.3 billion tons of food waste produced annually worldwide is attributable to the HoReCa (Hotel, Restaurant, Catering) industry (Danon *et al*, 2019). Given that this sector accounts for roughly 12% of all food waste, it is quickly emerging as an important issue. Additionally, due to the rising popularity of eating out, which is being fueled by rising incomes and tourism, HoReCa food waste (HFW) is now a significant problem for both developed and developing nations (Dhir *et al*, 2020, p.2; Wang *et al*, 2017, p.2). In order to reduce HFW, specific procedures connected to the operations of HoReCa businesses and consumer behavior were identified by the scientific literature. The analysis of HoReCa enterprises may comprise three phases: before-kitchen phase (FW in the storage facility and during storage preceding meals preparation), in-kitchen phase (FW during meal preparation) and after-kitchen phase (plate food waste). In the first two phases, FW is heavily influenced by firm business practices and supplier interaction. FW in the third phase is primarily determined by consumer behavior (Buczacki *et al*, 2021, p.6) In general, many HoReCa units adopt FW reduction strategies, such as assessing and engaging employees, revising inventory and purchasing methods, repurposing additional food and minimizing overproduction. Therefore, foodservice companies should prioritize continually menu adjustment, ingenious reproduction, prevention of overcooking, food donation actions to employees

or charitable organizations, marketing initiatives and implementation of the possibility for ordering smaller quantities (e.g. for children) (Buczacki *et al*, 2021, p.6; Erfe, 2018; Okumus, 2019, p.295; Vizzoto *et al*, 2020, p.268).

In order to decrease FW, numerous digital technologies can be adopted to enhance vertical collaboration between the technology user and other participants in the agri-food supply chain (Ciccullo *et al*, 2021, p.4). Technological advancements play a crucial role in waste prevention, minimization and re-use, as well as in the valorization of inevitable FW by recycling or recovery. Digital technologies addressing FW reduction and reuse at the consumer level have several goals, including extending the freshness of food products, reducing surplus food generation in retail, residences and HoReCa, increasing, as well as improving the efficiency of surplus food redistribution. Moreover, FW reduction solutions include technologies for food preservation, smart labelling and packaging, consumer-focused smart gadgets and food-sharing apps. Technology is crucial for improving the accuracy of any action performed in the HoReCa industry to reduce FW (Samsuddin *et al*, 2022, p. 6; UNEP DTU Partnership and United Nations Environment Programme, 2021).

Thankfully, technology is transforming the HoReCa industry in more manners than most people realize. Digital technologies, such as Artificial Intelligence (AI), Internet of Things (IoT) and Big Data, have specifically brought up new potential for this sector to reduce FW (Gull *et al*, 2021, p.4; Total Food Service, 2023).

2. Theoretical background

In terms of waste management, FW management has been ranked first. It is a serious topic that is constantly debated around the world. The quantity of FW generated is expected to increase by 1.9% between 2015 and 2030. To prevent rising waste, the food supply chain requires a digital transformation. To avoid negative consequences on the economy and environment as well as to prevent rising waste, it is crucial to develop effective FW management solutions, which can be enhanced by implementing a digital transformation (Lewis, 2022; Samsuddin *et al*, 2022, p. 1; Tomra, 2020).

Digital technologies have transformed the operations of most businesses and supporting the development of new business models aimed at increasing company profitability. The usage of digital solutions helps to store and distribute various forms of information, promote networking among businesses and plays a role in facilitating transactions of products and services between them. Therefore, acting as an intermediary between markets, digital technologies can store, share, manage, display, etc. data obtained from a variety of sources. They include the use of Big Data and IoT (enabling instant access to massive databases and facilitating connectivity between devices), as well as AI (providing high-quality information for sharing). These technologies can play a crucial role in FW management (Ahmadzadeh *et al*, 2023, p.1; Annosi *et al*, 2021, p.210; Martin-Rios *et al*, 2022, p.2; Ryax Technologies, 2023; Yoo *et al*, 2010, p.726). Since 1983 it has been asserted that HoReCa industry, especially restaurants, would undergo an automation revolution. Consumers, businesses, and society have shown an increased interest in adopting new technologies, such as AI, IoT and Big Data, over the past ten years. The HoReCa industry has also been showing an increasing amount of interest in these technologies (Nozawa *et al*, 2021, p.2) AI can be defined as the simulation of human intelligence processes by machines, particularly computer systems (Burns, 2023). For instance, the capability of computers to learn from previous experiences and teach themselves new abilities and behaviors is known as AI. The AI subfield, Machine Learning (ML), is centered on using algorithms and data to mimic how humans learn. When it is possible to identify process behavior from data, it is valuable. By processing a substantial volume of unstructured data (Bigdata) and finding patterns in data, computers can be trained to do specific jobs using AI. In order to generate a vast amount of data, the IoT makes device connectivity easier, allowing AI to make an assessment based on those patterns found (IBM, 2023; Sarabi, 2020).

By adopting an IoT ecosystem, the world becomes intelligent and embraces each aspect of existence. Thus, it becomes smarter and more intellectual as a result of this technology's use in businesses, workplaces, banks, supermarkets, security fields, hospitals, public spaces, as well as in HoReCa sector, especially in restaurants. Kitchen, the place where food is cooked and provided to

consumers to feed them, serves as the central component of the restaurant automation. However, the biggest issue is FW. Control, monitoring, and management of FW are notably important. By using IoT sensors and modules in order to create data and finding correlations and patterns in it through AI, HoReCa industry can be assisted in tracking and minimizing FW as well as in cost management, portion control and error reduction. But the potential for applying these digital technologies in the HoReCa sector can be much more useful in FW management (Berezina *et al*, 2019, p. 191; Gull *et al*, 2021, p.1) Being more specific, along with tracking food, management tools like optimizing food inventory and delivery times, creating smart menus, measuring recipe size accurately, automating the kitchen, improving smart storage and redistributing food can be acquired through the use of digital technologies (Bourke and Hymers, 2022; Mark Kubriak, 2023; Synergy Restaurant Consultants, 2023; UNEP DTU Partnership and United Nations Environment Programme, 2021).

3. Research methodology

This paper presents a systematic review of the literature on how digital technologies can be used to manage food waste in the HoReCa sector, along with some examples of digital tools available today. The research materials for this study comprise academic journals, government reports and industry reports. The academic journals were sourced from electronic databases such as Scopus and Google Scholar. The government and industry reports were sourced from the relevant websites, such as Restaurant Technology News, Total Food Service, Synergy Restaurant Consultants. The analysis of this phenomenon served to emphasize the food waste management in the HoReCa sector by adopting digital technologies and to provide an overview of some useful digital tools.

4. Findings

The tremendous expansion of data availability as well as of the methods for interpreting data have changed the service business (Cohen, 2018, p.1710). The incorporation of digital technologies into the food supply chain has been identified as very important for FW management (Annosi *et al*, 2021, p.210). Nowadays, digitality plays a significant role in the HoReCa industry in order to manage FW that cannot be ignored. As HoReCa industry is challenged by sustainability, foodservice units are required to build longer-term strategic plans as new management methods and behaviors regarding FW. (Martin-Rios *et al*, 2021, p.3; Roy *et al*, 2022, p.3688). A broad collaboration between foodservice enterprises and technology providers is useful (Calabrese *et al*, 2018, p.786). Technology suppliers are able to create data and apps that offer information about FW and show the benefits of digital solutions regarding food surplus management to foodservice organizations.

Development of innovative technologies to enhance the quantification, reduction and valorization of FW has been a part of the technological race for sustainable solutions in the HoReCa industry since 2010 (Martin-Rios *et al*, 2021, p.3; Martin-Rios *et al*, 2021, p.5). According to specific database related to FW management by using digital technologies, including scientific articles (Ahmadzadeh *et al*, 2023; Annosi *et al*, 2021; Celli *et al*, 2022; Goossens *et al*, 2022; Martin-Rios *et al*, 2020; Martin-Rios *et al*, 2021) and dedicated web resources there were identified the main values of the most known digital technologies and the essential features of some existing digital tools. Table 1 summarizes the key features of ones of the most representative digital tools for FW management in the HoReCa industry.

Table no. 1 The essential features of the most representative digital tools for FW management applicable in the HoReCa industry

Company name	Specific procedure to manage FW	Process category
Selfly Store	Intelligent storage areas featuring expiration date management function	Waste tracking
Kitro	Machine learning-based classification of FW	Waste tracking
Leanpath	A network of tracking stations for measuring FW	Waste tracking

Orbisk	Quantifying and automatically identifying the type of food that is thrown out	Waste tracking
5-Out	A software designed to improve purchasing decisions by forecast consumers' demand	Optimizing inventory and delivery times
Satis AI	A tool for avoiding mixed up orders	Optimizing inventory and delivery times
Distancematrix.ai	A tool for time delivery optimization	Optimizing inventory and delivery times
Meez	Digital platform for easy recipe organization	Kitchen automation
FoodOP	IoT-based platform designed for smart menu planning	Kitchen automation
Zerynth	Assisting restaurants in keeping perishable food fresh and safe.	Kitchen automation
Too Good to Go, Karma, Breading	Solutions for saving valuable food products by selling them at a discounted price	Food redistribution
The Food Rescue US, Goodr	Solutions for donating the surplus food to charity causes	Food redistribution

Source: own preelucration after (5-Out, 2023; Bozhinova, K., 2018; Corbo and Fraticelli, 2015, p. 137; FoodOP, 2023; Kubriak, 2023; Martin-Rios et al, 2021, p.6; Meez, 2023; Oddbox Team, 2021; Orbisk, 2023; Selfly Store, 2023; UNEP DTU Partnership and United Nations Environment Programme, 2021; Zerynth, 2023)

These digital technology providing companies support the transition of foodservice units from traditional measurements made with paper and pens to digital ones, optimization of inventory and delivery processes, automation of the restaurants kitchens and provide methods for food redistribution. The previously stated digital tools were grouped in four categories regarding process category in which they are applicable.

4.1. Waste tracking

By taking into consideration that the largest quantity of FW in foodservices comes from leftovers, it is essential to be adopted waste-tracking solutions. There are several methods for measuring FW. The first option is to employ manual or semi-automatic instruments, including paper forms, tables or websites. The second option consists of employing automated instruments or waste management systems (Eriksson *et al*, 2019, p.3; Goossens *et al*, 2022, p.2).

Firstly, numerous restaurants track manually when food is about to expire, which wastes a lot of assets. Monitoring expiration dates in almost real-time as well as developing automated sign-off sheets can be achieved adopting automation solutions powered by AI. These systems leverage data generated by kitchen personnel to automatically sync with software for inventory management based on existing information. In this way, restaurants gain knowledge about what products are still able to be used and, more crucially, the time until expiration date (Total Food Service, 2023). Being based on RFID technology, Selfly Store company provides storage spaces specifically designed in expiration date management, aiming to assist food business in reducing FW. The connection between Selfly Cloud and Selfly Intelligent Cabinet, both of them being powered by Stora Enso, allows food service units to automatically track expiry dates and receive instant notifications. Also, this system provides a remote price management function that helps in enhancing sales of products nearing expiration by suggesting discount criteria and featuring a screen on which can be displayed these discounts (Selfly Store, 2023).

Secondly, a lot of businesses have no idea about what it in their garbage bin is. HoReCa units can increase their profitability by paying attention to what products end up in the garbage bin (Martin-Rios *et al*, 2021, p.5). Smart bins have been designed to solve this issue. They gather and analyze FW data in order to reduce waste and save money (UNEP DTU Partnership and United Nations Environment Programme, 2021). The Kitro startup focuses on developing new FW management

solutions for the HoReCa industry (Martin-Rios *et al*, 2020, p.1130). It was designed to face a worldwide challenge by harnessing the digital technologies and putting them to be used for long-term change in FW area. Kitro's quantification approach is a high-end IoT combination between hardware and software. While the hardware is represented by a camera (placed above the client's existing trash bin) linked to a scale mounted beneath it, the software consists of distinguishing between unavoidable and avoidable waste by analysing the images captured by the camera. When new waste is disposed of in the bin, images of its content are collected. Its technology allows to make possible changes to the sort and size of portions offered being able to examine the returned plates. Thus, Kitro employs a revolutionary AI approach for autonomous food classification and helps HoReCa business to avoid daily wasting of important sums of money and essential resources which end up in the trash (Martin-Rios *et al*, 2021, p.6). In addition to Kitro, restaurant managers should adopt other digital solutions developed by FW quantification service providers, such as Leanpath or Orbisk (Leanpath, 2023; Orbisk, 2023).

4.2. Optimizing inventory and delivery times

In order to effectively predict a restaurant's most likely future stock demands, AI systems can be trained on historical data about past client purchases. The information gathered by these systems will assist restaurants in locating and purchasing food that is both reasonably priced and sufficiently fresh to avoid spoiling prior to serving (Synergy Restaurant Consultants, 2023; Total Food Service, 2023). With the help of 5-Out, a software designed to manage food inventory, restaurants are able to estimate consumers' demand by evaluating sales data. Thus, units can improve their purchasing decisions and make sure that they have available the proper quantity of ingredients to satisfy customers' requirements or to minimize costs associated with FW (5-Out, 2023).

ML techniques can be used to estimate demand for food goods. For instance, a retail company may develop a ML model to estimate demand for certain products using past sales and weather forecast data. A restaurant is able to prevent FW by making sure that the appropriate amount of food is prepared, picked up and delivered to the appropriate location at the appropriate time (Singh, 2023). Orders prepared by humans usually get mixed up. To enhance order sequencing, equipment monitoring, and packaging accuracy, Satis AI makes use of sensors placed around the cooking area. Specially designed to reduce human errors and significantly increase efficiency, AI-powered sensors are equipped with a variety of modules. By notifying the team when an order is mixed up, this digital technology claims to reduce FW by 50% as well as to minimize refunds. Along with Satis AI, Distancematrix.ai software can serve restaurants in preserving meals quality by optimizing delivery times. To achieve this, factors such as speed and rest periods of individual drivers, traffic, transportation methods are taken into consideration (Kubriak, 2023).

4.3. Kitchen automation

Kitchens may be monitored using voice and video recognition software which minimizes the need for human eyes. Restaurants managers can more effectively identify food spoilage and equipment problems by adopting AI systems in their businesses. In this way, carefully noticing the expiration dates of food products and tracking the incoming shipments process become easier. Besides closely monitoring the process of purchasing ingredients, it is also necessary to use them in adequate quantities in recipes. Developing accurate recipe sizing can be done with the help of AI systems. When recipes are sized incorrectly, a surplus result, costing money and increasing FW. ML algorithms can ensure kitchen staff that the quantity of ingredients used in each dish remains accurate. Therefore, this results in an appropriate serving size for a particular dish (e.g., kitchen staff could be informed when a specific dish requires more or fewer components than anticipated). They have enough time to make the necessary adjustments and stop FW before it starts (Gschnitzer, 2021; Total Food Service, 2023). The digital recipe manager, Meez platform, aims to develop the recipes organization by making this process easier. Its functions include content sorting according to the time of the year, menu or location, allergens tagging, avoid misplacing or forgetting a certain recipe. Along with other features such as quicker and more efficient team training, detailed food costing and nutrition analysis, this platform is able to reduce FW and overproduction by 20-30% (Meez, 2023).

Another useful digital tool is the smart menu-planning digital platform FoodOP, based on data from IoT, that provides a never-ending selection of recipes created by great chefs and recommendations for consumers (FoodOP, 2023).

Inside the kitchen, an automatically rotating of the menu items can help cut down on FW by decreasing food surplus (Total Food Service, 2023). Consumers' preferences can shift very quickly, especially in matters of taste (Smith and Lux, 1993, p.595). Thus, effective techniques regarding menu rotation are capable to prioritize various meals. This useful method aims to satisfy the different changes in consumers' tastes or to be a solution for the ingredients that begin to become scarce, during certain seasons of the year. Systems with AI enhancements are able to monitor the client's preferences. In this way, restaurants managers can give diners a new dining experience by changing menu over time based on AI system suggestions (Total Food Service, 2023).

In the age of digital menus and ordering, menu design is increasingly more relevant. Dynamic menu design and individualized recommendations are made possible by digital ordering (Roy *et al*, 2022, p.3702). FW can be reduced by increasing the use of digital ordering. Firstly, when consumers have additional customisation options, they can target the foods they require and want. Secondly, orders are processed without any human's errors when the ordering process is digitalized via mobile, web, or kiosks. These digital tools allow to easily take orders and send them straight to the kitchen, where they are accurately and thoroughly completed in accordance with the preferences of the consumers. Thus, by adapting the orders according to their needs and improving orders accuracy, digital ordering systems can reduce FW and generate financial savings for restaurants (Tacit, 2023).

Currently, the majority of commercial refrigeration-related businesses, including food service establishments, face a pressing need to track temperatures in real time (Zerynth, 2023). Another step to manage FW involves smart refrigeration systems. Tracking accurately and consistently the food from refrigerator is a difficult endeavor (Restaurant Technology News, 2019). But with the help of the IoT systems this task becomes easier. Longer food preservation is improved by adopting this digital technology. Unlike the classic ones, smart refrigeration systems are permanently monitoring the levels of temperature and humidity, and automatically adjusting the parameters to guarantee ideal storage conditions. Zerynth assists businesses in digitalizing their different processes (e.g., production). Particularly for refrigeration process, this industrial platform provides a solution based on IoT called Wi-Ref. This solution is very easy to be implemented within restaurant kitchens. If these two parameters are too low or excessively high, it tracks variables such as temperature and humidity and notifies the system to which it is connected. Zerynth helps restaurants to maintain the freshness and safety of perishable food (Zerynth, 2023).

4.4. Food redistribution

In recent years, there were developed a lot of methods referring to food redistribution during the final consumption stage (including HoReCa sector). This results in availability of various mobile technologies (apps) and websites that assist restaurants in food redistribution (Michelini *et al*, 2018, p.206; UNEP DTU Partnership and United Nations Environment Programme, 2021). Food service owners are using digital technology to address FW by enabling the recovery of the surplus food that would normally be thrown away. Therefore, digitality plays a huge role in connecting food that might be discarded with consumers or food banks (Cather, 2019).

On the one hand, by redistributing food to consumers, the food service business is sharing food for money. This for-profit strategy aims to generate income while reducing waste. The major goal of this concept is to reduce retail FW. One of the most representative digital tools is Too Good to Go app. It covers a large area of Europe and provides an interface where units from HoReCa list their unsold food. Users may then look up nearby restaurants on the map and buy food products for a small fraction of the initial retail price. Additionally, Too Good To Go features an option for users to enter their dietary needs and collaborates with units in the HoReCa sector to assist them in examining their specific FW issues. In the same way, users of the Karma app or Breeding website can purchase significantly discounted fresh food that might otherwise be discarded (Corbo and Fraticelli, 2015, p. 137; Oddbox Team, 2021; UNEP DTU Partnership and United Nations Environment Programme, 2021).

On the other hand, the foodservice business can donate the surplus food to food banks which means sharing for charity. Donors can be rewarded with financial incentives as well as they can easily reduce FW (Cather, 2019; UNEP DTU Partnership and United Nations Environment Programme, 2021). For instance, apps like The Food Rescue US and Goodr aim to combat food insecurity by creating a link between donors and organizations that help hungry people. While The Food Rescue US app features a request meal delivery option, the Goodr app enables companies to plan food pick-ups (Bozhinova, K., 2018).

5. Conclusions

Food waste is a global issue and occurs at the consumption stage. The HoReCa sector accounts for approximately 12% of total food waste, and the surge in out-of-home meals, increased earnings and tourism growth are all expected to enhance this contribution further. Foodservice units must not undervalue the role that digitality plays in managing food waste. By adopting and implementing digital technologies such as Artificial Intelligence, Internet of Things and Big data in food preparation processes, HoReCa sector can benefit from leftovers tracking (knowledge about expiration dates and leftovers), food inventory and delivery times optimization (improvement of purchase decisions and orders delivered more accurately and in time), kitchen automation (better recipes management) and food redistribution (almost all the food ends up being consumed). Based on these technologies, numerous companies have developed powerful digital tools aiming to prevent and minimize as much as possible food waste. For instance, digital storage spaces and kiosks, cameras, sensors, useful apps and websites, all powered by intelligent softwares, were specially designed to achieve a better food waste management in HoReCa industry.

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